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The design of Durban Harbour’s new entrance channel

The entrance channel of the Port of Durban is at present being widened and deepened to provide access for vessels up to an equivalent size of a 9 200 TEU container ship within internationally accepted navigational safety and channel availability norms. On completion, the Port of Durban – and South Africa – will occupy a favourable position on the north–south global trade route and will help to grow local and regional economies into the future.

As a natural estuarine harbour, at the confluence of many trade routes, the Port of Durban has developed into South Africa’s busiest multi-service port, handling a variety of commodities and vessels.

For the port to remain globally competitive, Transnet has embarked on a series of large-scale infrastructural developments. Of these, the deepening and widening of the entrance channel to the port of Durban is the first and forms the catalyst for further expansion within the port.

The development of the harbour breakwaters dates back to the 1840s through to the 1890s under the stewardship of civil engineers John Milne, Captain James Vetch and eventually Edward Innes, who in 1890 directed the completion of the north and south breakwater. Minor extensions, alterations and maintenance work have been carried out since, with the entrance channel still serving the port some 100 years later.

The main objective of the project is to provide the Port of Durban with a new entrance channel which allows for the safe access of all vessels up to an equivalent size of a 9 200 TEU (twenty-foot equivalent) container ship (length = 350 m, beam width = 45.6 m and draft = 14.5 m) under most weather conditions.

The design of the new entrance required consideration of a number of functional and port operational requirements. The primary functional requirements included navigational safety for vessels using the channel and a high degree of availability for all vessels up to – and including – the design ship. These requirements were to be met without inducing additional sedimentation of the channel, minimising the adverse impact...
of increased wave energy on the adjacent Bluff and Point berths, and maintained within the available land, utility and environmental constraints. In addition, the design was required to allow shipping traffic into the port during construction on a 24-hour basis without undue congestion.

**PROJECT DETAILS**

Prestedge Retief Dresser Wijnberg (Pty) Ltd (PRDW), supported by the Council for Scientific and Industrial Research (CSIR), in physical modelling and navigation assessments, were appointed in October 2002 by Transnet National Ports Authority to undertake the feasibility study. PRDW were then appointed in February 2006 to carry out the detail design of the deepening and widening of the harbour entrance channel.

The existing channel is orientated in the direction of the dominant winds, that is, south-westerly to north-easterly. The channel has an advertised depth of −12.8 m CDP (chart datum port) and a bottom width of 121 m at its narrowest. The depth is restricted by the presence of a sub-aqueous tunnel passing under the entrance channel and carrying municipal water, sewerage, electrical, communication and other services.

The width of the existing entrance channel is well below internationally recommended guidelines for the safe handling of vessels, which is further complicated by the presence of strong cross-currents (up to 2 knots) at the entrance. It is largely due to the skills of the Durban harbour pilots that large sea-going container vessels up to 4 000 TEU, car carriers, tankers, and bulk carriers can be safely manoeuvred into the harbour, albeit at somewhat elevated risk levels.

**DESIGN COMPONENTS**

**General layout**

During the preliminary design phase a number of channel alignments and layouts were considered in response to the functional requirements as defined by Transnet’s National Ports Authority. These layouts were subjected to a multi-criteria assessment based on navigational safety, impact on existing berths, land uptake, environmental impacts and capital costs. The preferred layout gave preference to the re-construction of a new north groyne with the channel cen-
change in berth availability would occur as a result of the proposed widening and deepening.

**New north groyne**

The wider and deeper entrance channel required the construction of a new north groyne. The primary function of the new north groyne was to dissipate wave energy, prevent the ingress of sediment into the navigable channel, and protect the banks and basic service ducts in the area.

The optimum length for the new north groyne was determined to be 550 m with a maximum depth at its seaward end of −17.5 m CDP. The groyne comprises graded rock, concrete armour units and a mass concrete cap with a crest height of +4.5 m CDP. The concrete armour units include 20 t dolosse as well as 5 t and 10 t antifer cubes. A typical cross-section of the new north groyne is shown in figure 4.

The main tool for verifying a breakwater design is physical model testing.

For the study a 1:100 scale 3D hydraulic model of the entrance channel was constructed to test the stability of the groyne against the 1:100-year storm event. This design storm event was determined by using measured wave data and a numerical wave propagation model, where wave heights were transformed to a location 150 m off the head of the proposed new north groyne. The design significant wave height for the head of the groyne was determined as 3.3 m, whilst a significant wave height of 1.3 m was used for the design of the revetments on the trunk of the structure. These wave heights are indicative of the sheltered position of the new north groyne, which is located in the lee of the existing south breakwater.

**South breakwater reinforcement**

Construction of the south breakwater commenced in 1885 and was largely completed by 1907. An extension of the structure by approximately 200 m was completed around 1932. As-built records are vague with historical figures suggesting a shallow foundation for the original structure. Subsequent sand bypass dredging implies much deeper depths at the toe of the structure and potential additional construction activities leaving significant uncertainty regarding actual as-built details. At this stage continued wave attack necessitated repairs that was constructed using 20 t dolosse. Figure 5 shows heavy overtopping of the structure during a storm wave attack.

The present structure shows a fair amount of damage and steep slopes along the channel side. Since the completion of the breakwater head, the cap has settled vertically by up to 0.7 m in places, resulting in large cracks (figure 6). As part of reinstating the concrete cap, its width was extended to allow access for cranes.
up to a capacity of approximately 700 t. Flexibility has to be maintained in terms of future sand bypass operations which may require accommodating more eroded toe levels than typical historic values. The proximity of dredge boundaries to the breakwater toe and unpredictability of dredge slopes due to coastal processes requires that the new toe be founded at least at the same depth as the existing structure. Existing toe levels will be determined by detailed jet probing executed as part of the construction contract. The rock toe is to be constructed immediately after this excavation has taken place to avoid sand accretion compromising breakwater toe levels. Toe dimensions were confirmed in a two-dimensional model study where vertical settlement of up to 5 m seaward of the toe was simulated.

The results of model tests indicated that changes in the bathymetry due to a deepened entrance channel would lead to increased wave attack on the head of the south breakwater as a result of wave focusing. PRDW were requested to carry out a design to reinforce the south breakwater in order to ensure its reinstatement to a standard corresponding to that of a new structure.

Owing to the increased wave attack on the head of the structure due to wave focusing, the damage levels were beyond acceptable design norms even after increasing the dolos size from 20 t to 30 t. In order to reduce wave focusing, configuration dredging (seaward of the head of the breakwater) was incorporated, but this did not solve the problem entirely. Increasing the dolos size beyond 30 t is considered impractical due to the risk of breakages. In addition, the potential for armour settlement in response to unpredictable toe settlement or the potential of discovering unexpected breakwater profiles during excavation of the toe suggested a need for robust units that would not break under such settlements. It was therefore decided that large antifer cube units with a mass of 45 t would be used along with configuration dredging. These units were tested and validated in the three-dimensional physical model at the CSIR hydraulics laboratory.

Demolition

The demolition works involved the removal of buildings and port structures along the northern bank of the entrance channel. In most cases, as-built drawings were sourced from Transnet National Ports Authority and photographic records from eThekwini Municipality. Quite a number of structures and services had no formal records, however, and an extensive on-site investigation had to be undertaken to fill in the gaps.

The demolition site is approximately 150 m wide by 900 m long and occupies some 10 ha. The site is zoned as light commercial and consists mainly of old cargo sheds and workshops that have been converted into restaurants and other tourist attractions. The demolition works consist of the following:

- Removal and disposal of asphalt and concrete paving
- Demolition and removal of various building types, including standard brick structures, old military gun emplacements, port buildings and sheds/warehouses
- Demolition and removal of various port structures, including quay walls, concrete caissons and concrete rubble
- Removal of the old north breakwater comprising rockfill, concrete blocks and general fill material

Demolition products, concrete, layerworks, etc, were used in the construction of the new north breakwater to reduce the imported fill content and to mitigate potential traffic impacts. Figure 8 shows the progress made on the demolition works.

Dredging

By law, marine disposal of dredged material is subject to the approval of the division of Marine and Coastal Management (MCM) of the Department of Environment Affairs and Tourism. This, in turn, is governed by international conventions to which South Africa is a signatory. The dredging and disposal permits were granted for the project in February 2007 with a validity of two years.

The existing marine disposal area (some 6,26 km$^2$), as used for annual maintenance dredging in the port, formed the basis of the application, with the planned disposal of up to 10 million m$^3$ of dredged spoil. If uniformly distributed over this area, the dredged material would raise the seabed level by an average of 1,7 m. The minimum water depth over the area is 70 m, so the change in bathymetry will not cause any measurable effect on wave
The most significant impact of the dredging and breakwater construction work is potentially its adverse effects on water quality, and specifically turbidity and suspended solids and the release of harmful constituents from the sediments into the water body. This impact is minimised by ongoing monitoring at critical locations and regulation of the contractor’s activities when threshold levels are approached.

The bulk of the dredging work will be undertaken using a trailer suction hopper dredger. Removal of isolated rock outcrops, and clearing of debris from the old north groyne structure, will be...
achieved by a large backhoe dredger, loading into hopper barges for marine disposal.

**PROJECT STATUS**
The main contractor for the entrance channel project, Dredging International/Group 5 Consortium, was appointed under the NEC 2 ECC option B form of contract and mobilisation began in May 2007. The removal of the existing north breakwater as well as the demolition of the north bank is under way (the progress is shown in figures 11a and 11b). Dredging by trailer suction hopper dredger and split hopper barge is also in progress. To date, 4.5 million cubic metres of a total of 10 million cubic metres has been dredged and disposed offshore at the specified disposal site. In March 2008 the construction of the new north groyne was about 10% complete and the reinforcing of the south breakwater was well under way. A total of 2 240 precast armour units with a mass ranging from 5 t to 45 t have been manufactured.

The project is expected to be completed by March 2010.

**Acknowledgement**
Prestedge Retief Dresner Wijnberg (Pty) Ltd would like to acknowledge Transnet Capital Projects and Transnet National Ports Authority (Durban) for supporting this article.
In this article, the author attempts to describe the wear mechanism in the interface between the wheel flanges running against the side of the rail crown when a railway wagon rounds a curve in a railway line. The cost of aggressive wear in the rail–wheel interface is compared to the cost of lubrication of the railway track and methods of lubricating the rail-wheel interface are described briefly. The trajectory of points on the wheel flange against the side of the rail is described and the effect of aggressive wear between the surfaces shown. The results of measurements of rail temperatures in the wear interface are discussed, as well as the frequency of occurrence of hot wheels on the Richards Bay coal export line.

**The Cost of Wear**

When the rail–wheel interface is lubricated, the wear rate decreases substantially: a dry wear rate of 0.127 to 0.178 mm/MGT (million gross tonnes of traffic) was measured in controlled tests. Lubricating the rail–wheel interface moderately well (medium enforcement) resulted in a wear rate of 0.0074 mm/MGT (17 times improvement) and good lubrication (high level of enforcement) resulted in 78 times (7 800 %) reduction in the wear rate to 0.0016 mm/MGT.

These measurements were done under well-controlled test and evaluation conditions at the Facility for Temperature and wear of rails on railway track.
Accelerated Service Testing at the Transportation Test Center of the Association of American Railroads in Colorado. The economic value of this reduction in wear and saving in replacement cost of rail and wheels is huge.

To replace the 182.5 km of high leg curve rail on the line carrying loaded coal traffic between Blackhill and Richards Bay will cost R103 million (at 2007 rail prices). If not lubricated at all, the rails on curves would have to be replaced after carrying 30 MGT, that is after 146 days (five months) at an average cost of R705 000 per day, labour cost excluded. If the line is lubricated well and allowing for only 50 times’ improvement, replacement of the rail is delayed to every 7 300 days at an average cost of R14 000 per day. The cost of application of lubricant is R6 000 per day, but the daily saving in rail cost is about R685 000. The cost of re-profiling and replacement of wheels is not included in this calculation, but it is generally accepted to be about double that of rail!

**LUBRICATING WHEEL FLANGES AND RAILS**

In practice, problems are usually experienced with efficient application of the lubricant to the rail–wheel interface. Various methods of lubrication have been developed and are applied on different railway systems.

Fitting lubrication devices on the locomotive wheels is not favoured in South Africa. The locomotives operating on the South African 1 065 mm gauge lines have very little space for additional devices on the bogies, and the fling-off of applied lubricant from the wheel flange causes the section of the bogie frame around the wheel to be covered with grease and to become very dirty. Therefore the devices are frowned upon by the locomotive maintenance staff and do not get maintained as they should.

An alternative method of lubrication is to use trackside lubrication devices usually installed at the beginning of some curves. The grease pumps are activated by the wheel tread and grease is pumped out on a wiper bar on the inside of the rail crown where the passing wheel flanges pick it up and deposit it in a reciprocating action on the wear face of the curves ahead. This system used to be favoured by Transnet, and at one stage they had about 5 000 trackside machines around the country, spanning 20 000 km of track all over South Africa. However, since these machines are out on the track, exposed to the elements and all weather conditions, they are labour intensive to maintain, and the management of the maintenance process is expensive and cumbersome.

On the Richards Bay coal export line and some of the main lines, a system is now used where dedicated vehicles with on-board lubricating equipment run on the track at regular intervals and deposit a bead of lubricant on the wear face of the curves. This system, though more costly than the trackside system, produces good results if managed properly. The vehicle also doubles as a patrol vehicle to identify problem spots on the track. However, the downside is that it occupies a slot in the schedule that could have been utilised by a train.

**QUANTIFYING LUBRICANT APPLICATION**

In closed systems such as gearboxes and, to a lesser extent, bearings, the working and wearing parts run within a reservoir of lubricant, and starvation of lubricant only occurs in very exceptional cases. The lubrication of rail and wheel flanges, on the contrary, can very easily deteriorate to a starvation situation where the lubricant becomes insufficient. It must therefore be ensured that lubricant is replenished regularly, and a relatively thick grease film acts as lubricant reservoir in this application. However, if too much grease is applied to the wheel, excess grease is flung off, causing environmental concerns, and excess grease also tends to creep onto the running surface of the rail. This can cause traction problems with resultant skidding and damage to the rail running surface.

With rail and wheel flange lubrication, grease has to be replenished on a regular basis since all the grease is lost and consumed. Because the lubrication system is extended over many kilometers of varying environmental, track geometry, traffic and operating conditions it is extremely difficult to measure and control all the factors influencing the system. The traffic profile, quantity and speed differ from day to day. Quantifying the application rates is some times more of an art than pure science.
An attempt was made to calculate the grease application rate on the Richards Bay Coal line by taking the figures available for the section Ntlasatse to Richards Bay, a distance of 137 km of double line consisting of about 48% curves. It is assumed that 131.52 km of curve was lubricated every day, the section being lubricated six out of seven days. Over 326 lubricating days, 68 drums (180 kg each) were used, and it is estimated that 10 kg of grease per drum goes to waste due to poor transfer and wastage practices. A total of 11 560 kg of grease was therefore applied over 326 days on 42,875.5 km of curve, consumed by an estimated 10 700 axles every day. This reduces to 0.2696 kg grease applied to each kilometre of curve, alternatively, 3,709 km of curve consumes 1 kg of grease. This gives 0.0252 gram/km curve/axle/day.

**OBSERVATIONS REGARDING THE WEAR OF THE RAIL**

Since the tread of the train wheel runs in rolling mode on the running surface of the rail, the wheel flange slides over the side of the rail. If the wheel flange were truly vertical, the path of a particle on the wheel over the rail would resemble that of a parabola where the particle would be in contact with the rail the whole time while describing the parabola.

Since the wheel flange to side of rail contact surface is a complex ‘s’ curve, sliding contact does not occur over the full face of the rail but in small spots on the wear face, depending on the profile of the particular wheel, that is, whether it is a new or an old, worn wheel. Asperities and any high spots would bear the brunt of this contact.

If the surface is well lubricated, the sliding contact, with a lateral force...
from loaded coal trucks of up to 6 t (nearly 60 KN), does very little measurable damage to the rail, resulting in a smooth, work-hardened wear surface with fatigue cracks forming over time. The angles of these cracks differ from curve to curve, depending on the traffic conditions and speed. Cases were sighted where the cracks were at about 90° with the horizontal where the traffic was running in both directions over the rail. However, on the Richards Bay Coalline, where there are dedicated lines for up and down traffic, it was found that the fatigue cracks were sloping with the direction of traffic (see figure 5). The angles with the horizontal measured between 62° and 78°, with the average around 68°. The cracks measured between 0.5 mm and 1.0 mm apart.

It is suggested that fatigue cracks first form at the colony boundaries of the pearlitic rail steel. Because of this divergent lamellar structure of the individual pearlitic colonies, the deformation behaviour is different in each pearlite colony and therefore high stress concentrations will occur at these boundaries during plastic deformation. When the yield stress is exceeded, fatigue cracks will form at the cluster boundaries due to the anisotropy (having different physical properties in different directions) of the clusters.6

As the train traverses the rail, small pieces of steel worn off the running surface or the gauge corner radius area of the rail, or from the cracked, fatigued surface of the side of the rail, would wedge into the sliding contact area between the wheel flange and the rail. If this happens when the interface is well lubricated, the intrusive steel particle is protected from friction and overheating by the lubricant and rolled into a relatively harmless thin, flat steel particle within the lubricated wear face. However, if this happens when the rail-wheel interface is dry or when lubricant starvation occurs, the full lateral force from the wheel would be concentrated on this unprotected little piece of steel. It would be squashed, rubbed and heated very rapidly between the wheel and the rail due to the lateral and frictional forces. It would momentarily weld itself to the rail and wheel, cool down and tear a piece of metal out of both or one of the surfaces. As a result of the rapid cooling process it would be martensitic in structure and could gouge out more steel from the wear surface before falling out.

The coarse, worn surface on the wheel flanges scoops up the last remnants of lubricant on the rail and the lubricant film is decimated rapidly. The pieces of steel gouged out of the rail and wheel flange surface fall and collect on the foot of the rail and around the extremities of the magnetised rail fasteners on electrified track. These shiny particles are nicknamed 'moondust' or 'rail dandruff' because of their shape, colour and size. Unfortunately, once this aggressive dry wear sets in, the damage to the rail and wheel flange surface is severe.

Inspection of some of the close-up rail wear photos seems to reveal small nodes of rail steel heated to discolouration suggesting temper colours: straw-brown and blue.

RAIL TEMPERATURE MEASUREMENTS

In an attempt to quantify the frictional forces, it was decided to measure the rise of the rail temperature as close as possible to the wear surface of the rail while at the same time measuring the lateral forces and wheel loads. A suitable curve was chosen on the Richards Bay Coalline at 59/9 km south of Vryheid and instrumented. The curve had a radius of 604 m, super-elevation of 20 mm and a design speed of 50 km/h. Temperature was measured with a thermistor embedded into a groove filed into the rail wear surface on the gauge side of the rail crown. The vertical wheel loads, lateral wheel loads and speed were derived by measuring the shear strain in the rail with strain gauges. The coefficient of friction was measured with a manually operated tribometer manufactured by Salient Systems and the ambient temperature was measured with a rail thermometer. The train and truck data (number and type) were obtained from the centralised traffic control office in Vryheid. All the parameters were recorded over a three and a half day period for a total of 57 trains that passed over the test site. The line had not been lubricated for the last 20 km and it was assumed that this would enable the line at the test site to be dry and the lubricant totally consumed by the third day.

The coarse, worn surface on the wheel flanges scoops up the last remnants of lubricant on the rail and the lubricant film is decimated rapidly. The pieces of steel gouged out of the rail and wheel flange surface fall and collect on the foot of the rail and around the extremities of the magnetised rail fasteners on electrified track. These shiny particles are nicknamed ‘moondust’ or ‘rail dandruff’ because of their shape, colour and size. Unfortunately, once this aggressive dry wear sets in, the damage to the rail and wheel flange surface is severe.
A rise in rail surface temperature of up to 12 °C was recorded under loaded 200-truck coal trains, and the coefficient of friction was recorded to be from 0.18 the first day to 0.37 on the last day. However, the rail was never really dry since a small amount of lubricant was carried over from beyond the non-lubricated portion of track. The coefficient of friction did not regress in a linear fashion since it was observed that grease was carried over larger distances by some wheels, probably depending on wheel profile and tracking ability of some bogies.

When the data were analysed, a very good correlation was found between the rise measured in rail temperature and the cumulative lateral force. It was assumed that this temperature rise could be attributed to the frictional forces between the wheel flange and the rail. Owing to the promising data collected, it was decided to return to the site to repeat the test, provided that the rail could be kept dry to see what temperature rise could be achieved.

The second battery of tests was done at the same site during August 2006 with eleven temperature probes (thermocouples) mounted on the high leg rail as shown in figure 9. This was done to measure the spread of the heat through the rail. The thermocouples in danger of being damaged by passing trains (numbers 3 and 4) were embedded in the rail by gluing them into grooves ground into the rail on the rail-wheel contact surface. All the other thermocouples were glued onto the surface of the rail. A twelfth thermocouple was embedded in the surface of the low leg rail (similar to the one shown as 3 in the high leg) right opposite the instrumented high leg rail. All the thermocouples were linked to an HBM MGC amplifier to record the temperatures.4

The objective of the measurements was to establish the relationship between the rise in rail temperature in the gauge corner rail–wheel interface induced by passing trains and the established coefficient of friction and train parameters such as speed, mass, number of wagons or the bogie type. Hence, many graphs were prepared by one of the team members to study any possible correlation between these variables.

No meaningful correlation was found between the increase in rail temperature and the coefficient of friction, speed of the trains, average axle load of the train or average lateral load on the high leg rail.

A strong correlation was found between the length of the train and the increase in rail temperature.

For trains of the same type, travelling at similar speed, the temperature did not increase with higher coefficient of friction on the wear surface of the high rail. However, it is thought that the condition of the bogies could be the controlling factor.4

The average increase in wear face temperature was 0.000506 °C per tonne for 200-truck trains with 100 tonne per truck payload, 0.000529 °C per tonne for mixed 200-truck coal trains and 0.01019 °C per tonne for 50-truck general freight trains.4

A graph of temperatures measured under a fully loaded 100 ton per truck train shows some interesting features:

- All the measurement points (thermocouples), even those at the foot of the rail, show a rise in temperature at the beginning of the passing train. It is surmised that this rise is due to the heat produced by the passing locomotives
- The thermocouples closest to direct contact with the wheel, that is numbers 3, 4 and 5, show the most immediate and highest rise in temperature
- The thermocouple on the surface of the low leg, number 12, shows an un-
expected high rise in temperature

The unexpected and simultaneous rise in temperature in the surface of the low leg rail was found to be fairly close to that of the high leg. When this was investigated, it was found that this rise in temperature can only be attributed to heat induced in the rail from the running surface contact between the rail and hot wheels. This is partially borne out by the good correlation found between the length of the train (number of wheels) and the increase in rail temperature.

This unexpected result of the test led to an investigation into the measurement of actual wheel temperatures.

**MEASURING WHEEL TEMPERATURES**

On the Richards Bay Coalline, there are a number of sites where wheel temperatures of all passing trains are measured by means of measuring devices set up next to the railway line. These are non-contact measuring devices measuring the wheel temperatures either at the central bearing area of the wheel or at the peripheral or tyre area of the wheel. If a wheel bearing fails, it will overheat and in extreme cases lead to a derailment with resultant costly damage to the rolling stock as well as to the track. Similarly, if the friction brakes on a particular truck do not release after an application, the wheel tread and tyre heats up and could result in the tyre coming off the wheel, also with a resultant very costly derailment.

Transnet therefore measures the wheel temperatures in order to identify overheated wheels so that the wagons with these wheels can be taken off the train to enable the required maintenance to be performed.

Wheel tyre temperature measurements for 392 970 wheels (approximately 480 trains) that passed one of the Coalline temperature measuring devices between September 2006 and June 2007 were then analysed.

It was found that the temperature of 1% of the wheels measured above 220 °C, which is the flash point of the molybdenum disulphide grease used to lubricate the wear face of the rail/wheel flange contact area. The number of
wheels above 300 °C was calculated to be 0.214 %.

CONCLUSION
These results explained the lack of correlation between the coefficient of friction and rail temperature rise in the temperature tests described in this paper. It also explained the high grease consumption on the line, and the fact that the grease disappears without trace. It seems that the grease is literally burned up.

References

This paper was presented at Tribology 2008, the 9th International Tribology Conference, which was presented by the South African Institute of Tribology at the University of Pretoria Conference Centre from 2 to 4 April 2008.
THE ADVANTAGES of continuously welded rails (CWR) over conventional non-welded rails are well known and the substantial reduction in total rail life-cycle cost is certainly its most attractive benefit. However, CWR has to be managed in such a way that the potential track failures that accompany it do not relegate the safety of the track.

Statistics of the coal export line in South Africa revealed that some 50–60% of all train delays are stress related. Track stress is responsible or contributes to the occurrence of rail breaks, track buckling, block joint failures, certain track geometry deviations and component failures in turnouts. This article describes an intelligent system that has been developed to manage CWR on a heavy-haul line and which has already been implemented on a track section of 200 km.

THE WILMA SYSTEM

WILMA is the acronym for Wayside Intelligent Longstress Management and is the name that has been chosen for the Transnet Freight Rail system to monitor and manage CWR. The system was developed with the following aims:

- To develop a wayside system that will monitor longitudinal rail stress in real time to enable better management of CWR
- To warn against possible track buckling and rail breaks
- To be a tool for planning and executing CWR maintenance
- To prevent derailments

CWR MANAGEMENT Theory

Tracks with continuously welded rails have to be managed for the occurrence of residual rail stresses and bending stresses caused by train loads as well as temperature stresses which are responsible for rail breaks and lateral stability problems such as track buckling.

The rail force ($N$) due to a temperature increase is calculated with the following formula (from Esveld?):

$$N = EAa\Delta T$$

In which:
$E = \text{Young’s modulus for the rail, (N/mm}^2\text{)}$

$A = \text{total cross-sectional area of the rail (mm}^2\text{)}$

$\alpha = \text{coefficient of expansion (/˚C)}$

$\Delta T = \text{T}_{\text{neutral}} - \text{T}_{\text{actual}} \text{(˚C)}$

The neutral (or stress free) rail temperature ($T_{\text{neutral}}$) is the temperature at which the track is neither in compression nor tension. The rail force will then be approximately 0. If the rail temperature rises above $T_{\text{neutral}}$, the track will be in compression while a decrease in rail temperature below $T_{\text{neutral}}$ will result in overall tension forces in the track.

The neutral temperature of the track can be measured by a number of methods.

**Measurement methods**

CWR measurements are usually carried out on Transnet Freight Rail lines by using one of the following methods:

- Cutting the rail combined with hand measurements
- The lifting frame method
- Strain gauge-based measurements

Cutting the rail combined with measuring the rail movement is accurate if measurements are done correctly, but it requires track occupation, the welding of a closure rail and it weakens the track structure.

The lifting frame method is also a time-consuming procedure which requires track occupation to loosen and fasten the rail fasteners and is only useable in tension conditions. The lifting frame used by Transnet Freight Rail has however been upgraded to enhance accuracy and performance.

*Strain gauging is extremely accurate and usable in any stress condition. It however requires a high skill level for initial installation and is expensive.*

A critical evaluation of the methods mentioned above has been carried out to develop the WILMA system that will be described below.

**SYSTEM DESCRIPTION**

The system is made up of the following components:

- Encapsulated strain gauges
- HBM MGC-Plus amplifier system
- HBM CP22 communication card
- RS232-GPRS communication interface unit
- Siemens Class10 GPRS Modem

All the strain and temperature gauges are encapsulated for ease of application and re-use and are manufactured by trained Transnet Freight Rail technicians adhering to strict quality control measures.

Applied instrumentation is covered by cover plates to protect against vandalism and damage due to on-track maintenance procedures. The cover plates are manufactured from mild steel and are galvanised to prevent rust. Two matching cover plates are bolted onto each other from both sides of the rail to protect the rail bound instrumentation (see figure 1).

The measurement hardware is installed in a steel cabinet placed in a concrete enclosure next to the track, which is either a concrete cubicle or a relay room.

Figure 2 shows the hardware chosen to amplify the rail stress and temperature measurements and which remotely sends the data to a central file server. A standalone amplifier with a plug-in display unit is utilised and can be expanded to more than 20 measurement channels.

The communications processor has RS232 connectivity and is remotely configurable via SMS. It connects to a server via GPRS to send data. Approved lightning protection forms part of the hardware that is housed in the steel cabinet.

Figure 3 shows the concrete cubicle with a safe door that is placed next to
the track to house the measurement hardware. Strain gauge cables are separately threaded through steel reinforced hydraulic hosing which runs along the sleepers and then vertically down into the track formation where it is buried. From outside the track formation the cables are conveyed to the concrete cubicle in galvanised steel pipes.

The last component of the system is the file server with monitoring software and large screen display (see figure 4). Data is received by the server and stored in a database from where the monitoring software can access the real time measurements. (The software is described in detail later in the article.)

The next section deals with the systematic approach that was followed to select the measurement sites.

SITE SELECTION

Sites were selected by interaction with track engineers and maintenance managers, by a desktop study of the call-out history of the line (including ultrasonic measuring car (UMC) faults and incidents that caused train delays) and by studying the general topography and layout of the line.

Sites were selected on a priority basis and the following list gives an indication of how sites were prioritised:

- Tunnel entrances and exits
- Track buckling and rail break areas
- Turnouts before and after deviations
- Long bridges
- Inside long tunnels
- Additional sites to bring about an even distribution of measurement sites along the track section

Approximately 100 measurement sites were chosen along the 200 km track section from Vryheid to Richards Bay. Sites were chosen in such a way that the spacing between the stations was not more than approximately 3 km.

CALIBRATION

A lifting frame developed by Van Tonder is used to calibrate the strain gauges that measure the longitudinal rail forces at each of the measurement stations. An example of such a frame is shown in figure 6.
The lifting frame works on the basic principle that if a piece of string is tensioned on both ends and then displaced at the centre of the string, a specific force is needed to displace it. The higher the tension in the string, the higher the force needed to displace it at its centre. The frame is pre-calibrated for each type of rail it will be used on.

The track fastenings are loosened over a distance of 20 m after which the lifting frame is used to lift the rail a distance of 70 mm. The force required to do this is then measured accurately and used to calculate the stress-free (neutral) rail temperature. The theory used implies that the frame can only be used when the rail is in tension.

This section completes the description, installation and calibration of the WILMA system. The next section describes the software that was developed to receive and interpret the data in an intelligent manner.

SOFTWARE
Infrastructure condition monitoring software (iCOMS) was developed for the following purposes:

- To configure a group of measuring stations in such a way that they will function as a system with specific infrastructure condition monitoring characteristics
- To receive data sent from GPRS modems at remote measuring stations and to store the different measurements in a database
- To visually present the data in a simple format
- To carry out elementary mathematical functions to the data
- To do trending and forecasting analyses on the accumulated data
- To present the results of the analyses in such a way that intelligent maintenance decisions can be deduced from it
- To apply specific maintenance and alarm conditions to the data and results
- To generate user-defined reports on infrastructure condition

The software comprises four components, namely a database module, calculation and modelling (trending and forecasting) modules, a graphical presentation module with maintenance and alarm conditions (the viewer) and a report generation module.

The database module stores all data received from the remote measuring stations in a structured way. A unique station ID is used to link the data to pre-configured measurement stations on the database. Currently, datasets are received from the 100 measuring stations at an interval of three minutes.

The main purpose of the calculation module is to convert the strain measurements to forces and to calculate the stress free temperature \(T_{\text{neutral}}\) at each specific measuring station. When longitudinal strain in the rail is measured, \(T_{\text{neutral}}\) can be calculated with the following equation:

\[
T_{\text{neutral}} = T_{\text{actual}} \times \frac{\epsilon}{\delta}
\]

In which:
- \(\epsilon\) = the measured longitudinal strain in the rail
- \(\delta\) = the measured rail elongation

The rail crown and side wear, which affect the cross-sectional area of the rail, are also taken into account when longitudinal rail forces are calculated.

The forecasting module estimates the expected rail temperature from forecasted air temperatures. In South Africa, the following relationship has been determined after extensive monitoring:

\[
Y = 1.64X - 8
\]

In which:
- \(Y\) = rail temperature (°C)
- \(X\) = air temperature (°C)

As these equations do not make provision for factors such as wind and shadow, the following relationships were established for the maximum and minimum expected rail temperatures:

\[
Y_{\text{max}} = X_{\text{max}} + 23
\]

\[
Y_{\text{min}} = X_{\text{min}} + 23
\]

Using the above equations, it is possible to predict which of the measurement stations might trigger the specified alarm limits in the near future.

The viewer can be installed on any PC connected to the Transnet Freight Rail intranet to view real time as well as historic data of the different measuring stations.

The report generation module generates three types of monthly reports from the accumulated data and the condition of the system. These reports include the following information:

**Condition report**

- Stations online
- Stations in normal/safe condition
- Stations requiring maintenance
- Stations with alarm conditions

It is envisaged that, once fully operational, the system will be widely used within Transnet Freight Rail by infrastructure managers, maintenance managers, the Coalline Operations Centre, production managers and finally by technology management for further research.
Maintenance report
- Monthly maintenance advisor
- Suggested sections for de-stressing
- Suggested temperature ranges
- Guidelines for de-stressing

Historical data report
- Monthly longitudinal rail force and temperature plots
- Monthly maintenance requirements
- Monthly alarm conditions
- Overall system health

SYSTEM INTEGRATION
Figure 7 gives a schematic representation of the WILMA system. A number of measurement devices are configured to form a measurement station. The measurement stations are then grouped together to form the WILMA system. The iCOMS software controls the WILMA system (amongst other systems) and sends reports to Transnet Freight Rail’s ITCMS (Integrated Infrastructure Condition Monitoring System – under development). The ITCMS is the twin brother of Transnet Freight Rail’s ITCMS (Integrated Train Condition Monitoring System) which monitors all condition aspects related to the rolling stock on the line.

Maintenance warnings and alarms are sent to the relevant depot for action while stop train alarms are sent to the CTC (Centralised Train Control) and SOC (Satellite Operations Centre).

It is envisaged that, once fully operational, the system will be widely used within Transnet Freight Rail by infrastructure managers, maintenance managers, the Coalline Operations Centre, production managers and finally by technology management for further research.

DATA PRESENTATION
Longitudinal rail force (left and right), as well as rail temperature, is measured at each measuring station. The stress, free (neutral) rail temperature is then calculated from the field measurements.

Unique upper and lower alarm limits are defined for each measurement station for the measured forces as well as the temperature measurements. These are based on experience, the local track conditions of the site as well as the desired temperature ranges for the climatic region in which the site is situated. The desired temperature range within a specific geographical area is the rail temperature range at which forces in CWR should not cause buckling in extreme heat or a rail break during extreme cold weather.

Figure 8 shows an example of the longitudinal rail force and the rail and stress free rail temperature data respectively as presented in the iCOMS detail display.

The upper and lower alarm limits are configured in such a way that the following maintenance actions and train alarms are generated:
- The enforcement of a speed restriction to lower the risk of a derailment due to rail buckling or a rail break
- The stopping of all trains over the specific track section
- De-stressing of the track when conditions of extreme heat or cold demand this
- Offloading of ballast to increase the lateral and longitudinal stability of the track

ADVANTAGES AND DISADVANTAGES
Advantages
The advantages of the system can be summarised as follows:
- Intelligent maintenance at the right time and place
- Continuous CWR rail force measurements
- Assist in derailment prevention
- Possible rail break and rail buckling detection
- Maintenance management and cost savings
- Continuous research possibilities due to system expandability
- Advantages to other maintenance actions (for instance tamping and placing of closures)
- Better understanding of CWR and track behaviour
- Supporting data in the unfortunate event of a derailment
- Improved track safety, reliability and availability

Disadvantages
The disadvantages of the system can be summarised by the following points:
- The system requires a high level of maintenance. A dedicated team has to maintain the supply of electricity, the rail bound instrumentation and the data acquisition system at each of the numerous measuring stations
- Specialised removal and replacement of instrumentation for certain maintenance operations, that is, ballast screening and rail replacement
- Like most other wayside equipment, the system is prone to damage by lightning

INFLUENCE ON TRACK MAINTENANCE
Although the system was designed to have a minimal impact on track maintenance, special attention is required depending on the type of maintenance that is carried out in close proximity to the measuring stations.

On-track maintenance
In the cases of tamping and rail grinding, these actions can proceed with caution. Extreme caution is required when ballast profiling is carried out. The rail mounted strain gauges and cabling have to be removed when ballast screening is carried out. The system is unaffected by the passage of geometry cars, the UMC (ultrasonic measuring car), grease cars and other high-rail vehicles.

Off-track maintenance
All manual off-track maintenance actions close to the measuring stations need to be supervised with extreme caution. In the cases of rail and sleeper replacement as well as the placing of closure rails, prior notification is required for the temporary removal of the measuring devices and cables.

CONCLUSIONS
The WILMA system has been developed to manage CWR on a heavy haul line in South Africa. Rail force and temperature are measured at a substantial number of measuring stations on a 200 km track section. These measurements are remotely sent to a central file server running software that stores the data, calculates useful track parameters from it, applies alarm limits to the calculated parameters and carries out trending and forecasting routines. The system is a useful and elegant tool in the world of high tech heavy haul and contributes to the safe and efficient operation of a railway line.

Acknowledgements
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References


This article was adapted from a paper presented by the same authors at a conference of the International Heavy Haul Association (IHHA) in Kiruna, Sweden, and entitled ‘An intelligent condition monitoring system for the management of continuously welded rails.”

Schematic representation of the WILMA system

Example of longitudinal rail force data
The philosophy behind cost-efficient track maintenance

RAILWAY IS A MODE of transport competing with a number of other modes of transport for business which is the sustenance of any business’ existence. Whether the business receives an adequate share of the market depends on a number of factors of which competitiveness is a major contributor.

In very simplified terms the cost of transporting goods will be calculated by adding up all the business expenses such as labour, energy, maintenance, depreciation (the construction costs divided by the functional life of the track) and profit, and dividing that by the total expected load to be carried per year to get to a rand per tonne rate.

As maintainers of track we control the maintenance and depreciation aspects of the calculation and can contribute towards competitiveness by a reduction in those costs. However, studies (in Austria) have shown that maintenance only accounts for 17% of the total maintenance budget as opposed to a minimum of 50% for depreciation costs. Savings on maintenance cost by doing less maintenance will prove to be very uneconomical as this will reduce the service life of the track and increase the depreciation cost.

The objective should therefore be to lower the track geometry deterioration rate and preserve the service life of the track by employing optimised maintenance strategies.

This article uses hypothetical examples to illustrate how the maintenance strategy can be optimised, measured over the life of the track. The examples are supported by relatively new research results by Professor Peter Veit from the Technical University of Graz in Austria, in his paper ‘Outsourcing in track maintenance’ as read at the OVG conference in September 2004.
An increase in track roughness will result in an increase in dynamic loads, which will accelerate the rate of deterioration. The curve AC represents deterioration of an asset with no maintenance intervention. If the deterioration is left unattended, the functionality of the asset will reduce until it can no longer be used. This can be compared with a motorcar that is bought new and over distance travelled, deteriorates in condition and wear to a point where it becomes unsafe to drive.

The same applies to the track. For the safe passage of traffic, the track cannot be allowed to deteriorate beyond the threshold for minimum allowable track condition. Similar to the motorcar, the deterioration rate of the track can be slowed down through planned maintenance actions which are carried out on time. However, the original as-built functional condition cannot be regained by typical maintenance input (as depicted by BD) due to the wear of the track components.

After maintenance input the track will continue to deteriorate (DE). Once again, as the deterioration approaches the threshold for minimum allowable track condition, maintenance input is required (EF) and, as before, the condition as achieved after the previous maintenance input cannot be regained.

This process continues with each maintenance input achieving a lower track condition than before and the interval between maintenance inputs reducing exponentially. This produces a new deterioration curve (curve AK) which is much longer than the curve AC without maintenance input. The life of the track has therefore been extended.

This process will continue until the period between required maintenance inputs becomes uneconomically short (compare distance GI with BE). Complete track renewal e.g. formation rehabilitation, replacement of sleepers, rails, fastenings, ballast or any combination of these components will then be required (IJ). The whole process will repeat itself.

1. Hypothetical track deterioration
2. Hypothetical track deterioration
3. Hypothetical track deterioration

The effect of maintenance on track life
Track deterioration curve with inadequate financial investment
The effect of high initial quality on track life
THE EFFECT OF INADEQUATE FINANCIAL INPUT OR POOR MAINTENANCE STRATEGIES ON TRACK LIFE

Track maintenance comprises a large percentage of any railway’s operational expenditure. When financial difficulty is experienced, the maintenance budget will usually be reduced first. The graph in figure 1 was based on the hypothesis that the necessary maintenance input in financial terms has been allowed for. The question arises what the case will be if the maintenance input is inadequate – that is, both in terms of maintenance intervention at a point below the maintenance threshold (too late) and/or insufficient input (too little) to achieve the highest possible condition.

Figure 2 illustrates how the deterioration curve will be much shorter than what the potential is if timeous and sufficient maintenance was carried out. The life expectancy of the track has been drastically reduced. In addition, the input required to renew the track (line AB) will greatly exceed the input that would have been required if timeous and sufficient maintenance was carried out (line CD).

THE EFFECT OF INITIAL QUALITY ON TRACK LIFE

The influence of the initial quality of the track also needs mentioning. Decisions made during the planning, design and construction phases of the track have far-reaching consequences for expenditure later in the life of the track structure. The use, for example, of lower standard track components, or lower standards of formation or drainage construction, may save money in construction costs, but the extra track maintenance cost and train delay times that result from this lower standard of work will consume these savings several times over. The higher the initial quality of the track, the greater the quality reserve, and the longer it will take before the next maintenance intervention becomes necessary, as illustrated in figure 3. The Tazara line is a good example of how a high initial quality with well-constructed cuttings and drains allowed a very long service life from the track despite limited maintenance being carried out.

Therefore, the selection of initial construction standards for new lines should be aimed at achieving high initial quality of track and the subsequent maintenance input should be aimed at activities which will lower the track geometry deterioration rate such as clean ballast, good drainage, profiled rails, lubrication, etc, which will extend the service life of the track.

These decisions must of course be taken with due consideration given to traffic density, speed and axle loads that will be carried by the track.

If the above principle is applied correctly, the lifecycle cost of the track will remain at affordable levels without having to undermine the service life of the track.

A few more assumptions, though proven in practice, can be made.

- A system should be in place to establish when the deterioration is approaching the threshold where maintenance is required. This requires the measuring of the track parameters and footplate inspections to establish the track information required for calculated decision-making.
- Every maintenance input should aim to reduce the deterioration rate, that is, durability of maintenance should be aimed for. Maximum durability can be achieved if appropriate and proven mechanised maintenance machinery is used. This is also aimed at achieving high initial quality, something that is difficult to achieve with hand labour.
- Whether or not mechanised methods are utilised, any track maintenance department needs a well managed, trained and motivated labour force. The extent to which the employees’ motivation, needs, skills, experience and values are properly aligned with the company’s objectives, needs, values and norms will directly influence the quality and durability of track work performed.
- Resources will invariably be limited and proper planning becomes crucial to utilise the resources effectively and economically. This can only be achieved if a maintenance management system is employee.
- The length of the deterioration curve will depend on how close the maintenance input brings the track condition back to the level before, taking into consideration the wear and tear.
in the track components. This implies that proven maintenance practices and maintenance strategies should be applied at all times.

**RESEARCH THAT SUPPORTS THE ABOVE HYPOTHETICAL EXAMPLES**

The paper presented by Professor Peter Veit ('Outsourcing in track maintenance') provides some of the vital technical and economical correlations of the track which supports the hypothetical example used above. The paper was based on the Austrian project which concentrates on the optimisation of track maintenance by implementing strategies that take the total cost of the track into account from initial construction to the next complete renewal. An understanding of the research results should be carefully considered by us in South Africa in an effort to optimise our maintenance strategies. The following are extracts from the paper by Professor Veit (including figures 4–6).

The evaluations and analysis of the Track Strategy project highlighted a number of facts (see figure 4) including:

- When the traffic decreases, the lifecycle costs for the track also decrease
- The total lifecycle cost comprises depreciation (the construction costs divided by the functional life of the track in years / tonnage / number of axle passes), running or operational costs and maintenance costs
- The additional operational costs as a result of maintenance (impact on traffic, occupations, etc) can exceed the maintenance costs
- The main conclusion of the analysis was that the optimisation of track costs, that is, reduction of the lifecycle costs, is only possible through a reduction of depreciation through the extension of the service life of the track. On the other hand, the analysis showed that there is little room for savings on maintenance costs since when maintenance is reduced, the life expectancy of the track will decrease sharply which will increase the depreciation costs. The result is very uneconomical, which is likely to
have the opposite effect – an increase in lifecycle cost. The analysis was therefore summarised as follows: adequate maintenance from the start will lead to a long service life, optimising the track economics.

The article also addressed the effect that maintenance has on the lifecycle of the track. It refers to actual results which are almost identical to the hypothetical example used in figure 1. Quality improvements are said to be dependent on, inter alia, the threshold for minimum allowable track condition (see figure 5).

If the threshold for maintenance intervention is set at point 1 (low threshold), the effect of too little maintenance will be hardly noticeable at first but the service life can already have been reduced due to the knock-on effect of the first track defect. For example, if the track roughness index is set to low before tamping takes place, the roughness will cause higher dynamic loading of the track which will cause crushing of the ballast, which in turn will result in fines in the ballast bed retaining moisture, etc; eventually resulting in damage to the permanent way material. When the maintenance measures are set for a low quality threshold, the evaluation showed relatively high initial improvements in quality values, however, this level is not sustainable and the deterioration will rise. The quality level achieved after maintenance will be lower than if measures had been implemented sooner. Intensive maintenance efforts at a later stage to extend the service life once more proved uneconomical.

The level at which the threshold is set is therefore of significant economic importance. Furthermore, calculations have shown that the threshold from an economic point of view should not be set at a fixed value but it should rather be linked to the age of the track. It can be proven that this type of threshold leads to a longer service life and is generally more economical.

The general tendency by maintenance managers is to maintain a constant threshold for maintenance intervention throughout the life of the track. In a practical example, the track quality index (TQI), as measured by the track recording car, is set on 1.6 for the Coalline before tamping takes place. The research analysis of the Austrian project however provides a different approach. Starting from the bottom of figure 6: an increasing threshold means that while the track is new, the threshold is set very low and investment in maintenance is limited. Initially the effect thereof cannot be seen. As the track ages, the threshold has to increase due to the increasing wear of the other track components, to maintain a reasonable availability and track life. However, the knock on effect referred to earlier has already taken its toll and will negatively impact on the life of the track. This is probably not a maintenance strategy, but rather the result of financial constraints or neglect.

With a constant threshold, maintenance intervention will always take place when the track condition has reached a predetermined level, irrespective of the age of the track such as the Coalline example. From the hypothetical figures provided, it can be seen that to maintain this quality level, the period between interventions will become shorter due to the wear of the track components.

The most economical approach to track maintenance was proved by the Austrians to be when money is invested in a high level of quality initially with corresponding maintenance which leads to a long service life, that is, economic advantages in the future. In other words, a long service life and lowest lifecycle cost can be expected when a high initial quality has been achieved during construction and when the threshold for maintenance intervention is at its highest while the track is still new. The threshold is then gradually reduced towards the end of the track life.

**CONCLUSION**

In South Africa, where the railways are not subsidised, they must pay out of profits for their ‘road’, unlike the trucking industry which uses public-funded roads. As maintainers we play a crucial role in making the railway competitive through the application of scientific maintenance strategies and practices which extends the life of the track and in so doing reduces the depreciation cost. This can be achieved through:

- Having a long-term approach and considering every effort in terms of the lifecycle cost. The worst approach will be to reduce maintenance in the short term to save on costs as this will have a detrimental long term effect and may very well put the railway out of business.
- The position/value of the maintenance threshold must receive careful consideration. The Austrian project confirms this philosophy by providing evidence that if maintenance intervention takes place too late or is inadequate, the depreciation value will increase which will make the railway uncompetitive.
- Implementing a decreasing threshold which will see track defects and preventative maintenance being addressed early during the life of the track. This is especially applicable to all the new turnouts that are currently being installed.

Wise planning and implementation of maintenance at regular intervals will extend the life of the track to remain economically viable for many years to the benefit of economic growth of our country, to the benefit of the environment from an energy consumption point of view and to the benefit of road users through reduced traffic congestion and fatal accidents.

**References**


INFRASET INFRASTRUCTURE Products is on schedule with the delivery of Gautrain’s concrete sleepers to the Gautrain Sleeper Joint Venture. These include B70 sleepers for the ballast track as well as sleepers for the 1 in 9 turnouts. Moreover, all the sleepers for the Marlboro depot have been delivered.

Infraset, which won the contract to supply both track and turnout sleepers against stiff international competition, is supplying a total of 190 000 sleepers manufactured to the Bombela Consortium’s requirements. In addition to the 1 in 9 turnout and B70 sleepers already supplied, they will include 1 in 12 and 1 in 18.5 turnout sleepers.

The standard gauge 2.5 m B70, which is designed for high-speed lines, is used widely in Europe, where over 40 million have been installed to date.

Kobus Burger, general manager railway products at Infraset, says the turnout sleepers are also being manufactured to European specifications and standards for high-speed passenger lines.

“We received the coordinates for the turnout sleepers from VAE South Africa during September last year and delivered the initial sets during the first week of December. VAE South Africa sets extremely high standards and specified that the sleepers be manufactured to tolerances of 0.25 mm.”

Burger observed that two notable milestones are integral to the railway line on this project.

“It is the first time that swingnose crossings have been used on 1 in 9 turnouts in South Africa and it is also the first time that rail cant is being deployed on 1 in 12 and 1 in 18.5 turnouts.”

Infraset, which won the contract to supply both track and turnout sleepers against stiff international competition, is supplying a total of 190 000 sleepers manufactured to the Bombela Consortium’s requirements. In addition to the 1 in 9 turnout and B70 sleepers already supplied, they will include 1 in 12 and 1 in 18.5 turnout sleepers.
Month end 30 April 2008

Gautrain construction update

SOUTHERN SECTION
Underground section
Park Station

Excavation of the single-track rail tunnel towards Emergency Shaft 2 in Houghton has reached approximately 310 m from the tunnel portal. Construction of the underground station box and multi-storey parkade foundation is making good progress.

Within the station box, waler beams and struts have been installed to provide temporary lateral support to the perimeter walls during station box excavation.

Emergency Shaft 1 (Hillbrow)
The single-track rail tunnel between Park Station and Sandton Station will feature seven emergency access shafts. These shafts will provide emergency services personnel access to the tunnels below. At the bases of these shafts there will be safe havens where passengers can gather in case of an emergency.

The land required for Emergency Shaft 1 in Hillbrow is in the process of being expropriated. Site establishment and shaft excavation will start once this process has been completed.

Emergency Shaft 2 (The Wilds, Houghton)
At Shaft E2, shaft lining was completed to the 38 m depth above the cavern and grouting ahead of the cavern excavation was in progress. Once this cavern is complete, an adit linking the bottom of the shaft to the tunnel alignment will be excavated, from where two rail tunnel sections will be excavated. The one tunnel will head south towards Park Station, while the other tunnel will head north towards Rosebank Station.

Emergency Shaft 3 (Riviera)
Construction of this shaft will start soon. The construction site has been hoarded and site establishment has commenced.

Emergency Shaft 4 (Houghton)
Excavation of this shaft has been completed to its 14.3 m final depth.
Rosebank Station

The giant Tunnel Boring Machine (TBM) has already installed approximately 460 tunnel lining segments rings in the single-track rail tunnel being bored towards Emergency Shaft E2. This equates to a distance of almost 690 m of tunnel bored below Oxford Road.

This moving factory uses latest international technology to bore a 3 km section of the tunnel from Rosebank Station southwards. The TBM has been purpose built to deal with the difficult geological conditions along this section of the route. The remainder of the single-track rail tunnel towards Park Station will be excavated using conventional drilling and blasting methods. The TBM, named Imbokodo, installs precast concrete tunnel lining segments behind it as it moves forward. It leaves behind a watertight and smooth lining to the 6.8 m diameter tunnel.

Tunnel lining segments are manufactured at an offsite facility and are delivered to site.

Excavation of the underground station box and its base slab is completed. Construction of the external walls within the station box is in progress. Excavation of the single-track rail tunnel towards Emergency Shaft 5 has reached 250 m.

Emergency Shaft 5 (Dunkeld, Rosebank)

Tunnelling southwards towards Sandton Station – the only section of tunnelling being excavated from this shaft – has progressed to approximately 315 m. Excavation of the safe haven chamber is progressing simultaneously.

A head house structure is visible above the shaft, which houses the overhead gantry crane. It is used for hoisting excavated rock and lowering and lifting materials and equipment.
The crane is clad with sound absorbing panels to limit noise created by construction work. This is a temporary structure, which will be removed once tunnelling operations are completed.

**Sandton Station**

Construction of the cavern for the underground station is in progress. Excavation of the three level parking basement is complete and construction of the parkade foundations has commenced.

Excavation of caverns in both directions from the 45 m deep shaft at the southern end of the station continued, with the single-track rail tunnel cavern towards the south having progressed to approximately 45 m.

**Mushroom Farm Park**

Two sets of tunnels are being excavated towards Sandton. The single-track tunnel has reached Sandton Station and remained at 472 m, while the double tunnel towards Sandton continued, reaching approximately 280 m by month end.

The double tunnel towards Marlboro Portal reached approximately 650 m. Later this year, the tunnel being excavated from Mushroom Farm Park will meet with the tunnel being excavated from Marlboro Portal to form one continuous tunnel.

Mushroom Farm Park is a temporary shaft used to provide access for tunnel construction.

The community park will be fully reinstated once construction operations are complete.

**Marlboro Portal**

Excavation of the double-track tunnel towards Mushroom Farm Park approached 1 870 m from the portal. Inside the tunnel, the final lining is being applied to the tunnel walls. Construction of the floor slab to support the railway tracks is in progress. Concrete walkways are being installed and construction of the dividing wall separating the two sets of tracks is in progress. Construction of the cut and cover structure adjoining the portal continued.

The portal at Marlboro is the point where the tunnel ‘day-lights’. It separates the underground and surface sections of the route.

**Surface alignment**

**Marlboro Station and N3 Underpass**

A continuous longspan elevated rail bridge is called a viaduct. Several viaducts are being built to cross rivers and roads on Gautrain’s route. The precast concrete deck segments for these viaducts are being manufactured at the precast yard.

At Viaducts 1a and 11, which cross the Jukskei River and East Bank Road in Alexander, the southern abutments – the last elements of substructure remaining – approached completion, ahead of the arrival of launching girder T1, which has completed...
its work at Viaduct 3. Once the launching girder is assembled, deck erection will commence.

Earthworks, retaining walls and associated drainage structures are in progress between the Marlboro Portal and the N3 Crossing, including in the area of the Marlboro Station, where station construction has now started.

Construction of a series of underpasses, where the two pairs of railway lines cross below the N3 highway alongside the Marlboro Road bridge, continues.

**NORTHERN SECTION**
**DEPOT TO HATFIELD STATION**
**Depot, precast yard and rail welding facility**

Construction of this section of the route between the N3 crossing and the depot is well advanced.

At Viaduct 2, over Modderfontein Spruit, Mbeam erection was completed, side panel installation is well advanced and casting of deck slabs on top of the Mbeams is in progress.

At the train depot, Gautrain’s 24 train sets will be maintained, serviced cleaned, and securely stabled overnight. The adjacent bus depot will perform a similar function for Gautrain’s dedicated fleet of 150 luxury buses. Construction of these facilities is well advanced, with the bus depot administration building already complete and the train depot offices and maintenance workshops targeted for completion within the next few months.

The welding of rails into 216 m long lengths has commenced at the temporary flash butt welding yard that has been set up adjacent to the train depot. This facility uses high-tech rail-welding methods which eliminate the need for jointed gaps between rail lengths. The laying of trackwork for the stabling sidings at the train depot has commenced.

The precast yard – also temporarily located at the depot – is equipped with twin concrete batching plants and several overhead gantries and tower cranes that are required to manufacture a variety of precast concrete elements. These include viaduct segments, bridge beams and parapets, tunnel walkway sections and noise barriers. From here, precast elements are transported to the various construction sites as needed. It is currently the largest precast facility in Africa.

**Midrand area**

Construction is now well under way in the vicinity of Midrand Station and continuing towards Centurion.

Construction of Viaduct 3 over Allandale Road is making good progress. All thirteen of the deck spans have now been erected and this launching girder will now be dismantled and transported to Viaducts 1a and 11 at Marlboro.

Deck segments are erected using massive purpose-built launching girders. These girders are launched across the supporting piers to rapidly assemble the precast deck segments. Segments are then glued and stressed together to form the deck spans. This international bridge deck assembly method enables construction to proceed with minimal disruption to existing infrastructure and traffic below. There are two of these underslung launching girders deployed on the project.
At Viaduct 4, which crosses Rietspruit and Olifantsfontein Road South, construction of the supporting piers and abutments is in progress.

Construction of a number of smaller road-over-rail bridges in this area continues, including at Ridge Road, West Road, New Road and George Road.

**Centurion area**
Viaduct 5 carries the elevated alignment through Centurion. It stretches over the John Vorster Interchange crossing the N1 in the south and then continues through Centurion to the Jean Avenue Interchange crossing the Ben Schoeman highway in the north.

The sinking of deep foundation shafts for Viaduct 5 at both of these interchanges continues, and construction of the supporting piers is in progress at the Jean Avenue section.

Several temporary steel pedestrian bridges have been erected over the N14 highway at the Jean Avenue Interchange and across the N1 at John Vorster Interchange to provide construction workers safe access across these busy highways.

Within Centurion itself, foundation construction – comprising excavation, preloading, grouting and piling – is under way at many of the viaduct pier locations, including those which will support the elevated platforms of Centurion Station. This station will be situated on the northern side of West Street close to Centurion Lake. Utility diversions throughout the Centurion area are ongoing.

**Pretoria area**
Construction of an underpass where the Gautrain rail track will cross underneath the Ben Schoeman to the south of Salvokop is in progress.

Piling for the pier foundations has started at Viaduct 7, which will cross Nelson Mandela Boulevard at the entrance to the city.

At Pretoria Station, the existing staff parking area has now been vacated to enable construction of the Gautrain Station to proceed. Hoarding has been erected around the construction site.

**Hatfield area**
Between Pretoria and Hatfield a number of bridges crossing the existing railway line require to be widened to accommodate the adjacent Gautrain tracks.
Abutment construction for the widening of the Lynnwood Road bridge continued, as did foundation work and piling at the Ridge Road bridge. This bridge will replace the existing bridge at Willow Road, which is to be demolished. Piling at the new Grosvenor Road bridge next to Hatfield Station and piling for the extension of Cilliers Street bridge commenced during April.

At Hatfield Station, piling for the parkade structure was in progress and construction of the base for the retaining wall along the adjacent SARCC alignment diversion got under way.

**EAST-WEST AIRPORT LINK**

*Airport Link (Marlboro Station to O R Tambo International Airport)*

Deck erection at Viaduct 13 over Centenary Way in Modderfontein, using launching girder T2, is approaching completion.

A short distance to the east, foundation and abutment construction continued at Viaduct 14, which will span Zuurfontein Road and the adjacent existing railway line.

Several other bridges and culverts are also currently being built along this section of the route.

**O R Tambo International Airport Station**

By far the longest viaduct on the east–west section of the route is the 1.5 km long Viaduct 15, which will carry the double-track railway line over the R21/R24 road network to the elevated O R Tambo International Airport Station. Viaduct foundations have been completed and construction of the supporting piers is well advanced.

Construction of the station concourse is in progress and is visible above the elevated dropoff road. This is immediately adjacent to the new Central Terminal Building which is currently under construction at the airport.

**OVERALL PROGRESS**

Construction started at the end of September 2006. Gautrain will be completed in two phases:

- The first phase has a duration of 45 months. It includes the network between O R Tambo International Airport and Sandton and includes the stations at O R Tambo, Rhodesfield, Marlboro and Sandton, together with the depot and operations control centre located near Allandale Road in Midrand.
- The second phase, being constructed concurrently, will be completed in 54 months, towards 2011. It includes the remainder of the rail network and stations linking Sandton to Park Station in Johannesburg and the route from Midrand to Hatfield.
IT WILL TAKE three months to dismantle and remove Gautrain’s giant 325 t tunnel-boring machine (TBM) and its 560 t of backup equipment after it has completed its 3 km drive underneath Oxford Road and onto Killarney.

This stretch of tunnelling started at Rosebank Station in January 2008. The TBM will finally come to a halt just short of Emergency Shaft 2, situated at The Wilds in Houghton, early in 2009.

The custom-designed mixed face earth pressure balance shield TBM is designed to cope with the challenging geology south of Rosebank. The tunnel borer is encountering complex conditions with a high water table passing through differing ground consisting of differing degrees of hard rock, sand and soft soil.

The TBM was built over a 12-month period in Germany at a cost of R300 million and was shipped to South Africa in the last quarter of last year.

When it reaches its final destination, dismantling of the TBM will take place in phases between March and May 2009. First the 145 m long back-up system comprising 13 gantry trailers will be removed. A diesel-powered locomotive with a 25 t pulling capacity will tow the trailers out of the 3 km tunnel back towards Rosebank Station where the TBM started.

**TBM LARGE: NOT THIS ONE**

When the trailers have been removed, dismantling of the front end of the machine (the main body) and cutter head can start inside the tunnel. The dismantled components and all the electric motors will also be taken out of the tunnel for reconditioning and use on other tunneling projects. These include:

- Thrust jacks
- Articulation cylinder
- Steering cylinder
- Rotary coupling
- Main drive
- The 6.8 m diameter cutting wheel, which houses 48 cutters, will be dismantled. The cutting wheel will have to be scrambled but the hubs of the cutters can be reused. The wheel is used for boring a 6.8 m diameter tunnel for a single-track rail line. As soon as a 1.5 m length of tunnel has been bored, a ring of pre-cast concrete tunnel lining segments is erected behind the cutter head. It leaves behind a watertight and smooth lining. However, the diameter of the lined tunnel is too small for the cutting wheel to be taken out of the completed tunnel in a single piece. Therefore, the cutting wheel needs to be dismantled before being transported out of the tunnel.

The 12 m outer steel skin of the front-end of the machine will remain where it is, in the tunnel. As it will be where the TBM comes to a halt, this short section of the tunnel is bigger than usual as it will not have been lined with concrete segments. The exposed steel skin over this short section will be covered with shotcrete to match the internal diameter of the precast concrete lining.

The remainder of the 15 km tunnel between Johannesburg Park Station and Marlboro Portal will be excavated using conventional drilling and blasting, as is done on the mines.

Tunnel borers are used on many...
projects around the world. Urban tunneling requires that the ground surface is left as undisturbed as possible to protect underground municipal services and nearby buildings. This is facilitated by the use of TBMs which generally disturb the surrounding ground less than drilling and blasting does. Another advantage of TBM technology is its ability to produce a smooth tunnel wall.

**GOOD PROGRESS ON THE TBM’S MAIDEN VOYAGE**

By the end of February, Gautrain’s TBM had successfully excavated 100 m on its maiden voyage, which started in January.

The TBM is progressing at about 9 m a day. When this moving factory is running to full capacity, it installs precast concrete tunnel lining rings at a rate of 12 per day. Each ring is 1.5 m wide and comprises six interlocking segments. A standard segment weighs 3.92 t.

When a ring of precast lining is to be installed inside the bored tunnel it requires the TBM to come to a temporary one-hour halt. As soon as the erection of the segments has been completed, the tunnel borer moves forward while the cutting wheel excavates the next section of the tunnel ahead. It advances a distance of 1.5 m at a time — equal to the width of the ring of precast concrete segments.

Work takes place 24 hours per day. The TBM functions on a 20 hour production shift with a four hour maintenance break. This includes the replenishment of equipment and stock such as foam or grouting which are carried on the gantry trailers. The extension of the conveyor belts which remove the excavated ground to the access pit however does not delay the process. Maintenance of or replacement of the cutters can be done from behind the cutter head. Access to do this is via an airlock, as the cutter wheel chamber has to be pressurised when the machine is passing through water bearing ground.

In order to transport the necessary materials and supplies to the TBM as it bores its way further along the tunnel, service rails are laid behind it inside the tunnel. A man rider is also used to transport TBM workers in and out of the tunnel. The heavy precast concrete segments, which weigh 3.92 t each, are transported on flat cars drawn by a diesel locomotive.

The TBM is directed or driven by a pilot (or driver) who sits in a control cabin surrounded by an array of computer screens. His job is facilitated by a sophisticated electronic guidance system which displays a target he has to follow. It allows the pilot to steer the machine and to continuously monitor the actual three-dimensional position of the machine in relation to the theoretical centre line of the tunnel at any given location along its route.

**ELECTRICITY REQUIREMENTS**

The TBM requires a total of 3.2 MW of power to drive the 325 t giant. A substation dedicated to the needs of the TBM is situated at the Rosebank Station construction site.

The cutter head is driven by seven motors and has 150 drag teeth for the soft ground mounted on it. It also has 40 single-disk cutters and four twin-disk cutters used for hard rock. The electric power rating of the cutting wheel is 2 450 kW.

The total thrust that the machine can develop against the ground is advances at a thrust of 4 000 t.

By the end of February, Gautrain’s TBM had successfully excavated 100 m on its maiden voyage, which started in January. The TBM is progressing at about 9 m a day. When this moving factory is running to full capacity, it installs precast concrete tunnel lining rings at a rate of 12 per day. Each ring is 1.5 m wide and comprises six interlocking segments. A standard segment weighs 3.92 t.
THE GANSBAAI DEVELOPMENT
set along the tranquil landscape of the
Atlantic Coast offers breathtaking views
in an unspoilt setting. This exclusive de-
velopment is situated 22 km south of the
beautiful resort town of Hermanus in the
Western Cape.

The exciting venture commenced two
years ago and entailed the design of some
1 000 erven, a retirement village and a
neighbourhood shopping centre. It has a
total project size of around 110 ha.

EFG Consulting Engineers is respon-
sible for the project management as well
as the design of all the infrastructure
services. These include the bulk services
for water and sewerage, which is literally
non-existent in the area.

Gideon Hahn from EFG Consulting
Engineers points out that the project pre-
sented numerous highlights. According
to Gideon, the terrain is completely un-
developed and has a duny landscape that
stretches for miles. Fynbos and other
natural vegetation also grow freely and
placed additional pressure on the team to
uphold the principles of environmental
conservation and restoration. In order
to assess the feasibility of the project, a
preliminary design was carried out that
included the planning and sizing of in-
ternal as well as bulk services.

Special emphasis was given to storm-
water drainage during the stormwater
design phase. ‘Where possible, open
stormwater systems were incorporated.
In addition, the number of detention
ponds will be kept to a minimum in
order to reduce maintenance needs.
Grass block channels will also be pro-
vided to take run-off from the roads to
the detention facilities,’ explains Hahn.

Gideon is an avid Civil Designer and
AllyCAD user and is considered to be
an expert in the software. He uses the
design packages for the compilation of all
his drawings and is skilled in the prepa-
ration of survey plans and the generation
During the project’s execution, there were many stipulations. One of these included traffic calming during the road design. This meant that measures had to be designed to discourage speeding and rat running. Raised intersections and the use of block paving were among the traffic calming measures employed.

According to Gideon, the site currently has a single gravel access road which will be replaced by a new access road from the trunk road once the construction of the development commences. During the execution of the project, EFG Engineers set about to undertake a traffic impact assessment study to assist with the geometric design. An important stipulation throughout the process was that special attention be given to environmental conservation and the restoration impacts of the construction process.

The greater Gansbaai area is currently served by a wastewater treatment plant near the municipal offices some 4 km from the proposed development with sewerage flow from the area to the works transported by tanker. The treatment plant currently has an operating capacity of 0,3 Mℓ per day, but as a medium-term interim measure, the existing plant is currently being upgraded to 1,0 Mℓ capacity and will have sufficient treatment capacity for the proposed developments in the area. ‘The design and planning of the new pump stations and rising main to the existing works has therefore commenced in earnest,’ explains Gideon.

‘The environmental impact assessment process is still continuing and we hope to get approval from the Department of Environmental Affairs and Development Planning shortly for the new works on the proposed site. The project has been divided into four phases and is likely to be completed in the next four to five years,’ he says.

Future developments in this coastal region include the compilation of a sewer master plan for the greater Gansbaai area. This master plan will, amongst others, identify a site for a new treatment works as well as a detailed reticulation network.
New high-tech crane set to double loading capacity

TRANSNET PORT TERMINALS’ Richards Bay multipurpose terminal team received a welcome injection into its crane fleet with the arrival of components of a brand new R38 million Liebherr LHM500 mobile harbour crane on board the Beluga Projects vessel earlier this month.

The equipment, weighing approximately 500 t, is the first crane to be purchased by the terminal in just over a decade. It boasts a lifting capacity of 140 t – and will initially be used to speed up the terminal’s neobulk handling operations to 20 moves per hour. Neobulk cargo refers to over-sized, single commodity cargo which is transported in skips rather than on a conveyor belt. Current cranes in use at the terminal are only able to complete eight to ten crane moves per hour of 20 t.

The Liebherr LHM 500 crane offers flexibility in its movement with its ability to swing vertically, horizontally and diagonally up to a radius of 51 m. Its handling efficiency is boosted by a container spreader able to lift 20 containers an hour if required, as well as a four-rope feature for versatility and the ability to operate a ‘grab’ facility if required. The crane is also able to handle substantial lifts and considerable distance from its centre.

The crane components were offloaded from the Beluga Projects vessel on the afternoon of arrival and partly assembled at the quayside over the following days using a 30-year-old Gottwaldt crane which had previously been used at Richards Bay harbour to position dolosse during initial construction of the pier. The Gottwaldt would then be transferred to Transnet National Ports Authority while the terminal’s 11-year-old Reggiane crane will be refurbished as it has reached its mid-life cycle.

Once offloaded and partly assembled, the new Liebherr crane would be driven approximately 250 m to its final destination at the terminal where assembly would be completed.

The R38 million crane investment forms part of Transnet Port Terminals’ hefty R300 million capital expenditure programme in Richards Bay to reinvigorate capacity and performance at the city’s multipurpose terminal over the next few years. In total, Transnet Ltd plans to spend R28 billion on port-related projects over the next five years to meet the country’s growing sea-based trade demands.
SPECIALIST CIVIL and geotechnical engineering contractor Esor Limited has played a key role in regeneration projects in the Johannesburg CBD, most recently for the new Absa mega office complex, the Universal Church of the Kingdom of God and a property development for Zurich Insurance Company (formerly SA Eagle).

Using its expertise in lateral support, piling and tunnel jacking, Esor is close to completing its commitments at three sites for Absa’s R1.2 billion new office development, Towers West.

Three city blocks within the area surrounded by Main, Troye, Anderson and Von Wielligh streets will house buildings up to thirteen storeys high, with interlinked basements providing necessary parking facilities for more than 3 000 Absa staff.

The scope of works comprised underground demolition, temporary lateral support, structural piling, the jacking of a tunnel and associated bulk earthworks.

Specific challenges on this contract included utilising existing basement retaining walls as part of the lateral support system, accommodating a variety of soil conditions, linking of two of the sites under Delvers Street, and the building and jacking of a concrete tunnel to connect to the third site,’ says Tebogo Modishane, Esor contracts manager.

Lateral support was provided by installing 600 mm diameter auger drilled cast-in-situ concrete perimeter piles, spaced 2.5 m apart, secured with rows of ground anchors. Wick drains were included, situated within arches intermediate to the piles, to ensure drainage of intrusive water away from the buildings’ basements.

On two sites pre-existing basement walls and foundations were first removed prior to adding 3 m of backfill, establishing a piling earth platform to facilitate the drilling of perimeter piles. The backfill was subsequently excavated, in approximately 2.5 m vertical stages, and ground anchors installed. Anchors comprised multiple lengths of steel cable drilled at 15 degrees through the piles. High pressure grouting secured them into the surrounding earth and cables were tensioned to between 300 kN and 750 kN, and finally secured against the surface of the piles with a combination of steel plates, anchor heads and collets.

‘In one case, where we could not remove the existing six metre deep basement wall, ground anchors were secured on steel stub soldiers from universal beams in pairs and steel plates, spreading the load on the wall’s surface,’ says Modishane.

‘Fifty millimetres of gunite was then applied to the wall and below that, to the 11 metre deep lowest level of the new basement, we excavated back a further 150 mm, guniting the entire surface in line with that above. Ground anchors were also applied here using the steel stub soldiers.’

The structural foundation piles were auger drilled cast-in-situ cage-reinforced concrete piles between 750 mm and
1 500 mm in diameter, to maximum depths of 25 m. Ground conditions varied and included shale, diabase and hard quartzite. In some places piles did not penetrate and conventional foundations were needed.

The basement interlink entailed the excavation and closure to traffic of the strip of Delvers Street passing between Anderson and Marshall streets. Delvers Street will be reconstructed, supported by a concrete slab on top of columns, and reopened to traffic at ground level.

The concrete tunnel to link the third site is 8,9 m wide by 2,6 m high and 17 m long. ‘We broke away the lower legs of piles already in place at that level, before excavating,’ says Modishane, ‘and constructed a temporary wall, ground anchored in place, against which to jack the tunnel.’

**CATHEDRAL**

Underground work for the new Universal Church of the Kingdom of God (UCKG) has been completed. The cathedral will be situated within an 8 m deep basement, with an above-ground structure of seven storeys.

The site is in the heart of the northern CBD and challenges included the proximity of Saint Mary’s Cathedral and other sensitive sites, underground services and a deeply weathered soil profile necessitating the use of underslurry piling, a rare solution in Gauteng.

Esor was responsible for demolitions to the existing basement, earthworks, lateral support and piling. Perimeter piles were not required and lateral support was installed on three sides only, the western end being hard up against existing buildings to the full 8 m depth required.

‘The basement and foundations of the previous building were demolished and removed. As it housed a basement of around four metres depth, the existing perimeter walls were not removed but were anchored using soil nails rather than ground anchors. Below the level of existing walls, down to the full new basement depth of eight metres, a 100 mm thick layer of gunite was applied,’ says Modishane.

On the northern and southern sides of these lower surfaces, steel stub soldiers from universal beams in pairs and plates were used to provide lateral support, secured by means of ground anchors. On the eastern side, given the presence of the Anglican cathedral as well as deep underground services, closely spaced soil nails were used instead of ground anchors.

‘Regarding structural piling for foundations, the presence of deeply weathered andesite with slicksided joints and ground water ruled out the use of conventionally drilled auger piles,’ explains Modishane. ‘Continuous flight auger (CFA) piles were considered but not favoured for economic reasons and the availability of plant at the time. We chose auger underslurry piles, which are rarely used in the stiff residual soils encountered on the Highveld.’

The piles were installed 20 m to 25 m deep.

**SA EAGLE DEVELOPMENT**

Esor also undertook earthworks, lateral support and piling for a property development for Zurich Insurance Company (formerly SA Eagle) in the Ferreirasdorp area, completing this extremely fast track project within three months.

The site is situated between Miriam Makeba, Marshall, Margaret Mcingana and Main streets, just west of the Magistrate’s Courts, and the project is recognised as the first new commercial development of significance in this area in a long while.

Some of the challenges included the need to relocate stormwater drains and plugging a water ring main, the unexpected presence of water in one portion of the site, and handling delays caused by the metal and engineering industry strike that took place at the beginning of the contract.

Soils included a diabase dyke on the western side as well as shale, and few problems were experienced in reaching target piling depths. Auger drilled cast-in-situ perimeter piles were installed, prior to carrying out excavations to depths of between 7,5 m and 18 m. Lateral support was provided by means of ground anchors. Up to five rows of anchors were necessary at certain parts of the site.

For the structural foundations, 124 No. auger cast-in-situ piles varying in diameter from 600 mm to 1 200 mm were installed.

**ONE-STOP SHOP**

Esor CEO Bernie Krone says that he is pleased that his teams have shown excellent performance on these challenging jobs and that his company has been able to play its part in the regeneration of the Johannesburg CBD. ‘It’s satisfying to be part of the resurgence of the CBD, which has so much history linked to it.’

He adds that the spectrum of Esor’s work in the Johannesburg CBD underscores the company’s positioning as a ‘one-stop geotechnical shop’ whose offerings include piling, lateral support, diaphragm walling, underpinning, structural shotcreting, grouting, shaft sinking, percussion drilling, dewatering, water wells, marine works, bridge footings, bridges and other specialist engineering works.
GUTSY FROM THE START
R P-D showed a keen interest in science from a very young age. Growing up in Queenstown, he remembers setting up his own ‘laboratory’ in an old stable.

‘Once, I made my own Bunsen burner by installing a tube through the lid of a Lyles Golden Syrup tin, half-filling it with methylated spirits, pressurising the tin with a bicycle pump and lighting the jet of meths emerging from the end of the tube.’ Needless to say, he lost all his eyelashes and eyebrows in the resulting explosion.

This was nothing compared to the day that he built a cannon with a ½-inch barrel, charged it with gunpowder and match heads, and stuffed lead shot down the barrel as the projectiles. He aimed for the top of his father’s garage door and fired, expecting only that the wood would be peppered with tiny holes from the shot. However, it resulted in the door lurching crazily and falling to the ground. For this experiment he was rewarded with ‘four of the best’ and had to cool his bum in a basin of cold water.

The premature death of his father, who was the headmaster at Queens College, left the 15-year-old R P-D the male head of the family. Money was tight and he changed his career plans from a six-year medical course to a four-year civil engineering course. Even so, university fees were not cheap and R P-D set his sights on winning the Sir Abe Bailey Bursary for the best matric results in the Border area. This he achieved, giving up all sport activities for the last semester of school to concentrate on Latin, which he considered his Achilles heel. He started his BSc Civil Engineering studies at the University of Cape Town in 1942 and was deeply disappointed at failing his medical when he wanted to join the army at the end of that year.

After graduating, R P-D joined MacNicol Construction on the Churchill pipeline, which was being built for Port Elizabeth Municipality. ‘The pipeline job was a great training ground as...
it involved survey, concrete works, timbering, under and over river crossings and excavations ranging from sand to rock to clays requiring support. From a shrewd Scot he learned about cost-accounting. ‘My family have had to put up with my crossing Ts and dotting Is ever since.’

Next step was to become site agent on the construction of a composite dam in the Zuurberg mountains in the Eastern Cape. Although still pretty green, R P-D showed his depth of thought, a trait for which he became renowned: ‘According to the design, the left flank earth dam section was to be founded on a natural clay blanket, resting on top of some 8 m of alluvium. This clay blanket was viewed as sufficiently impervious to make it unnecessary to excavate a cut-off down to rock. This worried R P-D and he excavated trial pits downstream of the dam and pumped in water. ‘To my consternation I found that, at 40 000 gallons per hour, I could not fill the hole as the water just seeped away into the alluvial material.’ When he told MacNicol about his concerns, the MD called a meeting. Although the inspecting engineer thought that the ‘youngster’ was right, construction went ahead according to design. In the end his fears proved accurate: ‘Water saturated the alluvium below the clay blanket, which settled, shearing the contact with the concrete spillway and cutting a channel 30 ft wide and 30 ft deep right down to the rock, virtually emptying the dam. Not many civil engineers can claim to have built a dam that failed, in the anticipation that it was likely to fail.’ Fortunately R P-D insisted on getting a signature every day that the work had been carried out strictly in accordance with the specs.

It was then that he started to court Renée Ella, a girl whom he had admired ‘from afar’ since school days, and whom he married in 1952. Soon afterwards, the newly-weds set off for the construction site of the Keerom Dam in a gorge in the Matroosberg mountains, near Worcester. The valley was so remote and isolated that it was nicknamed ‘Wegkruipl, the only means of communication to the outside world being by radio. R P-D felt that the site, a narrow gorge, was perfect for a blondin (cableway), so designed and built a home-made one that worked perfectly.

The following two years were spent in the consulting field with F E Kanthack & Partners (now Knight Piésold) on the design of the Kafue Hydroelectric Project in Northern Rhodesia (now Zambia). The couple had settled in Johannesburg with their first-born daughter, Janice (1953), who was soon followed by the second, Megan (1954).

In 1956 the Kafue project was suspended in favour of the Kariba Dam. R P-D, who had used his designs for Kafue to obtain his AMICE, moved back into contracting by accepting an offer to join the Cementation Company as contracts engineer on Kariba and other projects. Cementation had been sub-contractors on Keerom, so knew of his home-made cableway. In his first week he was told to build a cableway within six weeks, capable of carrying a two-ton truck across the Zambezi. Working 36 hours non-stop, he staggered into the workshop on a Monday morning with his drawings, ready for them to start manufacturing the components. He had met the time limit with a day to spare.

Still at Cementation, he applied and improved techniques for the stressed strengthening of a series of concrete dams throughout South Africa. During the construction of what is now the Dap Naudé Dam in Magoebskloof, his design for large-capacity steel anchor heads worked excellently in prototype and for the first twelve anchors. He was blamed when some failed subsequently. Many years later he discovered by accident that the failures were because a much harder steel had been used for the heads instead of the softer mild steel he had specified. Cable heads, identical to his original design, were later patented by a Swiss company, but it was too late for R P-D to oppose the application.

In what was a world first at the time, he applied the same technique to the provision of lateral support for a deep basement excavation face in Port Elizabeth. ‘I had looked at a basement being excavated in Johannesburg and it was a mass of struts and shores — very difficult to build around — and I suggested to my MD that perhaps we could use anchors to replace this mess. He may have mentioned this to a consultant in Port
Elizabeth. Shortly afterwards this consultant asked our Cape Town office whether Cementation thought that anchors could be used to support a basement excavation 15 m deep in PE. This concept is old hat nowadays, but in those days I was virtually standing alone as everyone said it was like trying to lift oneself by one’s shoelaces. At a depth of 12.5 ft we put in temporary struts, installed the anchors, tensioned them and removed the struts, all the while keeping our fingers crossed. The face stayed put. ‘The procedure was repeated in phases all the way down the entire 50 ft. R P-D tried to patent his technique, but his attorney advised him that it was simply a modification of pre-stressing and non-patentable. He then fought off patent applications from all over the world. ‘If I had been better advised, I would have been a very rich man.’

By this time R P-D and Renée’s third child, David, had been born (1956) and they happily bore the brunt of friends’ jokes about having their family in rapid ‘concussion’. R P-D was also accepted into Freemasonry. Because he had been so privileged in life, he felt that he would like to help those less fortunate. His involvement in the movement, known for its support to the needy, is an indispensable part of his life.

Persistent and resourceful
In 1960 the family moved to Cape Town when R P-D was appointed manager of the Cape branch of Cementation. One of his first tasks was the construction of the Apostles water tunnel through Table Mountain, which would traverse a geological fault zone about 500 m from the Camps Bay portal. ‘Of all the tunnelling operations I had been involved with, this one was the most difficult and challenging.

‘One afternoon I was met with the news that the tunnel roof was collapsing, the sidewalls were caving in, and the tunnelling team were knee-deep in water.’ R P-D discovered that the team, who had successfully penetrated a smaller parallel fault zone, had assumed that they were through the major one. They had proceeded quickly, realising that they had reached the real fault zone only when they were 15 ft into it. By retreating about 18 ft and creating a sandbag bulkhead in sound rock with large pipes carrying the water through the bulkhead, then injecting a weak sand-cement grout into the collapsed zone, he got the water under control. He finally emerged after 48 hours in the tunnel. A cement-bentonite mix was then used to form a grout curtain and the tunnel continued through this material. It took six months to penetrate the fault, whereas tunnelling at this site had previously advanced at up to 30 ft per day. ‘The completed tunnel attracted huge interest nationally and internationally, also because of the “raise” at the Disa Gorge end. Nearly 1 500 ft was driven uphill at an inclination of 30˚, an incredibly difficult operation.’

A technological achievement that R P-D regarded as simply a practical solution to an engineering problem was his technique of creating a gravity-type soil wall to keep boulders and cobbles from falling onto De Waal Drive. ‘After creating a “skin” of mesh-reinforced gunite over the face above the road, I tied the skin back into the soil mass with bolts, which were anchored in cement grout and tensioned.’ He never gave this technique a name, but 20 years later it was ‘invented’ in Europe and called soil nailing. It was taken up by GeoFranki, who refer to it as geo-nailing.

Vibroflotation was also unknown in South Africa at that time. R P-D watched this process in the UK and realised its potential as a ground improvement technique, so he imported a vibroflot from Cementation UK. ‘The first major contract was for the foundation treatment of the sugar silos in Durban, under the supervision of my colleague Duncan McColl, who, I believe, subsequently put vibroflotation on the map in South Africa.’

In 1963 R P-D was called back to Johannesburg to take control of all Cementation’s geotechnical work in southern Africa.
He and his wife were in the prime of their lives and did a great deal of the work themselves, on the property they had acquired in Bryanston, teaching their children the lesson of dignity in labour. RPD had more time to become involved with Queens College Old Boys’ Association and to move up the Freemason ranks, while Renée, who had a background in teaching, privately taught pupils with learning problems.

His work in the use of ground anchors for lateral support of basement excavations was widely applied in and around Johannesburg, the major sites being the Rand Daily Mail building at the Standard Bank Centre, the Star basement, and at least a dozen others.

Assertive and daring

On the Star excavation, which went down to 22 m, R P-D differed from the specialist consultant – then the doyen in geotechnics in South Africa – who believed that the top two rows of anchors were sufficient. R P-D believed that anchoring should be carried all the way to the bottom. At a depth of 18.3 m a huge wedge of weathered rock fell out from below the top anchors and a massive crack developed halfway across President Street. Had only the top two rows of anchors been installed, the collapse would have extended to the surface, and would have swallowed cars and pedestrians. After this, anchors were always taken all the way down to the bottom.

With the Trust Bank – at 31 m it was the deepest shear basement in the world at the time – a different approach was adopted. He recounts the background: ‘The City Engineer temporarily forbade the use of anchors. He said, “Since you brought this technology of ground anchoring to Johannesburg, people are putting down basements where they never previously thought of it; that means extra cars during peak times, and my streets just can’t cope.” Ruben Stander proposed a circular structure, but this was rejected by the architect as a waste of space. The concept of a ‘squashed circle’ then emerged – that is, four flat arches tangential to the sides of the city block and joined by four small arches at the corners. ‘However, there was the risk of the flat arches buckling under the earth pressures, and Ruben and I developed the concept of creating four huge flat jacks behind the corners and pressurising these with cement grout to induce an inward thrust at the corners and a corresponding outward thrust behind the flat arches.’

When putting theory into practice, R P-D admits to having had butterflies in his stomach each time they carried out the grouting operation. Before the job started, his friend Professor Jere Jennings phoned him, saying: ‘Ross, don’t do it, you’ll lose your reputation completely,’ but it worked. At a conference in Mexico in 1969 Ralph Peck expressed interest in the technique, and at a conference in Tokyo in the early 1990s the Trust Bank was described as being 25 years ahead of its time.

During this period R P-D carried out the foundation grouting of at least 20 dams throughout southern Africa. In the civil engineering field up north he became known as ‘Mr Cementation’ and was recognised as being among the top experts on grouting technology and ground anchors locally and internationally.

He also patented what he called the ‘porcupine’ technique for consolidating old goldmine workings without man-entry into the workings. The concept was to drill holes from the surface to intersect the stope at depth in competent rock and insert the ‘porcupines’ into these holes. These were made from a central tube with ‘quills’ attached. When they were inserted, the quills folded back. On entering the stope, they sprang out again to create an entanglement of wires across the stope. Concrete heavily ‘doped’ with fibre was then dumped through vertical holes on to the porcupines to form a bulkhead and the void filled with a cheap lean sand-cement-bentonite grout. When a section of Main Reef Road in Langlaagte collapsed over one of the old workings, the technique was used successfully and the road was re-opened.

In 1970 R P-D resigned from Cementation to become a shareholder and executive director of Westcott & Associates. ‘In some respects I was sorry to leave, because the work I did was stimulating and stretched me technically, but there were new possibilities in the move.

Six months later he founded Ground Engineering Ltd (GEL), with very limited capital. He made his first grout pump from pipe fittings, and the grout mixer was fabricated from a 44 gallon oil drum. Within two years GEL was becoming ‘a thorn in the flesh’ of the big geotechnical contractors, and in 1974 the Westcott Group accepted an offer from LTA to buy GEL, on condition that R P-D continued to run it. As CEO of LTA’s geotechnical arm, he widened the disciplines of GEL to include pipejacking, tunnelling, horizontal collector wells, ground freezing and diaphragm walling.

The first major contract with LTA was the stressed strengthening of the Laing Dam for the East London Municipality, where 600 tonne anchors were specified. ‘I had previously done anchors of 350 tonnes, but for 600 tonnes I was uncertain of the fixed anchorage length. I made a 36-strand anchor with a 2 metre fixed anchorage length. Because there was no jack in South Africa to test this size of anchor, I tensioned each strand individually up to 80% of its ultimate strength – a total of 900 tonnes. This satisfied me that a 4 metre fixed anchorage length would be OK. I once again used a blondin for the job, which went like clockwork. We had only one problem with the consulting engineer. He wanted to anchor the cables in the dry.’ Remembering the early experience of anchoring in the dry at Dap Naude Dam, R P-D argued that if he anchored the consultant’s way, the consultant would have to accept responsibility for the efficacy of the anchors, but if it were done his way, he would accept full responsibility. ‘We anchored all the cables “wet” and had not a single problem.’

An extremely taxing project at this time was the Huguenot pilot tunnel. It was constructed to explore the geology of the proposed road tunnel between Worcester and Paarl and to drive cross-cuts from the road tunnel to the pilot tunnel, so that in the event of a disaster in the tunnel, there would be an escape route. The rock tunnelling on the east side gave no problems, but the Paarl side gave plenty. The worst possible material for tunnelling was encountered – completely saturated residual granitic talus. ‘When tunnelling started on this end, we used spiling, but had mud rushes. Next we tried jacking “knives” ahead of the face. Again we had mud rushes. It was like trying to dig a hole next to the sea, as the material simply liquefied and
came at us.' Grouting ahead of the face using the tube-à-manchette system as an experiment for about 6 m worked perfectly, but this pilot tunnel was only about 3 m diameter, and part of the objective of the pilot tunnel was to establish methods for the first road tunnel, which would be 13 m in diameter. ‘We were not confident of taking a 13 m tunnel through this material under cover of a grout curtain, so decided with the consultants that freezing offered a better solution. We built our own freezing plant with the assistance of Deilmann of Germany. We froze the water around the tunnel, creating an ice-wall within which we could drive the tunnel, put in concrete support, and then allowed the ice to thaw. When the consultants called for tenders for freezing the first 160 m of the road tunnel on the Paarl end, we tendered with Foraki of the UK and won the tender. Once again the job went like clockwork.’

**INVESTIGATIVE AND PERCEPTIVE**

As a challenge to his engineers, R P-D put together teams consisting of a young and an older engineer, and got them to look for new geotechnical technologies that could be used in South Africa. Duncan McColl as the senior engineer, with Bernie Krone the young engineer, came up with dynamic consolidation (DC), which was developed by the French Menard Group.

Bernie, now CEO of Esor, says: ‘What can I say about a man who has had such a profound and varied influence on my life? Boss, mentor, colleague, and friend.’ He remembers his first impressions of R P-D: ‘I thought he was rather stiff, formal, a stickler for detail, a man with his eye on the time. These attributes haven’t changed and he still has an eye for time as he continues to make every second of his 84 years count. But he also had patience and tolerance. I left his office one day in a huff because of some minor criticism that I couldn’t bear and slammed the door so hard that his pictures fell off the wall. I apologised later and he forgave me instead of firing me. He always gave me the benefit of his considerable experience and knowledge, and this became even more obvious after I had left GEL and he had retired to the Cape. Ross introduced me to Freemasonry and we became friends – I am often privileged to have him stay over at my home when he is in Johannesburg.’

Following the recommendation from Duncan and Bernie to look at DC, R P-D obtained an exclusive licence from Menard to use the process in South Africa. On a contract involving a 2,1 km length of road that would carry the Johannesburg Western bypass over marshy ground, they found that the underlying material did not respond to conventional DC. ‘We therefore carried out a modification of DC, called dynamic substitution. This involved pounding mine waste rock through the marsh down to competent material, and carrying the road on a similar rock mattress – also consolidated by DC spanning..."
between the columns. We used a 40 tonne pounder dropped from a height of 30 metres and built a Menard tripod to handle it. Certainly no pounder of this size had been used in South Africa before, and probably hasn’t been used here since. ‘This was apparently the forerunner of many dynamic substitution jobs in other parts of the world.’

In 1976 tenders were called for the Drakensberg pump storage hydroelectric project – at over R100 million this was a major project by any standard. R P-D headed up the tendering team, a joint venture between LTA and Shaft Sinkers, and they won the contract. During construction R P-D was part of the management committee of Drakon, the joint venture formed to carry out the construction.

In the 1970s, while on a game drive at Londolozi, R P-D received a radio message from Jere Jennings to go to Zebediela immediately. On arrival, Jennings took him to Magoto Dam, which was piping badly. ‘The discharge was being caught in a 44 gallon oil drum and every hour the water was decanted and the sediment weighed. The rate of increase was frightening. Jere had already alerted the police to stand by to evacuate the valley at short notice if needed. He asked me how long I thought we had before the dam failed. I estimated seven days and he thought four. Nobody will ever know who was right because I managed to choke the piping by grouting in four days using some very unusual ‘additives’. Jere and I often disagreed on geotechnical issues, but our friendship always survived. This was no exception. He wanted me to drill just upstream of the leak, but I had spotted a small unusual feature in the foundation records about 50 metres away. I drilled the first hole where I wanted to, and injected fluorescense dye. Within 20 minutes the dye-discoloured water came out at the leak. It was then a case of using every trick in the trade to choke the piping. “We were lucky, but as Gary Player has said, “The more I practise, the luckier I get.”

In those years he became involved with Chapman’s Peak Drive. On viewing a major rockslide in 1977, Professor Tony Brink, who had been called down by Basil Kantey, said immediately: ‘This is a Ross job.’ Basil replied that he knew it was a ‘rush’ job. R P-D was called in and used what was considered the latest technology in anchoring at the time, but is not acceptable by today’s standards. Those anchors served their purpose for 25 years until they were replaced during the reconstruction in 2003.

In Cape Town, on a site just behind the City Hall, Ground Engineering carried out the largest diaphragm-wall project ever tackled in the country at the time. ‘Being reasonably close to the sea, the basement went well below the water table, and the object was to retain the sides and stop water inflow.’

Forming a joint venture with British geotechnical contractor Colcrete, he became involved in the grouting ahead of the Island Line, then under construction in Hong Kong. ‘The problem was that the tunnels were all below sea level, and some very sophisticated drilling and grouting was carried out, using cements, bentonites and chemicals.’

One of R P-D’s senior representatives in Hong Kong was Ernst Friedlaender. Ernst, who now lives in Sydney, Australia, commented: ‘Working for South Africa’s leading geotechnical contracting company, under Ross’s inspirational guidance, was a dream position to be in. He was always at the forefront of technology and innovation, driven by his passion for geotechnical contracting and carried by his ability to attract and inspire the people that worked for him. The words ‘can’t be done’ didn’t exist in his vocabulary. Many of the key players in our industry today have been groomed by or exposed to Ross in some form or other during their career. Ross’s success can be measured in many ways, but possibly is best represented by the network of people around the world that have been positively influenced by him. There are not many countries in the world where someone of influence does not know Ross Parry-Davies.’

A person who remembers him well is Helen Parker, R P-D’s former secretary. Demanding though he was – she recalls having to retype a 55-page report five times – R P-D was the most courteous and fair man she ever had the pleasure of working with. ‘I never
heard him raise his voice or use derogatory language to any of his staff, no matter the seriousness of the matter, or who was responsible. He would always sit one down in his office and discuss the matter to the point of a cordial resolution.’

This attitude was an offshoot of the culture of quality and integrity that prevailed in GEL. ‘It was an unwritten law that we simply did not lie to clients and consultants,’ R P-D commented. ‘It is so easy for an operator to make a foundation investigation look better than it really is. The whole staff knew that if anyone lied, he would be fired immediately. We eventually acquired the reputation of being quasi-consultants, because civil consultants would ask us for our advice on solutions for difficult geotechnical problems.’

**RESOLUTELY CONTINUING**

He retired from the LTA Group in 1987 and ‘to keep out of mischief’ he formed R Parry-Davies & Associates, a small consulting practice that provided a problem-solving and troubleshooting service within the civil engineering and geotechnical fields. From the start, he was as busy as ever, the monitoring of all the anchored structures on the national road network being one of his commissions.

By this time he was a qualified arbitrator and a fellow of the South African Association of Arbitrators, having passed the association’s exams in third place and outshining the younger members on the course. Eventually he acted as mediator, conciliator and arbitrator, as well as chief witness in several major disputes, and had the satisfaction of seeing these settled just before or during hearings.

He also heeded the call by his professional peers to commit his extensive knowledge to paper by registering for doctoral studies at the University of Pretoria. Repeating the rigorous routine he followed in his arbitration studies, he got up at five every morning to put in a few hours of work before going to the office. As usual, Renée was at his side, proofreading the 520-page dissertation. His thesis, ‘Grouting in Southern Africa’, was submitted in 1991, gaining him his PhD in Civil Engineering.

Using an unconventional modification of the jet grouting system in bouldery material – initially testing his theory in a glass-fronted container filled with rocks and sand – R P-D solved the problems engineers had encountered over a pier foundation of a jetty at Hobie Beach, Port Elizabeth. At a conference in New Orleans, where he presented a paper on this work, the eminent American geotechnical engineer Emilio D’Appolonia lauded it as ‘an inspiration of how revolutionary work should be done by experiment followed by execution’. ‘Of course, jet grouting in bouldery material is now commonplace,’ R P-D remarks.

As the geotechnical member on the panel of experts overseeing the construction of the Letsibogo Dam in Botswana, he...
directed the grouting, which was carried out by an international contractor. 'These people had never previously come across my system of recording grout takes that enabled one to see the whole picture at a glance.'

In 1997 R P-D and Renée bade farewell to Johannesburg and moved to Hout Bay in the Cape. 'I thought that my workload would dry up, but that just didn’t happen.' He continued his work for the Department of Transport, monitoring anchors throughout the country, and investigating anchored structures and cuttings for the South Peninsula Municipality throughout its region.

He still commuted regularly to Johannesburg, inter alia to discharge his masonic obligations to the chapters in his district. By this time the highest honour in Freemasonry, the 33rd degree, had been conferred on him.

Having become involved with the Hout Bay and Llandudno Heritage Trust, he cut his way through loads of red tape to have a replica of Thomas Bain’s tombstone placed in a prominent position on the rerouted Victoria Road above Llandudno. 'It was unveiled on Heritage Day in 2000, and in deference to Bain’s Scottish ancestry, I arranged for a piper to liven up the proceedings.'

He was appointed specialist advisor for the stressed strengthening of two old reservoirs on Table Mountain, built in 1896 and 1906, a project that won the SAICE Western Cape Branch Award for Technical Excellence in 2001. In 2003 he was appointed specialist geotechnical advisor on the restoration of Chapman’s Peak Drive, with the emphasis on ground anchoring to support the half-tunnel and to tie back the concrete structures. The project won the SAICE Civil Engineering Award for technical excellence that year. At the awards presentation ceremony in 2004, R P-D was elected an honorary fellow of SAICE. 'This is the highest honour that can be bestowed on a civil engineer in South Africa. Mike Shand said it was the only time that he saw me stunned into silence.'

Although he has slowed down in retirement, he still makes every second of his life count. He is currently documenting some of the professional developments he has pioneered, and is passionate about the conservation of our planet that is so much at risk because of man’s avarice. 'If I could express a wish, it would be to be remembered as one who cared for our fragile planet, a competent geotechnical civil engineer, and a humanist.'
On the move

Viwe Qegu

First woman on Vela VKE board
Viwe Qegu has recently joined the board of consulting engineering firm Vela VKE as a non-executive director.

Born in South Africa, Ms Qegu is a city planning scientist by profession and holds a master’s degree in City Planning and a BA (Law) degree. She worked at the Development Bank of Southern Africa (DBSA) as a trainee project manager, after which she practised as a city planner with the Centurion Town Council (now Tshwane Metropolitan Council) for seven years. She progressed to the position of a chief development planner, this being the highest planning position in the city.

Professional highlights include being a co-founder and board member for Women in Housing and also serving as a board member and trustee to various organisations. She previously received an award as the Femina Woman of the 90s in recognition of achievements in the sporting industry within South African society.

Gill Owens

Gill Owens retires after nearly 30 years with C&CI
Well-known construction industry personality Gill Owens recently retired after nearly three decades of service at the Cement & Concrete Institute (C&CI).

Gill joined C&CI as librarian in 1978 when the institute was still known as the Portland Cement Institute, and based in Richmond, Johannesburg.

After her appointment as C&CI marketing services manager in 1999, Gill assumed responsibility for the marketing support function of C&CI, including the promotion of the Information Centre; production of publications, newsletters, and monthly reports; public relations; and maintaining the C&CI website. She also edited Concrete Trends, the C&CI’s quarterly journal which received a 2007 ‘Highly Commended’ Sappi PiCA Award.

In her retirement, she will run her own new venture, Gill Owens Editing Services, and in this capacity will continue to edit Concrete Trends. She is currently also engaged in the latest revision of C&CI’s definitive reference publication, Fulton’s Concrete Technology.
Cellulose fibre reinforced cement fails University of Pretoria strength tests as a gravity piping material

TESTS CONDUCTED BY the University of Pretoria’s Civil Engineering Department reveal that the crushing strength of cellulose fibre reinforced cement (FRC) as a gravity piping material fails to meet several requirements laid down by SANS 819:2001 (Edition 3.2) for this type of gravity conduit.

The PIPES Division (Pipes, Infrastructure Products, and Engineering Solutions) of the Concrete Manufacturers Association (CMA) believes FRC pipe has several other shortcomings (referred to below) which cast doubt as to its role as a gravity piping material and has submitted related comments to the South African Bureau of Standards (SABS). Furthermore, the CMA’s PIPES Division is of the opinion that some of the claims about the performance of FRC gravity pipes appear to be at odds with some reputable information sources. These claims are also discussed here.

FRC was first introduced in the 1980s to manufacture asbestos-free flat sheets and has subsequently been applied to gravity pipes and other products previously manufactured with asbestos. Semi-rigid FRC piping was recently introduced with wall thicknesses up to 20% thinner than gravity piping made of steel reinforced concrete.

The tests conducted at the University of Pretoria centred on the crushing strength of 24 FRC pipe samples using SANS 819 (Edition 3.2) as the standard. Conducted in September 2005, the tests used sample material which included 200 mm long pipe sections with nominal diameters up to and including 300 mm, and 300 mm long sections for diameters in excess of 300 mm. Table 1 of SANS 819 (Edition 3.2) gives the required crushing strengths for the standard Series 1, 2, 3 and 4 as 40, 60, 90 and 120 kN/m² respectively, when they have been in water for at least 48 hours. It should be noted that these are ultimate requirements and not proof load requirements, as given by the standard D-Load requirements for steel reinforced concrete pipes. When the ratio of ultimate to proof load of 1.5, as recommended in the Nutec literature, is taken into account, the equivalent D-Load values are 27, 40, 60 and 80 kN/m² respectively.

Based on the SANS 819 standard, a pipe with a 600 mm nominal diameter should take a load of at least 7 kN (24 kN/m) for Series 1 and 11 kN (36 kN/m) for Series 2 pipes and only one of the 600 mm FRC Series 2 pipes tested met the crushing requirement. The minimum crushing strength required for

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Series 4 pipes with a nominal diameter of 300 mm is 7.0 kN (36 kN/m) and only one of the four sections tested met this standard.

Table 1 gives the measured properties of the pipes used for testing purposes. Sixteen pipe sections were tested wet and these tests indicated quite clearly that FRC pipes are significantly weaker when wet. They were able to support a crushing load in excess of 15 kN/m but were unable to achieve anywhere near the requisite crushing strength standard of 45 MPa. These tests were repeated on dry pipes, none of which had the requisite strength of 50 MPa. In fact the best result achieved was 41.8 MPa.

For the wet and dry test results refer to tables 2 and 3. None of the pipes tested had a strength as high as 50 MPa and the highest strength calculated for the pipes that were tested dry is 41.8 MPa. These results do however clearly indicate that the pipes are significantly stronger when tested dry than when tested wet. The dry behaviour is significantly more brittle, as can be seen from the comparative graph in figure 1.

It is often assumed that because FRC piping is lighter it can be installed faster. This is not necessarily the case. According to the CMA’s PIPES Division, FRC pipes can often take far longer to install, especially if the installation takes place in poorly bedded installations or unstable soils.

Unlike concrete pipes, which are largely self-supporting, FRC pipes require support from the surrounding soil. Furthermore, FRC pipes are made in 5 m sections and weigh essentially the same as the 2.5 m sections in which concrete pipes are manufactured. This means that the same equipment is required for the installation of both types of piping.

Other claims made about FRC pipes are that they offer superior chemical and abrasion resistance, better hydraulic characteristics and design parameters. In fact, according to the CMA, FRC piping absorbs much more water than reinforced concrete (RC) piping and is therefore more likely to be vulnerable to penetration and attack by aggressive chemicals.

Tests conducted by the University of Texas at Arlington, USA, in which actual service conditions were simulated, indicate that FRC pipes lose up to 4.8 times more wall thickness than RC pipes.

The CMA’s PIPES Division says that because FRC pipe is usually 20 % thinner than an RC pipe, any decrease in wall thickness is liable to have a far more damaging effect on structural strength properties.

Moreover, the division notes that excessive abrasion at the entrance to storm water systems will also have a detrimental effect on hydraulic capacity. Abrasion resistance, wall thickness, strength specification and a factor of safety on FRC piping are all elements which should be, but are not clearly spelt out by FRC manufacturers.

It is said that FRC piping has a low manning value of $n = 0.011$ and that this ensures vastly improved hydraulic characteristics over RC piping. In reality the manning ‘n’ value for RC pipe is also

### Table 2 Strength of pipes tested wet

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### Table 3 Strength of pipes tested dry

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<th>Wall (mm)</th>
<th>Failure load (N)</th>
<th>Strength (MPa)</th>
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<td>36.6</td>
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</tbody>
</table>
However, because designers must take the difference between laboratory testing and actual installed conditions into account, 'n' values of 0.012 and of 0.013 are usually specified for actual designs using both materials.

A safety factor of 1.5 is claimed for FRC pipes thereby offering the specifier a safe, proven alternative which will perform under high loading conditions.

The CMA’s PIPES Division says much of this safety margin is required to compensate for the fact that the safety factor is only based on a proof load as opposed to an ultimate load. Furthermore, it says it is well documented that FRC pipes lose strength when wet and suffer long-term strength loss under sustained loading. SANS 819:2001 requirements call for strength loss to be no greater than 5%. In Australia, FRC piping manufacturers indicate a loss of 50% when their piping is immersed in water and subjected to sustained loads.

According to the CMA no specification exists for the types or quality of fibre used in the manufacture of local FRC piping. The reinforcement of the piping is therefore not specified at all. By contrast, all the constituent materials, for example sand, stone, reinforcement and cement, are specified in reinforced concrete pipes. Another concern is that SANS 819:2006 only applies to fibre reinforced of pipes up to 1 000 mm diameters. There is no standard for larger-diameter fibre reinforced pipes.

Reinforced concrete pipes have a proven life of 100+ years and the structural performance is not influenced negatively by wet conditions. On the contrary, concrete strengths improve in wet and moist conditions.

ENQUIRIES
Concrete Manufacturers Association
John Cairns
T 011-805-6742
Since earliest times, humans have felt the need to gather around a focal point to relax, negotiate and entertain each other, and since earliest days this has been made possible by seating arenas or amphitheatres. Today, these structures are still very popular, except that the method of construction has become easier and building material more varied and versatile.

One of the more cost-effective ways to build a seating arena is to use precast, solid concrete units or interlocking concrete blocks that are relatively easily transported and installed. In addition, concrete is durable, doesn't burn and can be readily repaired or recycled. Most products on the market offer some sort of benefit, but the most all-rounded, and increasingly popular, is a specialised segmental concrete block developed by Terraforce, a local concrete product licensor with manufacturing outlets all over the world.

This block, the 4x4 step block, is part of Terraforce’s large range of hollow core, reversible retaining wall units that offer the most versatile segmental retaining system in South Africa. They require low hardware input for manufacture, low transport costs and low inventory requirements at sales outlets. Being hollow, yet strong, less concrete is needed to do the job when compared to solid block systems.

Initially, the 4x4 step block was intended for low retaining walls and smaller steps, but soon became very popular not only for stairway access, but to provide comfortable, practical stairs and seating arrangements at leisure amenities and school sport facilities. The blocks can stacked up without mortar, interlocking at the corners to form gentle curves and varying wall angles, but it is by turning the unit on its side to create steps that has made it so successful at creating small to medium-sized seating arrangements.

At the end of last year, the block was successfully used at the Tourism Centre in Kayamandi, Stellenbosch, to create an eye-catching amphitheatre – a simple neatly curved seating area required for viewing performances around a courtyard. Following the success of that project, two more arenas have recently been completed. Both were installed by Dassenberg Retaining, a Terraforce-approved retaining wall installer, who was also involved with the Kayamandi project.

The first amphitheatre to be completed is situated on Kronenburg estate, between Paarl and Wellington. Conceptualised by Robin Barnes, architect with JHP Architects and Town Planners, it has become the ideal social gathering place. According to Barnes it is designed on the same principal as the traditional Greco-Roman amphitheatre
where acoustics work on the principle that sound travels upwards. The centre of the circle would be the origin of the sound, whether it be a play, a musical or an oration.

The sound travels outward and upward without losing much energy within the bounds of the stepped stair tiers of the amphitheatre. The people sitting on the tiers also absorb the reverberated sound and have a dampening effect on the echoed sound. The clarity and quality of sound is thus carried in concentric sound waves to each part of the amphitheatre and experienced, virtually the same, by each person sitting at any position within the amphitheatre.

Says Barnes: ‘We decided to use the 4x4 step block system as it gave us flexibility in the radius we required and the ease in construction that it provides. The blocks fit together nicely and provide the correct anthropometric sizes for seating and staircases. Ultimately the client was provided a facility that could be used for weddings, musicals and seminars, whilst maintaining a cosy and intimate atmosphere within the amphitheatre, with the mountains as a backdrop. The project is a definite success; it not only works acoustically, but is aesthetically pleasing as well.’

Designed on strict guidelines supplied by Terraforce the amphitheatre is built on a sturdy concrete foundation, followed by a row of concrete filled L11 retaining blocks, laid to the specified radius. Next, the 4x4 step blocks, filled with wet concrete, were set – on top of the L11 blocks – in groups of four to allow for the inser-
tion of two 1.5 m long Y12 reinforcing bars, which facilitated the setting out of the radius. Behind each L11 and 4x4 block is a 400 mm wide layer of 3 % cement stabilised sand, with space for a 350 mm wide strip of 50x100x200 Corobrik clay pavers. The above steps were repeated until the desired height was reached.

The steps running down each side of the amphitheatre were easily incorporated by doubling up with rows of 4x4 step blocks. Finally, the arched screen wall across the open side of the amphitheatre was added, causing the reflected sound to enhance the direct sound waves therefore adding to the total sound quality and giving the added advantage of a stage and back stage area.

The second seating arrangement was initiated by Hans Roux of Grinaker-LTA who, with Group Five, WBHO and Western Cape Empowerment Contractors (WCEC), forms the Berg River Project Joint Venture (BRPJV) that was awarded the R550 million contract for the construction of the dam. Conceptualised by Dassenberg Retaining, it is situated on the eastern bank of the Berg River Dam which captures water in the upper reaches of the Berg River and will augment the supply of water to the City of Cape Town by 18 %. It filled for the first time in July last year and boasts the highest concrete-faced, rock-filled dam wall in South Africa. Hugo Pienaar, quantity surveyor for Dassenberg, says that the seating arena will provide visitors with a comfortable viewing platform to sit and admire the panoramic view of surrounding area and the vast expanse of water.

In terms of landscaping, the downstream face of the dam wall, visible from the main road into Franschhoek, has been re-vegetated with indigenous flora. This ensures that the dam and associated structures do not contrast with the surrounding landscape. Pienaar says that this is the reason the Terraforce 4x4 step block was chosen for construction of the seating arena: ‘A lot of money was spent rehabilitating the area, with new topsoil being placed and fynbos planted. Everything was very environmentally conscious, seeing that the Berg River Dam is the first dam in South Africa to be designed, constructed and operated in strict accordance with the guidelines of the United Nations World Commission on Dams. If you see at how the block and pavers blend in with the surrounding landscape, you can easily see that no other product would have been viable, especially one that is so versatile and durable.’

Construction of the arena proceeded the same way as with the Kronenburg amphitheatre, except for an increased radius and a flared design at the edges – instead of intrusive end walls – that provides increased stability to the structure. Another interesting detail involved creating corner pieces for the two 90° bends. Says Pienaar: ‘We simply took a 4x4 block and cut it at a 45° angle to form the two pieces that were then joined together with cement slurry. Finally, we have just been given the go-ahead to create U-shaped stormwater channel, using the same Corobrik pavers, around the entire radius of the arena to prevent structural damage in case of heavy rains.’
The role of civil engineering in a changing environment

IN THIS ARTICLE, the author describes his experiences from the time when he grew up in the area previously known as Venda until the present.

In the early 1980s this area was underserviced and lacked adequate water supply and other services. As a result most of the people sourced water from rivers, fountains and boreholes. Although the water was not purified, it was fit for drinking because there was less pollution in the river systems.

With time, some communities started to receive services and communal taps were installed at closer walking distances. This has certainly changed and improved people’s quality of life. Instead of walking long distances to fetch water, people could now use their time for other activities. This all was made possible by civil engineers, who have contributed to bringing about an improved quality of life.

Things continued to improve to the extent that some of the communities have running water in their yards, which is a vast improvement on the situation in the past. However, these improvements came with more challenges that continue to confront the people in the area. These include a lack of adequate resources and skills to maintain the facilities.

Although there is infrastructure for the supply of portable water to many households, the supporting infrastructure that enables continuous uninterrupted supply is inadequate. This is very similar to experiences in across the country and indicates that our resources are limited. It is therefore important that everyone takes care of these limited resources through
conservation and awareness of the scarcity of resources.

An added challenge is that since people now have access to clean water, the rivers are being neglected and they are not an option for sourcing water anymore. Maintenance of existing infrastructure is a major challenge because the demand for skills, as well as urbanisation, is depleting the skills base.

The lack of skills and resources has affected many areas including road infrastructure, which has deteriorated in many instances and requires re-construction.

The following issues need to be addressed as a first step towards resolving the current situation:

Stimulating the local economy This could be achieved by promoting decentralisation and encouraging firms to open factories in the area. As the area is known very fertile and produces a significant part of South Africa’s fruit, this could be used as a starting point.

Attracting appropriate civil engineering skills There is a need to come up with strategies to attract civil engineers with much-needed skills who have historically been responsible for delivering a visible service.

Training and development Providing prospective students with bursaries and similar support.

Musivili inzhiniara kha nzulele ine ya dzulela u tshintsha

Ili linwalo li nea zwidodombozwa zve munwali a zwi guda musi a tshi alutshela kha la Venda u swika zwino.

Munwali ori a tshi aluwa nga tshifhinga tsha minwahya ya gidi da tahe fumalo, vhathu vho vha vho tshi wana madi milamboni, zwisimani kana magwedzihoni ngaurishumelo ya madi o kunakiswaho yo vho i saathu u wanala kha mivhundu minzhi. Naho madi aya o vho a songo kunakiswahwa, o vho a tshi nwea asina malwadze: Izwi zwo konadzwe ngauri milambo yo vha i saa mashika.

Musi madzvha a tshi khou di ya phanda, vhathu vho thoro u wana dzitshumelo dzi ngaho sa madi e a disiwa tsini ha vhathu nga u dzingamiswa ha dzibomboa dza zwitaratani. Izwi zwa zwa ita uri vhutshilo ha vhathu vhu khwinisee. Vhathu vho vho ngo ngo tsha khulwane dzinjengano khulu vha tshi ya u kadi madi milamboni zwa sia vhe na tshifhinga tshinzi tsha u ita zwinwe zvihwe vhu thumelo. Zwotho zwi zwi konadzwa nga u shela mulenzhe hiku dzisivhina inzhiniara dze dzwa ita uri matshilo a vhathu a khwinisee. Vhathu vho vho ngo ngo tsha tshimbila dzinjengano khulu vha tshi ya u kadi madi milamboni zwa sia vhe na tshifhinga tshinzi tsha u ita zwinwe zvihwe vhu thumelo. Zwotho zwi zwi konadzwa nga u shela mulenzhe hiku dzisivhina inzhiniara dze dzwa ita uri matshilo a vhathu a khwinisee.

Zwizwa zwo bvela phanda na u kuniweza u swikeyela vhathu vho vha vho tshi vho vha madi midini yawho zwa zwa sumbedza mbelahanda khulwane kha vhathu musi hut shi vhambedzwa na maduvhuni a minwahya ya gidi datahe funzwa. Fheadzi izwi zwo zwi tshi ita ha vha na dzikhaedzve dze dzwa vha hone. Idzi dzo vha dzauri naho vhathu vho wana tshumelo, dzitshomendo a dzo ngo lingana uri dizi nga thusa vhathu vho the hino kufareleke kwa idzi tshomendo a kwo lingana zwa siva hutshiku vha na dzitshaidzo.

Naho nu u tshomendo dzote midini minzhi dzwa ndidzordzwe ya madi, madi a kunda u wana ngauri madamun ane a vhuukungu madi na dziphapi dza u a disa madi vhathu vho zwi swikeyela u thusa vhathu vhothe. Izwi a zwo ngo tshumelo a zwi konadzwa nga u bvela phanda, izwi zwo tangana ha vha dzitshomedzo dzine dza vha hone. Idzi dzo vha dzakonadzwa nga u bvela phanda, izwi zwi zwo viro zwi zwi tevelaho:

U tutuwadzwa ha zwa vhubbundzidzi Izwi zwi nga kunda zwi zwi zwi zwi huku dzivhina vha tshi bva kha dorobo kahiru dza iswa kha dorobo thukhu dzinga ha Venda. Shango la Venda li divhelwe u vha u lupfumo luhulu musi ri tshi ya kha zwa vhuluna. Ili sia li nga shumiswi sa line la nga bindudzidza khalo. Vhubbundzidzi vhutanga zwi nga sia hu mvelaphanda.

U kungwi ha vhadhivi vha mushumo va vhusivhini inzhiniara Nguwiru zwi khou vhonala zwaauri hu nu a shaehe ha vhadhivi vha mushumo, izwi zwi tonda uri zwi dzhielwe rezhle. Zwone zwi zwi a kunda u wana vhathu vha divhaho mushumo uri vha takalela u ya fheythu hune ha kha di bvela phanda. Zwo tea uri he sedziwe ndila dzwa u kungwa vhathu vho rhalo.

U funziwa na u bveladziswa ha vhathu U funziwa ha vhathu vho zwi nga konadzwa nga zwi fanaho na u rumelwa ha matshudzeni zviiwitori uri vha gude mushumo va vhusivhini inzhiniara.

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Sika Strengthens Hermanus Breakwater Precast Toskane

The picturesque seaside town of Hermanus was the location for a major harbour refurbishment project which involved a variety of Sika’s high-quality, innovative products and systems. The Department of Public Works appointed Consulting Engineers Ninham Shand who determined that as a result of the existing harbour being weakened, more than two and a half thousand new toskane would need to be manufactured to replace several deficiencies and to augment the existing toskane in order to strengthen the breakwaters and make the harbour safer.

The contractors (a joint venture between Sea & Shore Projects and Civil & Coastal Construction) used 21 000 l of Sika ViscoCrete-20HE in the construction of the 2 650 precast concrete toskane that would make up the breakwater for Hermanus Harbour. Sika ViscoCrete-20HE is a third-generation, high-performance superplastiser that is especially suitable for the production of concrete mixes which require high early strength development, powerful water reduction and excellent flow characteristics. It acts by different mechanisms; through surface adsorption and steric effects separating the binder particles, the following properties are achieved:

- Pronounced increase in the early strength development, resulting in very economic stripping times for precast and in-situ concrete
- Extremely powerful water reduction, resulting in high density, high strength and reduced permeability for water, etc
- Excellent plasticising effect, resulting in improved flowability, placing and compacting behaviour
- Reduced energy cost for steam-cured precast elements
- It is especially suitable for the production of self-compacting concrete
- Improved-shrinkage and creep behaviour
- Reduced closure times for repairs of roads, runways and harbours

Each toskane weighed 20 t and some 12 toskane were produced per day. In winter the moulds were stripped the same day without steam curing and transported after 24 hours so that packing density. The units were individually positioned using an electronic total station. This meant the contractors could refill moulds quickly and fulfill their contract obligations in time.

The production schedule for the precast units was between March and April 2007 and the construction period for the placing of the toskane in the breakwaters was between September 2006 and June 2007; this was completed timeously.

The contractors needed to attain a certain standard density and a high, 2MPa tensile early strength for rapid removal of the items from the moulds. This was accomplished using a dosage of 0,4 % bw c ViscoCrete 20HE and 400 kg/m³ RHPC to achieve early strength.

The JV purchased a specialist crane for the placement of the toskane due to their extreme weight and having to be placed 35 m from the breakwater. The harbour had to be widened to allow space for the crane to operate from and the JV then used Sika ViscoCrete-20HE for their site batch concrete to rebuild the harbour wall. The armour units were placed to specific x and y coordinates based on a theoretical packing density. The units were individually positioned using an electronic total station.

region looks towards Zimbabwe’s Power Plants

In a move that could alleviate Southern Africa’s struggle to cope with the growing demand for electricity, while helping Zimbabwe with its chronic shortage of foreign exchange, neighbouring countries have proposed recapitalising some power stations and coal mining, reported IRIN.

Eskom, Anglo Platinum, and the Botswana Power Company have shown an interest in Zimbabwean thermal power stations located in the capital, Harare, in Bulawayo, the second largest city, and in Munyati, near the town of Kwekwe in Midlands Province.

Anglo Platinum, which has been negatively affected by power outages in its home country, has asked to be allowed to export electricity to South Africa as part of its proposal.

In February, the Southern African Development Community (SADC) taskforce on implementation of power projects held an emergency meeting in Botswana on the state of energy supply in the region, attended by ministers of energy, at which a resolution was adopted to source funding for the energy sector.

The meeting heard that if this resolution were not implemented, development would be stifled, and that the region required US$46,4 billion for long-term development of the energy sector, while US$5 billion was needed to complete current energy projects by 2010.

Tomaz Salamao, SADC executive secretary, was quoted in the media saying: “The current electricity supply demand balance in the SADC region is precarious, as evidenced by the recent frequent recurrence of black-outs”. This is the main reason why the region needs an additional 300 MWs of generation capacity by 2010, reported IRIN.
outs and load shedding in virtually all the countries of the SADC mainland as well as Madagascar.’

Since the beginning of 2008, South Africa, Namibia and Zimbabwe have been among the countries in the region hit by widespread planned and unplanned outages, affecting every sector of the economy.

Eskom has blamed the blackouts on heavy rain in the coal-producing parts of the country, which it said had affected the quality of coal required for its coal-fired plants, and breakdowns at several of its key generating plants.

Money needed
Ben Rafemoyo, chief executive officer of the Zimbabwe Electricity Supply Authority (ZESA), recently told the Parliamentary Portfolio Committee on Mines, Energy, Environment and Tourism that his organisation needed US$3,8 billion for a complete overhaul of obsolescent equipment to generate at least 2000 MW needed to meet national requirements.

‘We are in a precarious financial position because our tariffs are very low,’ said Rafemoyo. The Hwange power station in Matabeleland North Province was producing 280 MW, when it could generate 750 MW at maximum capacity. Rafemoyo said the Kariba hydropower station on the Zambezi River, on the northern border with Zambia, had a generating capacity of 750 MW, but was producing 720 MW.

‘Other power stations can generate 170 MW but are not generating anything because of lack of coal. The older the machines at power stations, the more breakdowns we experience and these are costly to repair.’

Zimbabwe generates 1 000 MW, against a daily requirement of 1 500 MW, and imports 40% of its electricity from the Democratic Republic of Congo, Mozambique and South Africa. The country has had to resort to power rationing because of the shortfall, which has affected many industries, homes, schools and hospitals.

Coal shortages
Zimbabwean power stations have also been affected by coal shortages. Energy Minister Mike Nyambuya confirmed that failure to provide enough coal and ageing equipment had affected the country’s ability to fulfil its energy requirements.

‘...the last ten years,’ he said.

According to senior officials in the energy industry, Eskom was ready to pump up to US$25 million into the Hwange Colliery Company (HCC), Zimbabwe’s sole coal producer, to ensure reliable and uninterrupted coal supplies if the proposed takeover of the three thermal stations, with a combined potential of 500 MW, was formalised.

**HEAD OFFICE CAMPUS FOR DEPARTMENT OF FOREIGN AFFAIRS**

THE WORK ON THE new head office campus of the Department of Foreign Affairs (DFA) has commenced with an early works contract. Work started at the end of May 2007, after a bidding process of more than two years. Total construction should be completed by March 2009.

The new HQ is situated on the corner of Tom Jenkins Drive and Soutpansberg Road, in the residential suburb of Rietondale, Pretoria. The 15 ha government site is immediately north of the Daspoort Ridge, in the shadow of the ministers’ residences atop the ridge.

The project is being undertaken under the government’s public private partnership initiative, and offers ground-breaking opportunities for participation by previously disadvantaged sectors of the economy.

Vela VKE has been the technical adviser to the transaction adviser and the DFA since the end of 2003, when SPP were awarded the transaction adviser contract.

‘The development cost is approximately R1,3 billion,’ says the technical director of Vela VKE, Dave Gertzen. The 175 000 m² development will comprise two parking basements; four four-storey low-rise office towers; the Foreign Services Institute – which is responsible for the training of DFA delegates – and a state-of-the-art conference centre to host international conferences such as the African Union and SADC.

The design embraces communication between the various branches, which are currently scattered around the inner city. In a ‘blocking and stacking’ exercise and under the guidance of Foreign Affairs, branches are to be located for maximum interaction with each other.

To this end, vertical access is provided by escalators and lifts in core areas and horizontal access is via an internal ground floor street and skywalk bridges on the upper floors. ‘We are placing the branches which belong together, next to each other,’ says Gertzen. The new DFA campus will house approximately 2 200 personnel, including DFA’s growth forecast over the concession period.

The development also includes twin five-star boutique guesthouses to accommodate foreign dignitaries. One is a new lodge-style guesthouse situated in a remote corner of the main campus site and the other is the existing guesthouse in an upmarket suburb of Pretoria, which is to be refurbished to match the new guesthouse in standards and amenities.

Dave Gertzen says the proposed development underwent a rigorous public-

[Artist’s impression of the new head office for the Department of Foreign Affairs](#)
GOVERNMENT SHOULD BE MORE PROACTIVE IN DOING BACKGROUND SCREENING ON EMPLOYEES

THE PUBLIC SERVANTS who have recently been exposed as qualifications cheats were merely the tip of the iceberg and many more are waiting to be discovered should the government get its house in order and implement widespread background screening.

Ina van der Merwe, CEO of Kroll Background Screening, one of the largest qualifications verification companies in South Africa, said both government and the private sector had a major problem with bogus qualifications.

‘At the moment about 14 % of all qualifications sent to us for verifications turn out to be false. That includes everything from matric certificates to degrees and diplomas.’

Three years after efforts began to verify public servants’ qualifications, employees are resisting the process and government departments are dragging their feet about getting it done, a report tabled in Parliament found.

Sixteen public servants below middle management level – most of them in the Western Cape – had so far been found to have fraudulent qualifications, according to the Public Service Commission’s (PSC) report.

To date only seven provincial departments and two national departments had completed the process of background screening. Sixty provincial and 19 national departments were in the first stages of the job.

‘The main constraints cited were staff resistance to the verification process and that staff take too long to provide proof of qualifications. Where it is requested,’ read the report.

It recommended that heads of department took charge of the process.

‘A strong message needs to be sent to all public service officials that the verification of qualifications is part of the anti-corruption programme of government, and that lack of compliance may adversely affect the ethical credibility of the department as a whole.’

The focus on employees below middle management was the third phase of the process. In 2001 senior management had their qualifications verified.

In 2003 it was the turn of middle management. A confidential list of people who had falsified their qualifications was part of the resulting report.

IMPORTANT TRENDS IN QUALIFICATIONS AWARDED TO WOMEN AND BLACK LEARNERS

WHILE THE PROPORTION of qualifications awarded to black and women graduates has increased substantially, a key area of concern is that the majority of these qualifications are still at relatively low levels – 6 and 7 on the National Qualifications Framework.


Yvonne Shapiro, the director of the NLRD at SAQA, identifies some key points of interest from the report. ‘The proportion of qualifications awarded to black learners (African, coloured and Indian) increased from 44,9 % in 1995 to 63,7 % in 2004. However, most of this is still at the lower levels – 67,2 % at Level 6 and only 47,7 % at Level 8 and above. Similarly, women’s share in qualifications awarded increased from 47,9 % in 1995 to 56,0 % in 2004 but most is still at the lower levels with 55,8 % at Level 6 and only 43,1 % at Level 8 and above.

‘Overall, the average annual growth stands at 4,3 % with 98 029 qualifications awarded in 2004 with the largest average annual growth in the field of Business and Management Sciences – 8,4 % or 29 702 qualifications awarded in 2004.

‘Two areas of concern regarding the lowest average annual growth are in the fields of Social Sciences at only 2,4 % (39 781 qualifications in 2004) and Engineering Sciences and Technology, which has been identified nationally as a field of scarce and critical skills, also only 3,5 % (11 038 qualifications in 2004). There is a need to improve the senior certificate pass rate, especially in Maths and Science, in order to fulfil the requirements of this field.’

Snapshots of availability data were taken in 1994, 1999 and 2004. The total availability figures (the total number of people with their highest qualifications in each field – the South African ‘pool’) grew by 116,9 % (from 542 398 in 1994 to 1 176 496 in 2004). The largest growth was in Business and Management Sciences with 153,8 % growth of the field since 1994.

Availability figures by group

By gender

The proportion of women graduates in South Africa increased from 41,0 % in 1994 to 48,4 % in 2004 with the smallest share for women graduates in Engineering Sciences and Humanities field (56,3 %) and worst represented in the Engineering Sciences and Technology pool (31,2 %),’ explains Yvonne.

By field of study

- **Largest growth Business and Management Sciences**
  279 803 in 2004 (153,8 % growth of the field since 1994)
- **Lowest growth Health Sciences**
  117 303 in 2004 (92 % growth of the field since 1994)
- **Engineering Sciences and Technology**
  143 062 in 2004 (92 % growth of the field since 1994)

The focus on employees below middle management was the third phase of the process. In 2001 senior management had their qualifications verified.

In 2003 it was the turn of middle management. A confidential list of people who had falsified their qualifications was part of the resulting report.
Van der Merwe said government should introduce incentives for employees who dragged their feet or who were reluctant to hand in their qualifications for verification.

‘We know from our own experience over many years that qualifications cheating has become something of a national sport because it is so easy to get away with it. Unless government and companies in the private sector become proactive about the verification process this will remain a problem.’

She said the main problem with employees who were holding positions with bogus qualifications was the fact that they were unable to perform effectively because they lacked the educational skills and that this could be one of the reasons why certain government departments provided poor service delivery to the public.

‘They are also depriving honest employees who went to the trouble to achieve diplomas or degrees of jobs that should rightfully be filled by them.’

Kroll has in the past done background screening for several government departments, Van der Merwe said.

‘It is vital that government be ardent in their pre-employment processes. All prospective employees should be screened so that the government maintains a high degree of vigilance to guard against qualifications cheats,’ she said.

ANNUAL IMESA CONFERENCE
CALL FOR PAPERS

THE 72ND ANNUAL IMESA conference – recognised for its contribution to knowledge sharing in the local engineering industry – will be held at the Sand du Plessis Theatre Complex in Bloemfontein, from 29 to 31 October 2008.

The conference theme this year, ‘Innovation – The Road to Service Excellence’, covers a broad spectrum of topics to allow all disciplines in the municipal engineering field to make a contribution. Prospective authors wishing to present an oral and/or poster presentation at the conference are asked to submit it under one of the following session headings:

- Asset and Project Management
- Water Sanitation and Environmental Management
- Transportation, Roads and Storm water
- Operations, Maintenance and Refurbishment


Papers will be accepted on the understanding that the main author (or a co-author) will personally attend the conference as a fee-paying delegate and present the paper, in the required format and according to stipulated deadlines.

Giving recognition to well-engineered projects for infrastructure, this year’s conference includes the biennial IMESA Excellence Awards for Outstanding Infrastructure Engineering Projects. The objective of the award is to portray the art and science of civil engineering, illustrating how the profession finds answers to challenging infrastructure problems.

INFO

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NIGERIA: THE DESERT IS FAST ENCROACHING, BUT WHY?

EXPERTS AGREE THAT an estimated 35 % of land that was cultivable 50 years ago is now desert in 11 of Nigeria’s northern states, but what they are not so sure about is why.

‘These are indications of global warming which the world must grapple with,’ Igiri West, a Kano-based environmentalist, told IRIN. ‘The level of industrial and vehicular emissions [in industrialised countries] is so high that they are capable of drastically affecting the climate [in northern Nigeria].’

But Kabiru Yammama of the National Forest Conservation Council of Nigeria disagrees: ‘Deforestation constitutes 75 per cent of the environmental problems in northern Nigeria,’ he said.

‘The increasing need for wood fuel for domestic use has caused the rapid depletion of trees which has caused increasing havoc on the environment and put farming activities at great risk.’

Yammama said the population burns over 40.5 million tonnes of firewood each year which destroys over 400 000 ha of forest.

Environmental activists have been lobbying the government to create a desert control commission and pass a federal bill to address desertification, but parliament has not yet taken action.

Effects

One of the worst affected areas is Yobe State in northern Nigeria. ‘Sand dunes are encroaching at a rate of 30 hectares a year, taking over [entire] villages,’ Suleiman Garba, project manager of the federally funded North East Arid Zone Development Programme, told IRIN.

The symptoms are erosion, rain shortages and drought, said Basiru Buwa Adamu, Kano state director of afforestation, adding that the livelihoods of over 55 million people are threatened, more than the combined population of Mali, Burkina Faso, Senegal and Mauritania.

A report of Nigeria’s National Meteorological Agency released in early March 2008 said the rainy season in the north has dropped to 120 days from an average of 150 days 30 years ago and as a result crop yields have dropped by 20 %.

For environmentalist West this is an indication of global warming. ‘The Himalayas and the Arctic provide a cooling effect to global climates and temperatures that are becoming warmer by the day with the ice melting, causing climatic change globally. While the other parts of the world are experiencing flooding and excessive rainfall, here we are experiencing rain shortages and drought.’

Deforestation

Yet for Adamu, Kano State’s director of afforestation, ‘global warming pales into insignificance [compared] to the environmental problems which deforestation engenders’.

The forests in northern Nigeria have almost vanished and lumberjacks keep moving steadily southwards. Nigeria has the world’s highest deforestation rate of primary forests according to a 2005 UN Food and Agriculture Organisation report. ‘[This] puts it on track to lose virtually all of its primary forest within a few years,’ the report said.

Crop yields of farmers in more south-erly states such as Niger, Plateau, Kogi and Benue have dropped and, at the same time, northerners are migrating south looking for greener pastures for their cattle, and that leads to increased conflict over land.
ECOLOGICAL COASTAL CITY
IN CHINA EVOKES THE
DUTCH WADDEN SEA

THE ENGINEERING CONSULTANCY DHV has
been commissioned, together with the
Chinese planning institute Qinghua and the
Arup consultancy from the UK, to carry out a
prestigious coastal and urban development
project in China.

The coastal city is to be built on an area
of 150 km² and will soon have to provide
space for one million inhabitants. DHV won
the assignment by including in its concept
for the area an island and lagoon structure,
which reminds one of the Dutch Wadden Sea.
The concept allows for the creation of fresh
groundwater in a sustainable manner for use
in the city’s green spaces. The international
jury, consisting of experts from Italy, Sweden,
and China, complimented the proposal for
the way it combined coastal development,
energy, water, and transport into an attractive
urban design.

The new coastal city will be built in
Caofeidian, an industrial zone in North China
on the Bohai Sea. ‘Caofeidian has to become
the model for China and the rest of the
world of a Chinese ecological coastal city,’
says Dick Kevelam, DHV’s advisor on coastal
development. Because of the coastal location
in a salt-water area, and because of the
limited rainfall in the north of China, there
is little fresh water available for the future
inhabitants. ‘One of this project’s challenges
is to capture and recycle fresh water in as a
sustainable manner as possible,’ according to
Kevelam.

At high tide, the outer islands off the
coast form a sea defence wall that offers flood
protection for the lagoon, which is located
behind. The city is to be built on islands in the
lagoon. The islands will be raised a number
of meters above the salt water, by drawing
sand from the lagoon. The lagoon design
will restore part of the original tidal mud-flat
coast in this area and will save those areas
that still exist.

‘In this case we’re not creating land in
the sea, rather we’re returning water to the
land in a controlled manner, thus re-creating
a natural dynamic,’ as Kevelam puts it. In
order to adapt the Dutch know-how as much
as possible to China, DHV is working very
closely on the project with its colleagues in
Shanghai.

In early 2009, the city’s construction will
begin next to an industrial port comparable
in size to that of the Port of Rotterdam. The
port, which is being further developed very
rapidly, is today partly operational.

The Caofeidian New Coastal City is the
second large coastal project that DHV has
designed for China recently. In the other case,
the Chinese were enthusiastic about the
Delta Diamonds, a 75 km² polder land-recla-
mation project for the urban, economic, and
ecological development of Tianjin, China’s
largest import harbour. This project is cur-
rently under way.

BALANCING GRADUATE
OVERSUPPLY AND THE
SA SKILLS SHORTAGE

COGNISANT OF SOUTH AFRICA’S skills
shortage and the oversupply of matriculants
and graduates, the South African Tool, Die
and Mould (TDM) sector has taken steps to correct
this imbalance, a process that is going to take
about eight to ten years before it starts to bear
fruit.

The TDM sector is a key support sector
to manufacturing, one of the main drivers
of export growth. However, the sector has
deprecated over the past 20 years as a result of
deterioration in capacity, the skills base and
technology status.

In recent years the TDM industry has
suffered a steady decline due to a critical
shortage of skills, underinvestment in new
equipment and a lack of enterprise develop-
ment. According to Dirk van Dyk, national
programme manager of the National Tooling
Initiative (NTI) Intsimbi programme, a TDM
manufacturing industry intervention, if we do
not address the current situation proactively
the industry will suffer from job, skills and
economic loss.

This decline has caused industry demand
(such as the local automotive and packaging
industries) from the local TDM supplier base
to fall below 20%. It is estimated that the
TDM demand for these key sectors will ex-
ceed R6 billion by 2008.

Van Dyk says while several initiatives are
under way to revitalise the TDM sector, many
of these initiatives are running programmes
aimed at National Qualifications Framework
(NQF) levels 2 to 3.

‘Despite good intentions, this model is
flawed. By pumping people into NQF levels 2
and 3, we’re setting them up for employment
in production and maintenance of a declining
industry. However, what we really need to be
doing is getting the top people into place
so that the industry can win large contracts
which will directly create jobs for people at
the lower levels. We need to create a balance
and this means addressing all skills levels and
attracting specialty skills such as design engi-
neering to the industry.

‘If our specialist design engineers come
up with groundbreaking innovations that
help us win contracts, then we’re looking
at becoming a competitive player in the
industry again. And the people who have
entered the industry at NQF levels 2 and 3
will have jobs and the opportunity to grow into
more meaningful roles,’ says Van Dyk.

The Intsimbi programme, a joint
Toolmaking Association of South Africa
(TASA) and Department of Trade and Industry
(dti) initiative, was established to address the
gap in the country’s various skills interven-

Artist’s impression of Caofeidian new coastal city
tions. It is tackling the issue in two stages.

‘The first stage – and our short-term focus – is aimed at strengthening the capacity of existing initiatives at Further Education and Training (FET) colleges, technical universities, national universities and private sector initiatives. This will see the provision of upgraded curricula and state-of-the-art equipment to the various institutions,’ says Van Dyk.

The second stage is about customised interventions such as youth-based marketing campaigns, maths and science re-orientation programs, student assessment tool development projects and specialised skills development. ‘This is where our medium-to-long-term focus is,’ says Van Dyk. ‘There is a 70 per cent drop-out rate at technical colleges and universities and we need to introduce a higher level of assessment to determine candidates’ potential success in technical careers.’

In addition, this stage is about directing engineering generalists into specialised skills areas. ‘A mechanical engineer will not be able to come up with plastic injection moulding innovations, but if the engineer is trained as a design engineer for a specific technology platform such as a specialist designer for plastic injection moulded tooling, there is a much greater chance of success,’ says Van Dyk.

A mining skills project is being piloted in Limpopo Province where a skills GAP filling project is currently under way. The project has called on the private and public sectors to cooperate and current partners include industry partners Sandvik, Lonmin, Cambrien University, TASA and various SMMEs, and government partners the Department of Economic Development, the dti, the Department of Education and various academic institutions.

The Limpopo project will see skills GAP elimination in two main areas, the first being maths and science focused re-training for technical careers. This is for school leavers and candidates with prior learning. The second area is specialised mining skills training that is not currently being serviced by any of the tertiary education institutions such as training in specialised mechanised mining tooling skills.

Van Dyk says the initiatives are aligned with the Joint Initiative on Priority Skills Acquisition (JIPSA) model. ‘In some instances South Africa may import teachers to ensure that our learners receive globally recognised skills,’ he says.

Van Dyk says the sector cannot afford to train specialised engineers across the entire spectrum of industries. ‘We cannot produce all components. We need to identify specialist value chains and select components for production where we have potential for a high degree of success.

‘It is cause for concern that increasingly more tools, dies and moulds are being imported by local manufacturers. We are, in effect, exporting jobs rather than developing and retaining those skills in the country,’ he says.

The NTI will dramatically improve the circumstances of the TDM industry over the next eight years and transform it from being a net importer to becoming a net exporter. South Africa has the human and raw material resources to do this. ‘All we require is the correctly focused investment in skills, equipment and enterprise development.’

LIVIERO SHOWS ITS METTLE ON THE GAUTRAIN

LIVIERO CIVILS, one of the fastest-growing civil contractors in South Africa, is showing its mettle on a range of works on the Gautrain at the Rosebank and Sandton stations.

At Rosebank, Liviero has been responsible for the drill and blast (DB) and tunnel boring machine (TBM) base slabs, which in essence enable the drilling of the Gautrain tunnel to the north and the south of the Rosebank Station.

‘These slabs entail the supply and fix of all the related rebar, the concrete formwork and the actual pouring of the concrete,’ says Stuart Knight, Liviero Civils MD.

The base slab varies from 700 mm to 1,7 m thick and requires more than 3 000 m³ of concrete and 500 t of rebar.

The duration of the works was in the region of 18 weeks and was completed in January 2008.

Charles Wright, Liviero Civils contracts director, says the Gautrain is certainly one of the largest civil construction contracts in South African history and while the scope of works is sometimes extremely challenging from a practical point of view, the major challenge on the contract is the collaboration between the myriad parties involved in the wide range of tasks.

‘There is a great deal of interdependence on this job and I am pleased that the Liviero team has proved itself to be a very efficient and effective partner on this contract.’

SOLAR-POWERED AUTOMATIC LAWNMOWER!

IT MAKES PERFECT sense that nobody would want to mow the lawn when it is raining, so the premise for a solar-powered lawnmower is a no-brainer.

Husqvarna has launched the world’s first automatic electric solar-powered hybrid robotic lawnmower. The new lawnmower offers users happy to pay the £2 000 price tag the promise of never having to mow their lawn again …

This lawnmower can clear 2 300 m² of grass and is programmable to work only at certain times or days of the week. It has a battery life of approximately 40 minutes before a 40 minute charging time juices it up, but on a sunny day, its cutting time can be extended by another 50 %.
### UPGRAADING OF SANDKRAAL ROAD, GEORGE

The upgrading of Sandkraal Road in George, Western Cape, was identified through the George Mobility Strategy project, in which certain corridors in George were earmarked for upgrading to proper public transport routes. A public transport route was identified for provision for minibus taxis and buses, as per the proposed restructuring of the George Public Transport System, non-motorised transport, and dignified spaces.

The project, which is being managed by the George office of Vela VKE Consulting Engineers, comprises the upgrading and widening of a section of Sandkraal Road between Industrial Street and the N2 Interchange ramps. In general the objective is to improve the environment in order to stimulate business developments closer to communities, thus reducing walking, cycling and travelling. The total length of the Sandkraal Road Corridor is approximately 7.8 km.

The commencement date for this project was 12 February 2007 and the contract period is expected to run for 56 weeks.

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<td>22 June – 19 July University of Stellenbosch</td>
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<td>Business Finances for Built Environmental Professionals SAICEfin06/00004/08</td>
<td>Wolf Weidemann</td>
<td>Dawn Hermanus <a href="mailto:dhermanus@saice.org.za">dhermanus@saice.org.za</a></td>
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<td>17–18 July – Durban 6–7 November – Gauteng</td>
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<td>22–23 July – Gauteng</td>
<td>Basic Construction Estimating &amp; Planning SAICEcon06/00106/09</td>
<td>Phil Watson</td>
<td>Sharon Mugeri <a href="mailto:cpd.sharon@saice.org.za">cpd.sharon@saice.org.za</a></td>
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<td>Environmental Management for the Roads S Ballot</td>
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<td>27–31 October – Gauteng</td>
<td>Tailings Course 2008 SAICEcon07/00232/10</td>
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<td>2nd International Conference on Concrete Repair, Rehabilitation and Retrofiting <a href="http://www.civil.uct.ac.za/iccrr">www.civil.uct.ac.za/iccrr</a></td>
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