Civil Engineering

Railway & Harbour Engineering

Systems Approach to Infrastructure Delivery

Evolution, Environment & Engineers

May 2012 Vol 20 No 4
We believe an efficient rail system is a key component of a sustainable economy.
180 degrees

THE E-TOLLING SAGA has been in the spotlight in recent months. The issue has intensified now with the resignation of SANRAL’s CEO, Nazir Alli, who is also a longstanding member and Fellow of our Institution. It is common knowledge that SANRAL is one of the better-run organisations of its kind. Nazir is noted for being a highly competent, motivated and technically sound civil engineering business manager, operating in the government environment, and who stands in the gap that translates politics into engineering and engineering into politics. That breed is rare, and SAICE is sad to see Nazir leave.

While the circumstances around Nazir’s resignation are unknown, we will have to make sure that engineering skills, competence and excellence are never sacrificed in the interests of a political agenda.

I inserted this note a few minutes before the magazine had to go to print. SAICE will be responding to the e-tolling issue, as well as Nazir’s resignation, in the media, on our website and in the next magazine issue.

For this article, however, I’d like to discuss the youth of South Africa.

“Be quiet,” the lecturer thunders, his severity and straight face terminating the chuckles quickly. The auditorium drops into nervous silence. This was to be their induction into student life – 120 young contemporaries, selected from a list of some 400 applicants for the Higher Diploma in Civil Engineering; the cream of the crop about to start S1 at a popular university of technology. “How many degrees in a half circle?” the lecturer asks, pointing to a youngster sitting in the third row in the centre. The student whispers something. The lecturer draws closer. “Louder please.” The student mumbles, “Sir, it depends on the size of the half circle.”

In 2011 about 495 000 learners sat for their matric exams. Only 12% passed both maths core and physical science with more than 40%. This is the pool from where all professions come to drink. According to Allyson Lawless’s Numbers and Needs, about 1% of those who write this exam, will enter into engineering programmes. But if we think that the threat to engineering sustainability is limited to maths and science performances and a floundering education system, then the wool is firmly over our eyes.

Engineers operate within a balance of group work and focused independent work. Written, spoken and visual communication is critical, as are group dynamics. Asking questions and challenging ideas are part of what we do.

We are professionally obliged to provide creative and cost-effective solutions in a well thought through process, in an ethical manner. It is not up for debate – maths, science, accuracy, excellent general knowledge, and appreciation for local and national political and business environments are absolute requirements. But there are also those uncomfortable components associated with emotional awareness – respect, ethics and interdependent professional human relations. These are the people issues – being able to effectively communicate with the boss, other seniors, contemporaries and subordinates, under all circumstances.

I am not sure that the university can teach coming to work on time, respecting company resources, having regard for seniors, colleagues and clients, dressing appropriately and such like. This used to emanate from being part of a wholesome community which includes healthy family units, involvement in faith-based organisations, schools and other community-related avenues. Engineering seniors need to take into account that many engineering graduates come from single- or no-parent homes. The challenge is enhanced by the cultural differences that South Africa so richly enjoys.

Furthermore, learners are starting to suffer serious written and spoken impediments. Thanks to that instant communication, engineering issue. Chunks of the essay were copied verbatim from online articles – Google helped us both.

Previously the paradigm differences between the youth, the middle-aged and seniors were limited to differences in appreciation of music, hobbies and taste in clothing. But the youth and young engineers think and communicate differently from say ten years ago. I have noticed, however, that our training and development methods in the engineering environment have remained unchanged over the past 30 years – review the report or drawing over and over again, write the same lengthy compilations, advance the intelligent engineering graduate, marginalise the misfit and misunderstood graduate until s/he leaves. Feel free to work out practices that apply to your organisation.

While some wrestle the education system, perhaps it’s time we recreated ourselves, revised our operations, and started accommodating new succession planning methods for sustainable civil engineering.
ON THE COVER
Pulp and paper producer Sappi Southern Africa (Pty) Ltd awarded AVENG Grinaker-LTA Ground Engineering a R21 million order for piling works at the Ngodwana Paper Mill, Mpumalanga. The works form part of the expansion of the current mill. Here the Bauer MG 48 is being moved into position for yet another pile.

FROM THE CEO’S DESK
180 degrees

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INTRODUCTION
Pulp and paper producer Sappi Southern Africa (Pty) Ltd awarded AVENG Grinaker-LTA Ground Engineering a R21 million order for piling works at the Ngodwana Paper Mill, Mpumalanga, in October 2011. The piling works form part of Sappi’s GoCell project, which entails the expansion of the current mill for the production of chemical cellulose.

CHALLENGING GROUND CONDITIONS
The initial design, executed by ARQ Consulting Engineers, was based on the installation of full displacement piles (FDP), but, after several trial holes, it was established that the ground conditions consisted of stiffer clay than expected and FDPs were no longer regarded as the most optimal piling solution.

The Bauer MG 48 piling rig used for the installation was then converted for instrumented continuous flight auger piles (CFAs) and, after more trials, it was determined that concrete CFAs would be the optimal solution.

CONCRETE PILING
Concrete CFAs are a fairly new piling system in South Africa, compared to their...
predecessor, the grout CFA pile. Grout CFAs in general are preferred by contractors due to the high production rates gained by the construction sequence of the pile and the low-tech plant requirements. The process, however, becomes difficult when concrete is used to substitute grout.

The construction sequence entails the installation of the reinforcing cage into the predrilled auger after the completion of the concrete process. So, the thicker the mix, the more resistance is encountered when sliding the reinforcing cage into position.

Concrete piling is preferable for two major reasons. Firstly, the cost of concrete is economically more feasible than the cost of grout, due to its lower cement content. Secondly, the on-board instrumentation provides improved quality control, so that it is no longer necessary to rely solely on the competency of the operator.

AVENG Grinaker-LTA Ground Engineering is one of a few piling contractors to have successfully mastered this piling system in South Africa, and the company has indeed completed several successful projects to date.

The total scope of the piling works for Sappi’s GoCell project is estimated to be approximately 1 630 piles. The piling works are currently still under way and production rates as high as 280 m per day have been reached on the project, resulting in several sections of the plant’s foundation being completed ahead of the very tight schedule.

QUALITY ASSURANCE

As part of the quality assurance programme to verify design parameters, two static pile load tests were carried out by AVENG Grinaker-LTA Ground Engineering, in the digester area. The results were analysed by ARQ Consulting Engineers and it was found that the design values were accurately calculated with some margin for safety.

Non-destructive pile integrity testing has also been carried out on over 200 piles so far, using the pulse-echo method, or ‘tapping’ for short. A 100% pass rate was achieved.

AVENG Grinaker-LTA Ground Engineering has also achieved a zero lost time incident rating (LTI) on site, which proves that safety on site is considered a high priority, as is demonstrated by the company’s slogan: “Home without harm, everyone every day”.

CONCLUSION

It is evident that pulp and paper producer Sappi Southern Africa (Pty) Ltd has wisely chosen the latest technology in the industry to ensure the best quality product, the highest safety records, the fastest installation time and the best price.
Stefanutti Stocks Marine - is a specialised marine and structural rehabilitation contractor, priding itself on undertaking technically challenging projects in South Africa and throughout Africa.
The Transnet Infrastructure Plan (TIP) 2011 forecast a growth in the national total freight (all forms of transport) from the current 750 mtpa (million tons per annum) to around 1 800 mtpa in 2040. In the Rail Development Plan section of the TIP, Transnet is preparing for this by putting in place strategies to move those commodities that are currently transported by road, but that are more suitable for rail, back onto rail. This will result in an increase in traffic beyond the current rail infrastructure traffic limit. The Transnet capital programme therefore relies on optimising the lines. In this regard efficient track maintenance will undoubtedly make a huge contribution.

**AN INCREASE IN traffic on a railway line requires an exponential increase in the preventative track maintenance intervention frequency (shorter maintenance cycle) to ensure that the line remains reliable, available, maintainable and safe. However, the more trains there are in the system the less time there is to occupy the track for maintenance with mechanised machinery.**

To maintain the required maintenance cycle for the increased traffic without uneconomically and impractically increasing the number of machines working on the line, maximum performance and durability of production are expected of the maintenance machines. High-production mechanised maintenance machines will reduce the time required for maintenance, the number of machines required and the total cost of maintenance.

This article consists of two parts: Part 1 examines the necessity of using high-production track maintenance machinery to contribute towards line optimisation and reduction in maintenance costs. Part 2 examines public procurement legislation, and the importance and challenges of specifying the required machine adequately in terms of the procurement scoring system to ensure that the machine will be contracted.

**PART 1**

**HIGH-PRODUCTION MACHINES FOR HIGH TRAFFIC DENSITY LINES SAVE MONEY**

The field of mechanised track maintenance is very complex, with a wide variety of machines available for nearly every track maintenance activity. Over the years the technology employed on all of these machines has improved vastly to increase the production and durability needed to keep up with the demands of ever-increasing traffic volumes, high speeds and high axle loading. The technology is available, and in most cases already in South Africa.

For example, lifting, levelling, lining and tamping of the track are the most frequently performed mechanised maintenance activities, and it is therefore not surprising that the advancements in this technology have been huge. Thirty years ago the *Plasser 09-32* revolutionised main line tamping with the continuous action principle producing 39 sleepers per minute. Today the *Plasser 09-4X* produces in excess of 70 sleepers per minute! The fastest tamping machine in South Africa is the *Plasser 09-3X*, which produces a maximum of 60 sleepers per minute (Figure 1).

However, these main line tamping machines cannot tamp turnouts, due to...
the restricted track around the switch blade, the diverging rails and the frog. Tamping machines were therefore equipped with specialised features to tamp both turnouts and main line, and became known as universal tamping machines, but were of relatively low production when tamping open track (around 15 to 21 sleepers per minute). As the demand for maximum production in short maintenance windows grew, universal tamping machines became too slow to keep up with production demands on high-capacity lines. The 09-24 Dyna-CAT (Figure 2) bridged the compromise between specialised high-production turnout tamping and high-production main line tamping by tamping the heavy and long concrete 1:20 turnout in one pass in less than 30 minutes, and up to 36 sleepers per minute on the open line.

Maximum production is, however, not the only important criterion for high-capacity lines. The durability of the production is also very important, since this will determine the tamping cycle. Despite the technology used on Plasser & Theurer machines (having been researched and proven to produce the maximum possible durability by independent academics), the durability is today further enhanced by the use of dynamic track stabilising, integrated as part of the tamping machine or working independently directly behind the tamping machine. Research in South Africa by the Transnet Track Testing Centre showed that an extension of up to 30% between the tamping cycles is possible if the track is stabilised immediately after tamping. Today dynamic track stabilising is non-negotiable on heavy-haul and main lines and has become an integrated part of the tamping process.

Before the benefits of high-production machines can be quantified in monetary terms, it is necessary to explain the effect of track maintenance on train operations. Influencing factors would be traffic density, whether it is a single or double line, the number of turnouts, the number and radii of curves, the condition of the track material, etc. The variables are therefore vast, but the Sishen-Saldanha iron ore line will be used as a good example, due to its financial importance for Transnet and its unique characteristics in terms of it being a single line of 861 kilometres, with high traffic density (one train departing from either end at slightly over two-hour intervals), heavy axle loads (30 ton), 20 crossing loops at approximately 40 kilometre intervals, and high-value trains of up to 342 wagons.

With the current targeted 90 million gross tons of traffic on the ore line, the tamping cycle can be calculated at approximately five months, using empirical formulas. In other words, the 861 kilometre line must be tamped from top to bottom within five months before the next cycle must start again. With a 650 mm sleeper spacing, this means that 1 325 000 sleepers have to be tamped over this five-month period.

If, for example, one tamping machine with a nominal tamping rate of approximately 19 sleepers per minute is used, working for four hours per day during a 20-working-day month, an average of 91 200 sleepers per month would be tamped. One machine would therefore take 14.5 months to tamp the entire line. At a required five-month tamping cycle, three of these machines would be required, with three occupations along the line of at least six hours each to ensure a four-hour work period.

On busy lines such as the Sishen-Saldanha line, complicated further by it being a single line, occupations are created by using train-free slots to allow maintenance machines to occupy the line. This can be best illustrated using a typical train grid (see Figure 3).

The blue lines represent full trains leaving Sishen at two-hour intervals (rounded off for the sake of simplicity in this hypothetical example) and arriving in Saldanha 17 hours later. The red lines are the empty trains returning from Saldanha to Sishen, also at two-hour intervals, but they take 21 hours to reach Sishen, as they have to pause in the loops to allow the full trains to pass without stopping. At any point on the line a train (full or empty) will pass at just over one-hour intervals.

To create a train-free maintenance window (coloured green in Figure 3) for mechanised track maintenance, some of the slots in both directions must be occupied. Figure 3 shows a typical scenario: to create one maintenance window every day between 08:00 in the morning and 14:00 in the afternoon, slots F1 & F2, F13 & F14, and F25 & F26 in the full direction, and slots E9 & E10, E21 & E22, and E33 & E34 in the empty direction must be train-free for maintenance.
As a result of the train-free slots, default windows appear (coloured lilac in Figure 3). This is, however, only one window per day (and one at night), and if the tamping machine described above is used, at least three of these windows will be required.

Tamping is not the only maintenance activity on the line. Other activities that cannot be done between passing trains, and for which occupations would also be required, are ballast cleaning, rail replacement, ballast offloading and regulating, rail destressing, overhead track equipment maintenance, etc. It is clear that maintenance windows have an adverse effect on train operations and the freight throughput on the line. This explains why an increase in traffic will exceed the traffic limit for this line if the infrastructure remains the same, and/or maintenance methods, machinery and strategies are not adapted to accommodate the increase.

This over-congestion of maintenance windows can be alleviated by the use of high-production machines. Similar to the calculation above: one high-production tamping machine with a nominal tamping rate of 55 sleepers per minute (as opposed to 19) can tamp 264 000 sleepers per month, or a tamping cycle of five months for this 861 kilometre line. Therefore only one of these machines would be required, as opposed to three slower machines.

One high-production tamping machine with a nominal tamping rate of 55 sleepers per minute (as opposed to 19) can tamp 264 000 sleepers per month, or a tamping cycle of five months for this 861 kilometre line. Therefore only one of these machines would be required, as opposed to three slower machines.
APT 1500 R MOBILE FULLY AUTOMATIC FLASH BUTT RAIL WELDING ROBOT

• Rail tensioning of 150 tons is integrated in the welding head which have the following benefits:

  - Long welded rail sections can be automatically pulled up for welding at high production rates without the need for external pulling and tensioning devices
  - The last weld for the work site can be welded without a closure rail and without the need for a thermite weld
  - Defective rails can now be repaired in cold weather, up to 20° below the neutral temperature range

• The process is fully automated and therefore not dependent on operator skill and experience

• Complies fully with the EN14587-2 flash butt welding standard
However, these high-production mainline tamping machines cannot tamp turnouts (turnouts were not considered in the above example). In practice at least one universal tamping machine would be required to tamp the turnouts. The mix of high-production universal tamping machines and high-production main line tamping machines will depend on the characteristics of a particular line.

The contract cost of high-production machines would be more than for low-production machines. However, the contract cost should not be considered in isolation. It is the total cost involved in an occupation for mechanised maintenance, of which the machine is but one component, that must be considered. These costs include the following, but will vary depending on the different types of maintenance activities:

- The cost of Transnet personnel: A permanent way inspector, track master, flagmen, overhead track equipment linesmen, a signalling technician, labour for each of these, vehicles and tools would be required for each occupation.
- Diesel locomotive, train driver, his assistant and a shunter: The combined cost of this can be conservatively estimated at R30 000 per day. For some types of maintenance activities more than one locomotive and other rolling stock may also be required.
- Loss of revenue due to the occupation: As higher traffic volumes are envisaged, loss of revenue will be a particular concern, as lost train slots will never be caught up again due to the congestion on busy lines. Every slot that is used for maintenance has the opportunity cost to the railway of the income generated by a train. A quick internet search revealed that the commodity value on the international market of each ore train can be R40 million on average (http://www.indexmundi.com/commodities). At a conservative estimate that the income for the Railways is only 10% of the commodity value, each occupation of two slots has an opportunity cost of R8 million! The loss to the South African economy is, however, R80 million. To put this into perspective, the contract cost of a typical low-production tamping machine package would be approximately R50 000 per day (occupation), and of a high-production tamping machine package around R80 000 per day. Should only the contract values be compared, without considering their production capacity, it is clear which machine would be contracted.

However, if the total cost to the client is considered, the higher cost of the high-production tamping machine is completely irrelevant.

Correctly specifying and evaluating the required machine during the procurement process is therefore of paramount importance in terms of the expected outcome of the contract. Contracting a machine which is not capable of the expected production, due to failure of the supply chain process during the evaluation of tenders, would have financial implications far exceeding the maintenance contract value itself.

The biggest challenge to getting the required machine, however, is related to the supply chain management process and the legislation that regulates it.

PART 2
WHAT IS THE INFLUENCE OF LEGISLATION ON CONTRACTING THE MACHINE THAT IS REQUIRED?

Various acts, regulations and guidelines prescribe the manner, format and content for the preparation and administration of procurement documents in organ-of-state tenders. The most important of these is the Preferential Procurement Policy Framework Act (PPPFA), which simply states that an organ of state must determine its preferential procurement policy and implement it within the framework of a preference point system based on the contract value. The point system is based on either 80 or 90 points allocated to price, and either 20 or 10 points allocated to specific goals, such as contracting with persons, or categories of persons, who had been historically disadvantaged by unfair discrimination on the basis of race, gender or disability. The contract must then be awarded to the tenderer who scores the highest points, unless objective criteria justify the award to another tenderer.

The 2011 Preferential Procurement Regulations (the Regulations), published in terms of the PPPFA, provide the criteria for evaluating tenders where the quality or functionality of the product or service, of which production or performance would be one, may have a decisive influence on the outcome of the contract. Clause 4 of the Regulations states that:

(1) An organ of state must indicate in the invitation to submit a tender if that tender will be evaluated on functionality.

(2) The evaluation criteria for measuring functionality must be objective.

(3) When evaluating tenders on functionality, the:
   (a) evaluation criteria for measuring functionality,
   (b) weight of each criterion,
   (c) applicable values, and
   (d) minimum qualifying score for functionality,
   must be clearly specified in the invitation to submit a tender.

(4) No tender must be regarded as an acceptable tender if it fails to achieve the minimum qualifying score for functionality as indicated in the tender invitation.

(5) Tenders that have achieved the minimum score for functionality must be evaluated further in terms of the preference point systems prescribed in regulations 5 and 6 [the 90/10 or 80/20 point system].

Quality or functionality can therefore be introduced in the procurement documentation as eligibility criteria (pre-qualification criteria) as a means of ‘gate-keeping’ to ensure that only those tenderers who are likely to deliver the required quality or functionality continue to compete for the award of the contract.

The scoring of functionality is therefore merely to establish that the tenderer is capable of providing the service, and to reject the tender submissions of those who fail to attain the threshold score. Thereafter the tender offers can be evaluated on the basis of price and preference alone. The points scored for functionality will therefore not contribute towards establishing the successful tenderer in terms of price and preference evaluation.

The result is that a cheaper lower-production and/or substandard machine can make it through the eligibility process (‘gate’) and score the highest points due to its lower price, unless technology and speed are specified as non-negotiable. The tender board will then have to contract this machine according to the PPPFA without any discretion (performance or production can by law not be used again as objective criteria to award the tender to a bidder who did not score the highest points).

Referring back to Part 1 above, the
higher-production machine may be more expensive in terms of the contract value, but if the overall cost of maintenance is considered, the lower-production machine’s so-called saving will be negligible, due to it requiring longer or more train slots to achieve the same output as the high-production machine. This can be illustrated at the hand of the following hypothetical example:

The Railways advertises an invitation to tender for a tamping machine to tamp an 800 kilometre single line at a six-month tamping cycle. The tamping machine must therefore be capable of tamping 1 600 km (2 461 000 sleepers) in a 230-working-day year. Train slots are two hours apart and provision is made for two slots per day for tamping, providing an effective four-hour working day (refer again to Figure 3). It is an ore line and the income to the railway is approximately R4 million per train. Calculations by the Railways showed that a tamping machine with a minimum tamping production of 45 sleepers per minute would be required (45 slp/min x 60 min x 4 hrs/day = 10 800 slp/day x 230 days = 2 484 000 slp/year > 2 461 000 slp/year required). The tender documentation is advertised as such and two tenders are received, as illustrated in Table 1.

In terms of the PPPFA, even if Tenderer B received the full 10 points for preference (equity) and Tenderer A does not, the contract must still be awarded to Tenderer A if the price component is purely based on the contract value, since Tenderer A will achieve the highest points. However, as explained in Part 1 above, the lower-production machine would require more occupations than a higher-production machine at the expense of the opportunity costs of income generating trains, as illustrated in Table 2.

Therefore, despite Tenderer B’s contract price being R3.5 million more expensive per annum, this is insignificant compared with the saving of R448 million per annum brought about by the fewer occupations required by Tenderer B’s higher production machine and the resulting more trains that can be run. This does not even include other occupations costs, as discussed in Part 1.

High-speed technology is only cost-effective if the benefits that it provides are factored into the evaluation. This article therefore calls on the Railways to consider a different approach to calculating the price component of tenders while still remaining within the framework of the PPPFA. This would require the price component to be calculated considering the overall cost to the railway per occupation, and the production achieved, as opposed to a contract value alone. This article will not at this stage propose a formula for such a calculation, since the variables are vast, but to find the best value for money and to optimise line availability, this concept requires further investigation.

This article recognises that not all lines have a traffic density where production would make such a large difference in terms of opportunity costs, but the other costs mentioned in Part 1, such as personnel costs and locomotive requirements, should still be considered.

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Tenderer A</th>
<th>Tenderer B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine production offered</td>
<td>45 sleepers/min</td>
<td>55 sleepers/min</td>
</tr>
<tr>
<td>Contract price (per annum)</td>
<td>R14 900 000</td>
<td>R18 400 000</td>
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</table>

Table 2

<table>
<thead>
<tr>
<th></th>
<th>Tenderer A</th>
<th>Tenderer B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required production per year</td>
<td>2 461 000 sleepers</td>
<td></td>
</tr>
<tr>
<td>Production in four hours per day</td>
<td>10 800 sleepers</td>
<td>14 400 sleepers</td>
</tr>
<tr>
<td>Production in 230 days per year</td>
<td>2 484 000 sleepers</td>
<td>3 312 000 sleepers</td>
</tr>
<tr>
<td>No of days/occupations required(^1)</td>
<td>227 occupations</td>
<td>171 occupations</td>
</tr>
<tr>
<td>Opportunity cost of maintenance(^2)</td>
<td>R1 816 million</td>
<td>R1 368 million</td>
</tr>
</tbody>
</table>

\(^1\) No of days/occupations required = Required production per year × production capability in a four-hour day
\(^2\) Opportunity cost of maintenance = No of occupations required × R4 mil/train × two trains per four-hour occupation
Aveng Manufacturing Infraset produces a diverse range of quality, precast concrete products. Our prestressed railway products include:

- Various types of railway sleepers
  - siding;
  - mainline; and
  - heavy haul sleepers.
- Special Application sleepers
  - low profile sleepers;
  - check rail sleepers;
  - stacker reclaimers;
  - expansion joint sleepers;
  - turnout sleepers;
  - universal sleeper and infrabolt system;
  - LVT (low vibration track) track slab;
  - 1435 gauge sleepers.
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- Railway culverts
- Level crossings, cattle grids and drain channels

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- LOWER FORMATION & RAIL STRESSES
- REDUCED INSTALLATION PERIODS
- PASSENGER SAFETY
- MINIMAL MAINTENANCE
- WARRANTIES OFFERED

TMT is a South African developed system which can be used with confidence in many different applications.

STRAY CURRENT: This is a universal problem on all electrified DC current lines. TMT has been proven to solve this by arresting and neutralizing the stray current.

Cast in conduit for cabling, signalling or communications.
An inside look at the stresses due to lateral forces in Tubular Modular Track

PROJECT DESCRIPTION

The Tubular Modular Track system is a relatively new innovation in railway technology. This ballastless track structure provides a more stable and reliable track structure, and requires less track maintenance. These improvements in railway track structures are important, as there is a demand for higher capacity, faster, safer and more economical public transport systems. This research project focused on the strains and stresses experienced by the gauge bar, in three different sections along a track structure, namely a transitional curve, a circular curve and a tangent section of track.

The testing was done by installing strain gauges at different positions on the gauge bars on an active PRASA (Passenger Rail Agency of South Africa) line in Hatfield, Pretoria, to the west of Rissik Station, as shown in Figure 1.

Tubular Modular Track (TMT) is a non-ballasted track system developed in South Africa and implemented since 1989. Originally used in the mining industry, Tubular Track also has applications in the passenger and freight transport sectors, as it provides a stable and low-maintenance track.
A moving train induces complex loading on a railway track. The resultant force can be divided into three separate components, namely a vertical, longitudinal and a lateral force component, as illustrated in Figure 3.

The focus of this study was on the lateral forces induced on the track and on the behaviour of a specific component, the gauge bar, when subjected to train loading. The resultant lateral force on the track has mainly four contributing factors – firstly, the lateral force of the wheel flange pressing on the outer rail; secondly, the lateral force due to centrifugal force; thirdly, a component for cross wind; and lastly dynamic lateral forces.
OBJECTIVES OF STUDY
The objectives of the project were as follows:
■ To determine the strains and stresses induced by lateral forces in the gauge bar at different sections of the TMT test section, namely tangent track, the circular curve and the transitional curve.
■ To investigate the strains and stresses throughout the top of the gauge bar of a TMT system.
■ To confirm how the results can be optimised to enhance the performance of the TMT system with regard to the gauge bar.

TESTING
Three gauge bars were used for the testing, one on the tangent portion of the track, one in the transitional curve and one in the circular curve, as indicated in Figure 4. This was to identify the portion of the track in which the highest lateral forces were generated.

Strain gauges were installed at different positions along a gauge bar (Figure 5) in each of the above-mentioned sections of the track. As the trains passed the test section, the strains were measured and recorded.

RESULTS FROM TESTING
Typical results obtained from the strain gauge readings are shown in Figure 6. The figure shows the strains of all seven strain gauges of one gauge bar as a single train passes. In this
Gauge bars can be subjected to tension as well as compression forces. The top of the gauge bar, between the two rails, experienced tension, regardless of its position in the track. In the transition zone, the outside of the gauge bar was in pure tension, and in the circular curve in pure compression. However, on the straight portion of the track, the outside of the gauge bar experienced, firstly, compression as the train wheel neared the gauge bar, tension as the wheel reached the gauge bar and then compression as the train wheel moved away.

CONCLUSIONS

The following conclusions were drawn after evaluating the results:

- The largest stresses were generated in the transitional curve. Exceptions were measured where the maximum was located in the circular curve. This is a result of the relative lateral movement of the train as it travels through the curve.
- Different strains measurements were obtained along the top of the gauge bar. The highest stresses were measured next to the weld connecting the gauge beam and the shoulder plate. The high peak stresses are believed to be as a result of the welding, as well as the change in stiffness between the combined action of the gauge beam and shoulder plate in comparison to the gauge beam only.
- Gauge bars can be subjected to tension as well as compression forces. The top of the gauge bar, between the two rails, experienced tension, regardless of its position in the track. In the transition zone, the outside of the gauge bar was in pure tension, and in the circular curve in pure compression. However, on the straight portion of the track, the outside of the gauge bar experienced, firstly, compression as the train wheel neared the gauge bar, tension as the wheel reached the gauge bar and then compression as the train wheel moved away.

Two factors were identified to have an influence on the stresses in the gauge bar, namely the weight of the train and the speed of the train. As expected, the heavier the train, the higher the stresses that were measured. On the other hand, it was observed that higher speeds resulted in lower gauge bar stresses. This can be explained in terms of the balancing speed of this specific curve. Due to the close proximity of the site to the station, most trains travelled at lower speeds than what the curve had been designed for. This excess in super-elevation at low speed is responsible for the unbalance in lateral forces and the resultant higher gauge bar stresses.

- When designing the gauge bars for Tubular Modular Track, it should be taken into account that the gauge bar can experience tension and compression forces depending on its position in the track section, and not only compression stresses as originally designed for.

ACKNOWLEDGEMENTS

The following organisations and people are gratefully acknowledged for contributing towards this research:

- Tubular Modular Track for site arrangements and assistance.
- PRASA Metrorail for access to the site and the opportunity to carry out the research.
- Jaco Vorster and Jaap Peens (University of Pretoria) for instrumentation, site work and guidance.
- Transnet Freight Rail (Track Technology) for advice and collaborating with the University of Pretoria.
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Performance of resilient rail pads used in Tubular Modular Track under South African service conditions

BACKGROUND
Of the many requirements modern railways must meet, those of safety, speed, efficiency and cost-effectiveness are paramount. These requirements have been the driving force for railway engineers to develop new and innovative track structures. Conventional track structures consisting of a superstructure resting on a ballast bed have over time given way to ballastless track structures. These innovative structures, though often costly to construct, remain feasible due to the decreased maintenance requirements. Lower maintenance requirements lead to fewer interruptions to traffic, and considerable cost savings over the design life of the structure.

Ballastless track structures, however, lack the resiliency provided by the ballast bed in conventional track structures. Resiliency requirements in ballastless track are met by incorporating resilient elements such as rail pads, placed discreetly or continuously between the rail and the supporting structure, into the design. Resilient rail pads play an important role in ballastless track structures. One such role is the damping of dynamic forces caused by the movement of rolling stock. Without this damping, the resulting vibrations could cause accelerated deterioration of structural components, rolling stock and unwanted ground-borne vibrations which could negatively impact the environment adjacent to the structure.

Rail pads are manufactured from a variety of materials, selected on the basis of properties which will impact the performance of the final product. A desirable property is that of durability. A durable pad will perform well under service conditions without the need for regular replacement. Railway engineers must therefore select rail pads carefully, as a pad whose properties are suited to the conditions to which it will be subjected will most likely meet performance requirements.

AIMS AND OBJECTIVES
The objective of the study was the comparison of four different rail pads on the basis of performance. Performance data obtained was used to recommend a suitable rail pad for use on Tubular Modular Track which could result in a durable and cost-effective system for application in the South African rail transport network. Rail pads were assessed on the basis of in-service deflection and vibration attenuation.

PROJECT DESCRIPTION
Experimental work for the study was carried out on a section of Tubular Modular Track (TMT) which forms part of the Pretoria Metrorail system. TMT is a ballastless track structure developed in South Africa. The track structure consists of longitudinal reinforced concrete beams which are supported on an engineered foundation and held in position by galvanised steel gauge bars. Fastening systems that are fixed to steel gussets and stirrups which encircle the concrete beam hold the rail in place. The track modules are precast off site in lengths of 5.9 m and then assembled on site. Figure 1 shows the TMT structure at the test site. The test section was a 384 m long curve. The location of the test sites along the curve are indicated in Figure 2.

Three of the four rail pads assessed in the study were an Amorium rubber-bonded cork pad which will be referred to as the Portuguese pad, a Tiflex FC 55 rubber-bonded cork pad and a studded...
Hytrel pad supplied by Pandrol. The fourth pad tested was an HDPE pad. Results obtained for the HDPE pad served as a basis of comparison for the other pads assessed. Rail pads were supplied and installed in continuous lengths of 6 m. Figure 3 shows a length of studded Hytrel pad.

Deflection measurements were taken using a technique relatively new in the field of in-service railway deflection monitoring. The technique is known as Remote Video Monitoring (RVM). The RVM technique is based on that of Particle Image Velocimetry (PIV). PIV is an optical deflection measurement device which can be applied in both field and laboratory investigations of track deflection. The RVM system makes use of a high-definition video camera which captures images of the movement of a target applied to the track component under study. The video is then analysed using software which calculates the vertical and horizontal displacement of the target. RVM measurements are sensitive to sudden changes in lighting, such as shadows caused by the passing of trains. To ensure the quality of data collected using the RVM technique, a shading technique was developed at the University of Pretoria. The technique took the form of a simple PVC cover as shown in Figure 4.

A further performance aspect which was assessed as part of the study was the vibration attenuation of the rail pads. The attenuation was determined by placing accelerometers on the concrete beam of the TMT module and on the rail, as can be seen in Figure 5. The difference in the acceleration of the concrete beam and that of the rail is the vibration attenuation capability of the rail pad. Figure 6 shows the complete instrumentation setup on site.

RESULTS
Rail pad deflection was determined by subtracting the relative deflection of the concrete module from that of the rail. Figure 7 shows a plot of deflection (mm) against time (s) for the TMT rail and beam, while Figure 8 shows the deflection of the Portuguese pad. Similarly, acceleration data was used to determine the vibration attenuation capabilities of each pad. Figure 9 shows a plot of acceleration data obtained from testing. Results for each of the pads tested are summarised in Table 1 (see page 22).

CONCLUSIONS
From the assessment of the data collected during the field experimentation, the following conclusions were drawn:

■ Of the pads investigated, the Portuguese pad and the Tiflex pad had similar vibration attenuation and deflection characteristics. The mean deflection of these two pads falls between that of HDPE and the studded

Hytrel pad. When compared to HDPE, these results could be expected, as the Portuguese and Tiflex pads are less stiff than the HDPE pad.

■ The increased deflection value of the studded Hytrel pad, in comparison to the rubber-bonded cork pads, could be contributed to the surface profile of the pad. The studded profile is such that a stud on one side of the pad does not line
up with a stud on the opposite side of the pad, allowing for increased deflection.

- Vibration attenuation capabilities of the Hytrel pad are the highest of all the pads tested.
- The improved performance of the Hytrel pad is partly due to its surface profile, but also to the inherent stiffness and damping properties of the Hytrel material.

RECOMMENDATIONS

Recommendations from the study are as follows:

- Whilst both the Tiflex and Portuguese pads provided relatively low vibration attenuation, their continued use needs to be investigated to determine their effect on track deterioration. Their continued use on Tubular Modular Track cannot be endorsed or discouraged.
- The studded Hytrel pad appears to give improved performance when compared to the other pads tested and its use in Tubular Modular Track is recommended.
- Further research into the durability of all the pads investigated is recommended. The most cost-effective pad can only be selected when deterioration rates of the pads are known. Continuous replacement of a more cost-effective pad cannot be justified when an increased investment can result in a pad that not only has improved performance, but also extended service life. A detailed cost analysis is recommended.

ACKNOWLEDGEMENTS

The following organisations are gratefully acknowledged for contributing towards this research:

- Tubular Modular Track for site arrangements and assistance.
- PRASA Metrorail for access to the site and the opportunity to carry out the research.
- Transnet Freight Rail (Track Technology) for advice and collaborating with the University of Pretoria.
- Jaco Vorster (UP) for the instrumentation and field work.

<table>
<thead>
<tr>
<th>Pad</th>
<th>Average deflection (mm)</th>
<th>Average vibration (g)</th>
<th>Vibration attenuation (%)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Rail</td>
<td>Beam</td>
<td>Pad</td>
</tr>
<tr>
<td>Portuguese pad</td>
<td>0.506</td>
<td>0.391</td>
<td>0.114</td>
</tr>
<tr>
<td>Tiflex pad</td>
<td>0.733</td>
<td>0.625</td>
<td>0.108</td>
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<tr>
<td>Hytrel pad</td>
<td>0.641</td>
<td>0.476</td>
<td>0.165</td>
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<tr>
<td>HDPE pad</td>
<td>0.567</td>
<td>0.657</td>
<td>0.090</td>
</tr>
</tbody>
</table>
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Gautrain helps to improve mobility and provides the backbone of a more integrated transport system for the People of Gauteng, for People on the Move.
Gautrain in a nutshell
- train system, fares and ticketing

TRAIN SYSTEM
The Gautrain system has 24 train sets, each consisting of four cars. This is equivalent to 96 rail cars designed to run at an operational speed of 160 km per hour. Of the 96 rail cars, ten are specifically customised for use on the airport link, and contain additional features such as extra luggage space and wider seats. The other 86 rail cars are designed for commuter service.

While the standard train set comprises four rail cars, the configuration can be varied to ensure flexibility of service. To increase capacity after the initial period, an increasing number of train sets will be operated as eight-car train sets, comprising two four-car units coupled together. The train sets serving the airport link are made up of four-car sets, with the two front cars of the set being the customised airport cars.

Comfort
- Trains ride on air suspension to ensure smooth travel at 160 km per hour.
- Each car has two electrically operated sliding plug doors on each side, and two roof-mounted units, providing heating, ventilation and air-conditioning (HVAC).
- Each four-car commuter train set can comfortably carry up to 321 seated passengers.
- Attractive upholstery adds to the comfort — soft, woven cloth that is durable and easy to clean. Upholstery and carpets were custom-designed for Gautrain.
- On-level boarding, which is a standard feature of underground railways worldwide, is also the norm on Gautrain.
Matching the height and minimising the horizontal gap between Gautrain’s rail car floor and the platform allows easy access for children, mobility-impaired commuters, shoppers with heavy bags and the elderly – no ‘mind the gap’ on Gautrain.

■ Each train set has a section allocated for wheelchairs. The entire Gautrain system also accommodates mobility-, sight- and hearing-impaired passengers.
■ Cleaning personnel, as well as an automatic train washing plant, ensure that trains are kept clean inside and outside.

Real-time passenger information
■ Gautrain is fitted with a fully integrated audio and visual passenger information system (PIS).
■ External visual information consists of a destination display using ultra-bright yellow LEDs fitted to the front of the train.
■ Inside the train, each rail car is fitted with two high-resolution display units which provide information regarding the train’s destination, updates on its progress along the route, and notifications as stations are approached.
■ In the event of delays, train drivers and conductors are able to broadcast announcements using the train’s public address system.

Safety and security
■ Tight security on trains and stations is maintained through access control and electronic surveillance, with over 650 closed-circuit television (CCTV) cameras and visible policing.
■ Two CCTV cameras per car record to an on-board DVD system. While images are stored locally they may also be viewed on the intelligent display unit (IDU) in the driver’s cab.
■ The audio system supports two-way passenger emergency communication between alarm units in the passenger areas and the driver in the active cab.
■ In the event of an accident, security threat, power failure or other emergency, alarm systems will register at the operational control centre located in the maintenance depot for the immediate dispatching of the necessary safety, repair and emergency services. There is direct communication with all the relevant authorities, such as the South African Police Services and the Gauteng Provincial Disaster Management Centre.
■ Gautrain’s state-of-the-art design incorporates crash-and-crushes worthiness, and is fully compliant with modern safety requirements.
■ Customised to meet local conditions, such as steep gradients of 4% (compared with typically 1.5% on the lines Electrostar cars currently operate in the UK), a relatively harsh operational environment and potentially high passenger loads, the Electrostar rail cars feature enhanced propulsion with motorisation of 75% of all axles.

Train control
■ Trains are stabled overnight at the maintenance depot.
■ Central control of the system is managed from the operational control centre situated at the depot, and is provided by the EBI screen centralised traffic control system.
■ Relying on integrated computer systems, the operational control centre monitors the continuous supply of power throughout the Gautrain network.
■ A fully computerised rail signalling system is managed from the operational control centre. Efficient signalling prevents train-to-train collisions, ensures safe movements at switches and crossings, and maintains safe train headways.
■ The automatic train protection (ATP) system monitors the top speed limit of...
160 km per hour, as well as every lesser speed limitation, which is pre-set for every section of track. Should the driver exceed the posted speed limit at any point by more than three km per hour, an alarm will sound in his cab. At more than six km per hour above the posted speed limit the train’s service brakes will be automatically applied to slow the train to below the posted speed limit. The system also has the ability to bring a train safely to a stop in the unlikely event that a driver is incapacitated.

Functional and technical performance measuring is carried out on an ongoing basis. This includes:

**Ride comfort**: includes vertical and lateral accelerations and jerks; interior noise, vibration and harshness; vehicle heating, ventilation and air quality; pressure pulses; and passenger amenities such as information systems.

**Journey time**: includes traction and braking performance, and an over-speed test to at least 170 km/h.

**Environmental compliance**: refers to emitted noise limits, vibration, pressure gradient limits and ambient conditions to ensure passenger comfort, amongst others.

**Operation plan stability**: includes normal peak-day timetable operation, recovery from an operational delay, abnormal operating conditions, recovery from fault conditions, degraded modes of operation, and single-line operation over any section of route.

**Reliability, availability, maintainability and safety (RAMS)**: equipment and systems testing to demonstrate:
- **MTTR** (mean time to repair)
- **MTBF** (mean time between failure)
- **Failure mode** (predictability)
- **Degraded mode** (to determine the behaviour of the system in the event of the failure of one or more sub-systems)
- **Maintenance plan** (based on the performance and reasonably expected failures to optimise the availability of a system)
- **Safety** (addressed in a detailed risk assessment and hazard analysis designed to identify all possible risks and to implement mitigation measures to reduce the risk to acceptable levels in accordance with international practice, rail safety and the Rail Safety Regulator (RSR)).

**Energy requirements**
- The main propulsion substation (MPS) located within the depot is fed from two independent Eskom 88 kV feeders. Each Eskom feeder in turn supplies two separate Gautrain transformers.
- Each of the four Gautrain transformers has sufficient capacity to power the train propulsion system, thus achieving a high level of redundancy and hence assurance of electrical power availability.
- As the car bodies are fabricated mainly from aluminium alloy they have a relatively low mass and are therefore more energy efficient than South Africa’s present rolling stock.
- Automatically applied regenerative braking will in the majority of instances be more than sufficient to brake the train without the need to also apply its efficient disc-braking system. This will also contribute to reduced energy consumption.

---

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FARES AND TICKETING

The automatic fare collection (AFC) system is designed to serve the Gautrain in the following respects:

■ It provides convenient access for all to railway-, feeder bus- and parking services.
■ It facilitates revenue collection by means of the fare media.
■ It protects revenue by means of its security resources.
■ It promotes the use of public transport over car use through discounted fares for park-and-ride customers.
■ It facilitates control of business performance through product management and management information reporting.
■ It provides many opportunities for expanding, extending and developing the business, including the support of a variety of alternatives for inter-operability with other transit systems.

Special consideration has been given to the needs of people with disabilities, to minimise queues and to make ticket purchasing and car parking access and payment as simple as possible. Wide entry gates were provided at all stations for use by anybody requiring extra space such as wheelchair users, those with baggage and adults accompanied by small children in pushchairs or buggies.

Fare media

The fare collection system is based on a state-of-the-art contactless smart-card (CSC) system which enables customers to load a variety of different journey products, ranging from single trips to monthly tickets, onto the same credit-card-sized card and to re-use the same card again and again without having to buy a new ticket for each journey.

The CSC is a contactless means of payment using a smart chip and radio frequency identification (RFID) that will enable customers to simply hold their card near a Gautrain card reader (located at all entrances and exists to stations and parking areas, and on the buses) in order for the system to register their journey.

The CSC system will allow seamless transfers between Gautrain’s bus, train...
and parking services. Customers using more than one service within a single journey enjoy a reduced fare.

Customers are able to register their cards with the Gautrain operator, who will enable immediate blacklisting of the card should it be lost or stolen. Any unutilised value on the lost card can then be transferred to a new card.

CSCs are available from all ticket offices and ticket vending machines at Gautrain stations, as well as from selected off-site retailers. Payment for products is possible using coins, cash, debit card, credit card and by direct debit from a bank account, either manually or automatically by prior agreement.

Cash is accepted on buses or at the fare gates.

Integration with other transit systems
The contactless smart card is capable of being modified to carry the ticketing products of other transit systems, and stored value could be made valid on such systems subject to commercial agreement and adequate security provisions.

Part of current proposals undergoing refinement for future implementation is the intention to port or emulate the contactless smart card functionality onto the bank cards of the four clearing banks. This will alleviate the need for clients to have a contactless smart card if they have suitable bank cards, thereby improving accessibility. The bank cards may also facilitate inter-operability with other transit systems, for example by sharing the purse facility which could be developed into a full-blown electronic purse.

Security resources
The AFC system automatically generates auditable transaction data, as well as management reports, and secures revenue by access control, fare media security and system-wide security techniques:

■ Access control takes the form of physical, automatic barriers at stations and car parks and, on feeder buses, validation devices which give out audible warnings to bus drivers. CSCs (or products on them) may be blacklisted to prevent their use.

■ In addition to blacklisting, the CSCs use a variety of electronic access controls, data encryption and error-correcting technologies. Contactless media incorporate mechanisms to prevent incomplete transactions from being recorded as if they had been completed (known as anti-tear).

■ System-wide security techniques enable devices system-wide to recognise one another (by mutual authentication). Transactions are associated with the date, time and the machine that created them. For manned machines, the identity of the operator is also traceable.

Fare levels
Gautrain has a balanced approach in its fare policy aimed at making the service attractive and affordable to broad sectors of the population. In principle, Gautrain fares will be lower than the cost of using a private car for the same journey, but more expensive than those of existing taxi and PRASA rail fares. Fare levels were set just before the opening of the system and will be adjusted periodically.

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Severe coastal erosion caused by storm damage is an ecological and economic crisis and the destruction of private property along large expanses of South African coastline carries a heavy emotional and financial cost.

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Transnet's Postmasburg Link Line

THE NEW 32 KM Postmasburg link line enables the expansion of iron ore supply from the Northern Cape areas, and forms part of Transnet's commitment to the expansion of rail and port capacity along the 861 km Sishen-Saldanha iron ore export corridor. The Postmasburg link line, which serves the new Sishen South mine, is the first new line of this length to be completed by Transnet in 32 years.

The construction of the line forms part of Phase 1C of the Sishen-Saldanha corridor expansion programme. The construction included 948 000 m³ of earthworks; road-over-rail bridges; 2 816 metres of culverts/pipes; the laying of 50 550 concrete sleepers, 120 000 tons of ballast and 4 000 tons of rail; and the erection of 670 overhead track equipment masts, with 32 km of catenary and earth wire.

A significant milestone was achieved in the month of November 2011 when the first 114-wagon train travelled on the newly established line. Construction of the line started in May 2010 and was completed in November of the following year. Other components that formed part of the rail capacity expansion programme included an increase in rolling stock (wagons and locomotives), upgrading of railway electrical infrastructure, construction of additional train-passing loops, and the introduction into service of longer trains (342 wagons at 100 tons/wagon payload).

The successful completion of the Postmasburg link line means that 9 million tons per annum of the total 60 mtpa (million tons per annum) expansion will be transported along the new line.

The original, single-track Sishen-Saldanha line was opened in 1976 for heavy iron ore trains. Since then a number of expansions have taken place, with the most recently completed expansion taking the line capacity to 60 mtpa.

The completed phases have resulted in an additional 1.5 km being added to each of the existing crossing loops. The new infrastructure will accommodate additional locomotives deployed at various positions within the train sets, controlled through radio distributed power technology, hauling up to 342 wagons. These are the longest operational trains in the world. Each train can now consist of an additional 126 wagons, which, at 100 tons per wagon, has increased the capacity by 12 600 tons per trip.

A joint venture by Hatch, Mott MacDonald and Goba (HMG) managed the construction of the project.

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TRANSNET’S R10 BILLION Port of Ngqura is South Africa’s first new port built in over 25 years. The historic port north of Port Elizabeth has a strategic geographic position protecting it from the prevailing southwesterly winds. It has an advantage over other South African ports in that it is a deep-water port, with a depth of between 16 and 18 metres, allowing it to accommodate the new-generation container vessels.

A Transnet Capital Projects team was mandated to carry out the construction of this notable transshipment hub. The establishment of the port commenced in 2006 with the completion of the feasibility study. In November 2006 Transnet approved the project budget, and a momentous milestone was achieved when the site was decided upon and approved in January 2007.

Transnet’s plan with the construction of the port has been to establish a world-class transshipment hub with world-class equipment that would enable the port to perform to the highest international standards. Various milestones have been recorded since the creation of the Eastern Cape’s pride. In 2007, the first concrete was poured and the process was completed in July 2008. Container-handling equipment for the port was delivered in 2008, including ship-to-shore cranes and rubber-tyred gantries.

The port boasts a South African Institution of Civil Engineering (SAICE) award received in 2010, which recognised the engineering excellence applied in the construction of the port. Positive feedback has also been received from international shipping lines, as well as from the business community in the Eastern Cape region. In 2009, MSC Catania made history by becoming the first commercial vessel to discharge its cargo at South Africa’s new deep-water Port of Ngqura.

The second commercial vessel to call at Ngqura was the 275 metre MSC Shanghai with a draught of 14.5 metres. The vessel entered the port on Tuesday 6 October 2009 to discharge cargo at Ngqura’s container terminal. This was the first time a large vessel was able to call at Port Elizabeth, as it could take advantage of the Port of Ngqura’s deep-water capacity – an entrance channel depth of 18 metres and a basin depth of 16 metres. The MSC Shanghai off-loaded 50 containers and loaded 101 containers, with an average of 17 containers being handled per hour.

The Ngqura Container Terminal was officially opened by President Jacob Zuma, who hailed the port as a key strategic infrastructure project for South Africa.

INFO

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The container terminal at the Port of Ngqura went live for commercial operations in October 2009.
Our quality fly ash enhances the durability of concrete even in the harshest marine conditions. Extending the lifespan of concrete ensures longer protection and reduced maintenance for coastal infrastructure.
Floating breakwater system to save mangroves at the Port of Richards Bay

INTRODUCTION
The construction of Berth 208, a new additional bulk liquid berth, in the Port of Richards Bay, has been completed. This berth shares a border with the eChwebeni Natural Heritage Site (NHS), which is part of an original mangrove site that existed prior to the development of the port. The environmental impact assessment (EIA) for Berth 208 identified potential impacts in respect of this site, with specific concern for the expected increased shoreline erosion due to greater ship movement. The record of decision (RoD) recommended that a solution be found to address the ongoing erosion between the existing Berth 209 (and the newly commissioned adjacent Berth 208) and Spinach Point.

The floating breakwater system (or floating pontoons) option was preferred from an environmental perspective. As noted above, the mangroves (woody plants that grow at the interface between land and sea in sheltered and lagoon waters at tropical and sub-tropical latitudes) in the natural heritage site represent part of an original mangrove stand which existed prior to the development of the port. The area is thus particularly worthy of conservation, and its designation by Transnet SOC Limited, under authority of the Transnet National Ports Authority (TNPA), underscores the conservation significance of the site.

Three species of mangrove trees occur in the NHS, namely the white mangrove (*Avicennia marina*), the black mangrove (*Bruguiera gymnorrhiza*) and the red mangrove (*Rhizophora mucronata*). The eChwebeni NHS is one of the few areas in the country where all three species co-exist.

eCHWEBENI NATURAL HERITAGE SITE SHORELINE EROSION
The study identified two major impacts, namely the erosion of the shoreline, and paradoxically, the deposition of sand by high tidal waters immediately landward of the eroded zone along the shoreline. The erosion of the shoreline has resulted in the loss of white mangrove, which is a primary coloniser of the NHS ecotonal habitat.

The sand deposited by high tidal waters onto the mangrove shelf of the eChwebeni NHS forms a levee that interferes with drainage from the land to the harbour, thus reducing the tidal interchange, causing the death of mangroves and a change in the composition of the vegetation cover at the site. All the channels that allow tidal interchange are threatened by sediment deposition, and some are completely blocked.

The cause of the problem is the wake wave generated by the movement of vessels in and out of the harbour close to the site. Tugboat waves are considered to be the most significant in terms of erosive potential.

Any solution sought must be aimed at preventing or reducing the generation of wake waves, either through restricting the speed of the tugboats or through a floating breakwater system. The latter was preferred when both technical and environmental performance criteria were considered.

DESCRIPTION OF THE FLOATING BREAKWATER SYSTEM
For the design of the pontoons the CSIR (Council for Scientific and Industrial Research) captured true data from the site, which was used to build a model to test the design criteria. This model test confirmed the effectiveness of the floating breakwater system.
The pontoons are placed away from the shoreline in open water, and since the pontoons float, water flow will not be obstructed. A total of 44 concrete pontoons, each weighing approximately 63 tons and being 15 m long x 5 m wide x 1.5 m deep, were precast and lifted onto the water and moored into position. The pontoons are coupled together with specialised connectors and then moored to the seabed. The pontoons will eventually extend over a distance of approximately 700 m from the existing walkway of Berth 208 to Spinach Point. They act as a floating wave-attenuating structure.

The floating breakwater system and the mooring system were designed by WSP (Pty) Ltd and Seafl ex (a Swedish supplier of the Seafl ex mooring system) respectively.

ENVIRONMENTAL PERFORMANCE OF THE FLOATING BREAKWATER SYSTEM

The floating breakwater system is designed to achieve 70–80% wave reduction efficiency. Three environmental performance criteria were assessed, and the conclusions were as follows:

- The floating breakwater system (pontoons) allows sufficient tidal exchange between the mangroves and open port waters.
- The system allows faunal migration between mangroves and open tidal waters.
- As the floating pontoons are in open water away from the shoreline, they do not obstruct water flow, while the helix anchors on the seabed create artificial habitat likely to be used by invertebrates and fish. Similarly, the submerged sections of the pontoons will create artificial habitat likely to be colonised by invertebrates and fish. The floating pontoons could also become a significant roost area for birds.

TOTAL COST OF THE PROJECT

A budget of R50 million was allocated to the project, which is expected to take a year to complete. Stefanutti Stocks (Pty) Ltd is the main contractor for the construction of the floating breakwater system (floating pontoons).

TRANSNET ENVIRONMENTAL GOVERNANCE FRAMEWORK

As with all projects within Transnet Capital Projects, the project is governed by strict environmental controls. The following documents have been developed to ensure that the project is implemented in an environmentally sound manner and in line with the NEMA (National Environmental Management Act) principles for sustainable development. These documents include the following:

- TCP Construction Environmental Management Plan, which sets out roles and responsibilities for environmental management for the employer and the contractor.
- TCP Standard Environmental Specifications, which outline the minimum environmental standards for projects under implementation or in the construction phase.
- TCP Project Environmental Specifications, of which the following documents form a part: (1) Berth 208 Phase 1 – Environmental Authorisation and Associated EMP, (2) TNPA EMP, and (3) the eChwebeni NHS EMP.

As per recommendation, Transnet Capital Projects has appointed an Environmental Control Officer to monitor compliance in respect of all of the above. The construction works will adhere to the eChwebeni NHS Environmental Management Plan aimed at the preservation of this natural heritage site.

CONCLUSION

From the environmental perspective the floating breakwater system is considered the best overall solution. This project clearly demonstrates Transnet SOC Limited’s commitment to ensure that environmentally responsible and innovative solutions are found to potential impacts that its operations and infrastructure investments might have on the environment.

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Gorgon Project, Australia - an overview

PIONEER MATERIALS OFFLOADING FACILITY

In June 2009 Murray & Roberts Marine was awarded the contract for the design and construction of the Pioneer Materials Offloading Facility (PMOF) which forms part of the initial works to facilitate the offloading of plant and equipment for the construction of the LNG plant.

The PMOF includes seven berthing and mooring dolphins, abutment structures comprising a Ro-Ro berth, a modular carrier berth, a barge berth and miscellaneous navigation aids and small-craft landings.

The mooring and berthing dolphins are piled steel structures equipped with mooring bollards and parallel motion fenders. The dolphins are designed to accommodate berthing and mooring on either side simultaneously.

Precast concrete caissons were used for the Ro-Ro and barge berths, with a cast in-situ capping slab.

A combination of steel tubular and sheet-pile piles, or ‘combi wall’, was used for the modular carrier berth, as the in-front water depth was greater than in front of the other abutment structures. A cast in-situ concrete slab was used as the capping for the berth.

The PMOF was constructed on a reclaimed island about one kilometre from the shore. The reclaimed island is at the end of a causeway which forms part of the four kilometre LNG jetty.

ENGINEERING

The design of the PMOF had to take into consideration not only the effects of

The Gorgon Project, currently in its third year of construction, is one of the world's largest natural gas projects and the largest single-resource natural gas project in Australia's history. The project will develop the Gorgon and Jansz gas fields, located within the greater Gorgon area, about 130 kilometres off the northwest coast of Western Australia. The gas will be processed in a 15 million tonne per annum liquefied natural gas (LNG) plant currently being constructed on Barrow Island. Barrow Island, a Class A nature reserve, is located 80 kilometres off the coast of Western Australia, and about 1 200 kilometres north of Perth. The LNG will be offloaded onto LNG tankers, for transport to international markets, via a four kilometre long loading jetty. The domestic gas will be piped to the Western Australian mainland.
cyclones, but the remoteness of the site and the stringent quarantine requirements imposed to ensure that the pristine Class A nature reserve was not compromised.

Constructability played an important role in the development of the design to ensure ease of construction once on site. Much of the works were designed to be pre-constructed off-site in an attempt to reduce the programme and impact on site.

Local knowledge was a key factor in the design, and most of the permanent works engineering was carried out by specialist Australian consultants. Extensive physical modelling was carried out by the CSIR in Stellenbosch. The modelling had to determine the load effects of cyclonic waves on the abutment structures, as well as the extent of scour behind and in front of the caissons during a cyclone event.

The construction methodology and design of the temporary works were carried out in-house by the engineering department of Murray & Roberts Marine, in consultation with specialist consultants, with the objective of ensuring that an efficient and constructible design was achieved.

CONSTRUCTION

The seven structural steel dolphin jackets, each weighing 250 t, and associated pile frames, were fabricated in Batam, Indonesia. The jackets were fabricated complete with all fendering, bollards, walkways and electrical fittings. The pile frames were fabricated in pairs complete with bracing. A heavy-lift ship was used to transport and place the jackets in position. This proved challenging, as there was no proper berthing facility for the ship, which had to be stationed a few metres from the abutment structures in order to place the jackets in position.

A jack-up barge was used as a stable platform to drill the holes on site, into which the pile frames were socketed and grouted. Once all the pile frames had been grouted into position, the jackets were placed over them and the annulus between the jacket tubular member and the piles was grouted.

The 11 caissons, each weighing 450 t, were constructed in Henderson, south of Perth. Once completed, they were transported by heavy-lift trailer to a quayside where they were loaded onto a heavy-lift ship. Due to depth limitations, which prevented the heavy-lift ship from entering the PMOF area, the caissons were off-loaded about six kilometres offshore and...
towed to their position by tug. They were placed in their final position on a previously prepared stone foundation, using a floating crane. A concrete capping slab, using pre-assembled reinforcement cages, was then cast in-situ.

The module carrier berth was constructed using a ‘combi wall’ of steel tubular piles and sheet piles alternating. A purpose-built piling frame was designed and built to facilitate the drilling of the pile holes into which the tubular piles were grouted. Sheet piles were then driven between the tubular piles. A deck slab was constructed from reinforced concrete supported on internal piles, which were socketed into the rock.

**CYCLONES**

As Barrow Island falls within the cyclone zone of Western Australia, construction planning had to take into consideration demobilisation activities during cyclone season. Since mobilisation to site in January 2011, the site has had to demobilise 16 times due to cyclone events. The demobilisation includes removing all marine craft to the sheltered anchorage at Dampier and securing all plant, equipment and offices. Although the accommodation on the island is designed to withstand cyclone events, most personnel are evacuated with only essential personnel remaining.

**QUARANTINE AND LOGISTICS**

Barrow Island was last connected to the mainland some 8 000 years ago, and during those years of isolation a collection of unique fauna and flora has evolved, earning it its status as a Class A nature reserve. Access to the island
is severely restricted and all people, plant, equipment, supplies and materials heading there must go through a stringent quarantine inspection process. This includes inspecting and cleaning of all marine vessel hulls.

All the plant, equipment, materials and supplies (with the exception of the heavy lift ship cargo) for the PMOF were brought to site by supply barge from a supply base in Dampier, about 120 kilometres away on mainland Australia.

Precise planning was essential to ensure deliveries arrived on site timeously. This proved to be a challenge, as anything needed urgently on site would take at least ten days to get there.

At the commencement of the PMOF works there were other marine activities, such as dredging and revetment construction, under way, with a number of large marine construction craft in a very small area. Daily marine ‘simops’ (simultaneous operations) meetings had to be held to ensure the smooth running of the operations.

**PROJECT FINALISATION**

At the time of writing this article the majority of the works had been completed, with a portion of the module carrier berth capping slab still to be cast.

The construction of the PMOF, although relatively straightforward, was a challenging and unusual project due to its remoteness, cyclones and stringent quarantine requirements. The facility was also built to oil and gas industry standards, requiring quality measures not normally associated with a facility of this nature.

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Some thoughts on the economics of dry docks

**PREAMBLE**

The following comments are a distillation of forty years of experience with dry docks and the technology of dry docks. As such they are pragmatic and much of the basis has been developed as part of feasibility studies or the development of actual projects. Some aspects have been included in refereed papers and are hence persuasive, but a word of caution: these comments have not yet been formally examined in a scientific way. The most significant aspect I foresee comes from the relatively simplistic presentation given here. In practice there may well be a great deal of variation from individual case to individual case.

**ECONOMIC BASIS OF DRY DOCKING**

The economics of dry docks are somewhat peculiar. As a rule of thumb, ship owners will accept a docking fee that does not exceed 10% of the overall cost of the work done during the docking without complaining. Generally, ships are mobile and their owners will begin to think of going to other ports if the charges rise too high. Where the site is relatively isolated, the dock can get away with somewhat higher charges before resistance sets in. Docking charges at this 10% level are generally sufficient to cover operating costs and running maintenance. But it is completely inadequate to cover the amortisation of the capital cost. Again, as a rule, dock costs are scale dependent, i.e. both the capital cost and the operating and maintenance costs, expressed as cost per ton of capacity, are least for large docks and greatest for small docks.

Ship repairers can afford to acquire their own docks. If they own the dock, they not only control their business, they control the whole of the monies spent on ship repair during docking and the profit on these monies. They can afford to plough back a significant portion of their profit in amortising the dock. Not only does the money stay in the business as capital asset, the tax benefits of the write-off of this investment create a gearing effect that increases the apparent amount of money invested. This does mean that the valuation of a ship repair company, owning its own dry dock, is characterised by a very large single asset.

Alternatively a dry dock facility can be a ‘common user facility’ by which is meant a facility where anyone, boat owner, ship repairer or agent, can bring a ship to dock, and where anyone, the owner himself or any ship repairer or contractor duly appointed, can work on the vessel.

If a dry dock is unencumbered by any capital cost and is endowed to some extent to assist with occasional major maintenance costs, then it can operate as a viable, but not very profitable, common user facility. This unlikely scenario could

Although of a crude nature, a number of ‘rules of thumb’ characterise the economics of dry docks quite reliably. These economics are dominated by the pattern of ownership of the dock. Almost inevitably, either a dry docking facility is owned by a ship repairer who will have exclusive use of the dock or it is owned by the public sector and run as a common user facility. The economics of these two systems are quite different. Failure to understand these basics can cripple a proposal for a dry docking facility.
perhaps where a military dock, no longer needed, is donated to a community or to a training facility teaching ship repair and dry dock operation.

To any fleet, whether it be shipping, fishing, undersea mining, oil exploration or any other function and the community it supports, a dry dock, however it is owned, is a major communal asset. Not only does it make possible the economic activity of the fleet that sustains the community – ships cannot continue to operate without the back-up of dry docks and ship repair – it also provides ship repair as an added source of employment for the community.

Even if there is only one dry dock in a port and it is owned by the local ship repairer, unless the port is remote from any other ports with docking facilities, it will not constitute a monopoly with respect to shipping. However, with respect to employment in the dock and to the local community, it will.

If the public sector – whether it is local, regional or national – benefits from the tax revenues that flow from shipping and the associated ship repair, it has a duty to ensure that dry docking facilities are available as communal assets. In some cases, the ship repairer industry will be able to provide such facilities. Where this is possible, the public sector will be well advised to avoid becoming involved in the ownership of dry docks. Instead, as far as possible, they should cooperate with the ship repairers and assist them in acquiring their facilities. However, they must also ensure that there are a number of ship repairers, each with their own dry dock facilities, to avoid a monopoly situation. If the ship repairers do not provide the facilities, then it is up to the public sector to do so in the interests of the community.

The total annual tax revenues, both direct and indirect, generated from shipping and ship repair activities will far exceed the net annual liabilities of the dry docking facility.

A warning, however – the provision of a publicly owned common user dry dock leads to ‘riding a tiger’. Once a dock becomes a common user facility, it is difficult to revert to ship repairer ownership. The business models of the community, the fleet and particularly the ship repairers become completely oriented to this common user access to the facility of the dock. The sale of a public dock to a single ship repairer will lead to a catastrophic disruption of the local business environment. The economics of dry docks mean that the new owner has no option but to run it for his exclusive use. If it is the only dock in a port or a region, ship repair using that dock becomes a monopoly. The community and the fleet can only do business with the owner and the other ship repairers can only remain in business if they can find employment as sub-contractors to the owner.

The provision of competent management and operating staff is another problem for public docks. The shipping industry in general, ship repair in particular – at an artisan level, shipwrights – are well able to adapt to this function, but it does not lend itself to general administrative, commercial or non-maritime industrial capabilities. Hence, one finds that public docks are commonly operated by port authorities.

Two interesting case studies are the South African Commercial Ports and the South African Fishing Harbours.

South Africa has more dry docking capacity than any other southern hemisphere nation – almost as much as the rest put together. The large facilities in the commercial ports were all built between 1880 and 1945 at the behest of the Royal Navy as military facilities, and were joint ventures between them and the South African government. The assets and the operation were placed with the port authorities. At the time they operated as a service entity. The economics of dry docks did not enter the picture. The facilities were well run and maintained and charges were reasonable. Since then the port authority has been restructured and run as a commercial entity. Now the economics of the dry docks are relevant. Charges have increased, service and maintenance have decreased, and the port authority has not entertained any expansion of dry docking facilities. Currently they are looking for ways to privatise the facilities. Despite a major feasibility study, they have been unsuccessful to date.

The South African pelagic fishery came into existence explosively in the aftermath of the Second World War. Starting with relatively small purse-seiners with a relatively small range, the industry based itself at small harbours spread along the coast at, what at that time were remote, undeveloped sites. The capital requirements meant that the participants were large companies who were able to construct fish-processing factories at these sites and, initially, minimal harbour facilities, including slipways to service the boats. In the mid-1960s the state stepped in to build proper small harbours at these sites, including much more sophisticated slipways – a process that evolved the ‘Cape-type’ slipway. Once these common user facilities became available, the fishing companies allowed their own facilities to degenerate and soon abandoned them. The only private slipway still operating is owned by a ship repairer.

Given the comments above, there is no easy way to dispose of a public dock, even if there is a compelling reason to do so. Where, to avoid this, the asset is transferred to the port authority, more problems arise. The apparent value will inflate their asset register but, since the object is to provide a common user facility, there will be no concomitant return on investment, and this in turn will reflect on the authority’s balance sheet.

The only practical way around this is to keep all the financials, assets, costs and incomes in the public domain and acquire the use of the site by purchase or rent, as appropriate. Operation and management of the docks and provision of technical guidance on major maintenance or capital improvements can be provided on a contract basis with the port authority or any other competent entity. If, however, the scope and number of dry docking facilities justify it, a dedicated, competent public institution can be established to handle all these functions and still provide dry docking on a common user basis.

REFERENCES
Mackie, K.P. Small Mechanical Dry Docking Systems – Fifth International Conference on Coastal and Port Engineering in Developing Countries, Cape Town, 1999.
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A FEW YEARS AGO the committee of the SAICE Railway and Harbour Engineering Division decided to develop its own website with the aim of promoting railway and harbour engineering to engineers in industry and to the general public. At the same time, the website would provide an updated list of the Division’s members, and information regarding the Division’s annual activities, and would also reduce the administrative work related to annual events by, for example, automating delegates’ registration.

Presently the website, which is in a state of continuous construction and upgrading, provides the following information:

1. The annual events planned and implemented by the Division’s committee.
2. Conferences and events happening around the world, which are important for the development of railway and harbour engineering.
3. Papers and articles published not only by the Division’s members and local railway and harbour engineers, but that have also been published elsewhere around the world.
4. Interesting photographs of railway and harbour works and equipment in southern Africa and other countries, which contribute to the development of railway and harbour engineering.
5. Railway and harbour engineering standards available in South Africa, as well as standards from other countries. These are a source of information to engineers in particular, and the public in general. The list of standards is updated continually and shows only the title and number of the standard, the source and the scope of the particular standard. It is not the intention of the Division to have freely available to anybody the full text of each standard on its website. The purpose is only to inform about the existence of the various standards, indicating where it can be obtained and what the standard is all about.
6. Papers submitted to the Railway and Harbour symposia. These symposia have been organised by the Division since the early 2000s and take place every second year (the next one will be in October this year).
7. Links to the websites of various railway and port organisations in neighbouring countries where information of interest about railway and harbour engineering might be found, particularly in Namibia, Zimbabwe, Swaziland, Mozambique, Malawi, Angola, Tanzania and Kenya.

The website (http://saicerailwayandharbour.co.za) is organised in the following manner:

The home page is divided into five fields:

1. Header field, displaying two photos, one of a railway line turnout and the other of a harbour, flanked by the Division’s name, and the Institution’s and Division’s logos.
2. Below the logos, a row of buttons indicate the Home Page, the Photo Gallery, the Archive, Papers and Articles, Registration for Division Membership, FAQs (Frequent Asked Questions), Contact Us and News.
3. Next, on the right-hand side of the home page, one finds the activities planned by the Division for this year, notices of lectures and conferences, and notices of any new items that have been added to the website. On the left-hand side, a menu with the following items appears:
   - SAICE Constitution and Division Rules
   - Division’s membership list

4. The website is registered with Facebook, thereby encouraging discussions relevant to railway and harbour engineering. The Facebook logo appears on the home page.
5. At the bottom of the home page is a breakdown of how the Division is presently organised.

Information which has lost its actuality is not deleted but sent to the Archive, and can be accessed by clicking on the Archive button.

In order to ascertain the interest this website generates, a hit counter was enabled to register a new hit every time the website is visited.

The numbers of items that can be added to this website are many and various, but implementation is determined by the cost to maintain the website. It is the intention of the Division that the website should sustain itself financially.
A systems approach to the effective delivery of infrastructure

INTRODUCTION

Skills and systems are required to efficiently and effectively deliver infrastructure. Systems are underpinned by:

- **processes** – a succession of logically related actions occurring or performed in a definite manner which culminate in the completion of a major deliverable or the attainment of a milestone
- **procedures** – the formal steps to be taken in the performance of a specific task, which may be evoked in the course of a process
- **methods** – a documented, systematically-ordered collection of rules or approaches.

Systems need to be supported by policy, governance/management arrangements, and documentation which communicate what has been decided upon during the execution of a process or part thereof.

Systems, processes, procedures and methods can be standardised and documented for common and repeated use for the achievement of the optimum degree of order in a given context. This in turn provides a solid platform for effective skills development, as it permits staff to work in a uniform and generic manner, and

---

**Notes:**
1. The CPS can be applied almost anywhere within the IGS
2. The IDMS is structured around the IGS and CPS
training interventions to be developed to capacitate those engaged in the performance of various activities.

The CIDB (Construction Industry Development Board), in partnership with other organs of state, has since its inception in 2000 developed the following systems to support infrastructure delivery:

■ A construction procurement system (CPS), which enables contracts to be created, managed and fulfilled, relating to the provision of goods, services and engineering and construction works or disposals or any combination thereof.

■ An Infrastructure Gateway System (IGS), which provides a number of control points (gates) in the infrastructure delivery management process where a decision is required before proceeding from one stage to another.

■ The Infrastructure Delivery Management System (IDMS), which forms the backbone of the management of projects relating to the delivery and maintenance of infrastructure.

These three systems interact with one another as illustrated in Figure 1 and, if systematically and correctly applied, have the potential to improve the performance of public sector clients in the delivery and maintenance of infrastructure. This can make a major contribution to job creation and thereby to stimulating economic growth.

CONSTRUCTION PROCUREMENT SYSTEM (CPS)

Introduction

Procurement is the process which creates, manages and fulfils contracts. Procurement commences once a need for goods, services, engineering and construction works or disposals has been identified, and it ends when the goods are received, the services or engineering and construction works are completed or the asset is disposed of.

There are six basic activities associated with procurement processes, which establish actions and deliverables/milestones associated with the procurement process, as indicated in Figure 2. Procedures and methods used in conjunction with policies guiding the selection of options and the application thereof are required to implement these procurement processes. Procurement documents are needed to communicate to tenderers a procuring entity’s procedures and requirements up to the awarding of a contract, and to establish the basis for the contract that is entered into with the successful tenderer, i.e. the agreed
terms and conditions, the prices and the nature and quality of the goods, services or construction works that are required. Procurement processes and procedures need to be managed and controlled (see Figure 2). Accordingly, governance activities need to be linked to milestones in the procurement process. At the same time, policies are required to govern the usage and application of particular procurement procedures, requirements for recording, reporting and risk management, procedures for dealing with specific procurement related issues, assignment of responsibilities, etc.

Procurement processes are accordingly underpinned by methods and procedures and are informed and shaped by the policies of the procuring entity. A procurement system therefore comprises:

- rules and guidelines governing procedures and methods
- procurement documents which include terms and conditions, procedures and requirements
- governance arrangements to manage and control procurement
- organisational policies which deal with issues such as:
  - the usage and application of particular procurement procedures
  - requirements for recording, reporting and management of risk
  - procedures for dealing with specific procurement issues
  - the usage of procurement to promote social and developmental objectives
  - the assignment of responsibilities for the performance of activities associated with the various processes.

Aligning the CPS with legislation

Section 217 of the Constitution of the Republic of South Africa (Act 108 of 1996) establishes the primary and broad secondary procurement objectives in South Africa as follows:

Primary objective

Procurement system is to be fair, equitable, transparent, competitive and cost effective.

Secondary objective

Procurement policy may provide for:

a) categories of preference in the allocation of contracts; and
b) the protection or advancement of persons, or categories of persons, disadvantaged by unfair discrimination.

Procurement by organs of state (national and provincial departments, municipalities, constitutional entities and public entities) is also governed by the following pieces of legislation:

- Public Finance Management Act (Act 1 of 1999)
- Promotion of Administrative Justice Act (Act 3 of 2000)
- Preferential Procurement Policy Framework Act (Act 5 of 2000)
- Construction Industry Development Board Act (Act 38 of 2000)
- Broad-Based Black Economic Empowerment Act (Act 53 of 2003)
- Prevention and Combating of Corrupt Activities Act (Act 12 of 2004)

Section 76(4) of the Public Finance Management Act permits National Treasury to make regulations or issue instructions applicable to all institutions to which the Act applies, concerning the determination of a framework for an appropriate procurement and provisioning system which is fair, equitable, transparent, competitive and cost effective.

The procurement provisions of the Municipal Finance Management Act are similar, but contain more details regarding the system. Section 112 permits the Minister of Finance to issue a prescribed regulatory framework for supply chain management that covers a number of specific issues.

The Supply Chain Management Regulations issued in terms of the Public Finance Management Act and Municipal Finance Management Act establish requirements for the governance of procurement processes, and establish high-level government policy. Each organ of state has to determine its own procedures and policies which are consistent with the legislative framework.

The Construction Industry Development Board Act defines the construction industry as the broad conglomeration of industries and sectors which add value in the creation and maintenance of fixed assets within the built environment. According to construction procurement involves not only engineering and construction works contracts, but also:
supply contracts that involve the purchase of construction materials and equipment
■ service contracts relating to any aspect of construction, including professional services, and
■ the disposal of surplus materials and equipment and demolitions.

The CIDB has issued the following prescripts in terms of the Construction Industry Development Board Act which are applicable to all organs of state when procuring goods, services or works from the construction industry:
■ a CIDB Code of Conduct for the Parties engaged in Construction Procurement
■ a CIDB Standard for Uniformity in Construction Procurement (CIDB, 2004), which establishes minimum requirements for:
  ■ the solicitation of tender offers using standard conditions for the calling for expressions of interest and standard conditions of tender
  ■ the use of standard forms of contract
  ■ a range of standard procurement procedures and methods
  ■ the formatting and compilation of procurement documents
  ■ the application of the register of contractors to public sector contracts.

Best practice guidelines recognised by the Construction Industry Development Board.

Table 1: Typical contents of a document describing an organisation’s Construction Procurement System

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<td>4.2.5 Gratifications, hospitality and gifts</td>
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<td>4.2.6 Breaches</td>
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<td>4.2.7 Placing of contractors under restrictions</td>
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<td></td>
<td>4.3 Procurement activities, key actions, responsibilities and gates</td>
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<td></td>
<td>4.4 Roles and responsibilities in relation to the procurement processes, activities and controls</td>
<td>4.4.1 Documentation Review Team</td>
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<td>4.4.2 Evaluation Panels Construction</td>
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<td>4.4.3 Procurement Committee</td>
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<td>4.4.4 Disposal Committee</td>
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<td>4.4.5 Delegated Authority to award a contract or order</td>
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<td>4.4.6 Compliance monitoring and auditing</td>
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<td>4.5 Complaints and challenges</td>
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<td>4.6 Secondary procurement policy</td>
<td>4.6.1 General requirements</td>
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<td></td>
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<td>4.6.2 Permitted targeted procurement procedures</td>
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<td></td>
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<td>4.6.3 Broad Based Black Economic Empowerment</td>
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<td></td>
<td>4.7 Usage of standard procurement procedures</td>
<td>4.7.1 General requirements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.7.2 Framework agreements</td>
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<td></td>
<td></td>
<td>4.7.3 Lists of pre-approved contractors</td>
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<td></td>
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<td>4.7.4 Disposals</td>
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<td>4.7.5 Unsolicited proposals</td>
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<td>4.8 Procurement documents</td>
<td>4.8.1 General requirements</td>
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<td></td>
<td></td>
<td>4.8.2 Standard forms of contract</td>
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<td>4.8.3 Auction data</td>
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<td>4.8.4 Standardised documents</td>
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<td>4.8.5 Tender assessment schedules</td>
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<td>4.8.6 Guarantees</td>
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<td></td>
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<td>4.8.7 Retention</td>
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<td></td>
<td></td>
<td>4.8.8 Delay damages</td>
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<td></td>
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<td>4.8.9 Price escalation</td>
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<td></td>
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<td>4.8.10 Insurances</td>
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<tr>
<td></td>
<td></td>
<td>4.8.11 Communications</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.8.12 Intellectual property rights</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.8.13 Disputes arising during the performance of a contract</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.8.14 Quality standards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.8.15 Budgetary items</td>
</tr>
</tbody>
</table>
Board, including SANS 294 and SANS 1403, and practice notes and standardised procurement issued by the Board, enable the Standard for Uniformity in Construction Procurement to be implemented. These documents, together with the Standard for Uniformity in Construction Procurement, have now been incorporated into an eight-part series of international standards (ISO 10845).

An organisation’s construction procurement system can be put in place by capturing system requirements in a single document covering policies, processes, procedures and methods framed around the use of standards and standard forms of contract and the South African legislative framework. Such a document should deal with the topics and sub-topics outlined in Table 1.

**INFRASTRUCTURE GATEWAY SYSTEM (IGS)**

The CIDB Infrastructure Gateway System (IGS) provides a number of control points (gates) in projects relating to the delivery and maintenance of infrastructure where a decision is required before proceeding from one stage to another. Such decisions need to be based on information that is provided and if correctly executed, provides assurance that a project involving the delivery or maintenance of infrastructure remains within agreed mandates, aligns with the purpose for which it was conceived and can progress successfully from one stage to the next. The CIDB IGS is based on the information flow as set out in Table 2.

### Table 1: Typical contents of a document describing an organisation’s Construction Procurement System (continued)

<table>
<thead>
<tr>
<th>Gate No</th>
<th>Information (deliverable) provided for a decision to be made at a gate / conclude a stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.9</td>
<td>Calls for expressions of interest and invitations to submit tender offers</td>
</tr>
<tr>
<td>4.9.1</td>
<td>General requirements</td>
</tr>
<tr>
<td>4.9.2</td>
<td>Advertising</td>
</tr>
<tr>
<td>4.9.3</td>
<td>Issuing of procurement documents</td>
</tr>
<tr>
<td>4.9.4</td>
<td>Clarification meetings and issuing of addenda</td>
</tr>
<tr>
<td>4.9.5</td>
<td>Receipt and safeguarding of submissions</td>
</tr>
<tr>
<td>4.9.6</td>
<td>Opening of submissions</td>
</tr>
<tr>
<td>4.9.7</td>
<td>Evaluation of submissions</td>
</tr>
<tr>
<td>4.9.8</td>
<td>Notice to unsuccessful tenderers and respondents</td>
</tr>
<tr>
<td>4.9.9</td>
<td>Debriefing of respondents and tenderers</td>
</tr>
<tr>
<td>4.9.10</td>
<td>Written reasons for actions taken</td>
</tr>
<tr>
<td>4.9.11</td>
<td>Request for access to information</td>
</tr>
<tr>
<td>4.10</td>
<td>Award of contracts</td>
</tr>
<tr>
<td>4.10.1</td>
<td>General requirements</td>
</tr>
<tr>
<td>4.10.2</td>
<td>Vendor registrations</td>
</tr>
<tr>
<td>4.11</td>
<td>Administration of contracts</td>
</tr>
<tr>
<td>4.11.1</td>
<td>General requirements</td>
</tr>
<tr>
<td>4.11.2</td>
<td>Records and reporting</td>
</tr>
<tr>
<td>4.11.3</td>
<td>Authorised increase in the final contract amount</td>
</tr>
<tr>
<td>4.11.4</td>
<td>Invoicing</td>
</tr>
<tr>
<td>4.12</td>
<td>Occupational health and safety</td>
</tr>
<tr>
<td>4.13</td>
<td>Departures from procedures</td>
</tr>
</tbody>
</table>

### Table 2: Gates, stages and end of stage deliverables in the Infrastructure Gateway System

<table>
<thead>
<tr>
<th>Gate No</th>
<th>Information (deliverable) provided for a decision to be made at a gate / conclude a stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Infrastructure plan which identifies long-term needs and links prioritised needs to a forecasted budget for the next few years</td>
</tr>
<tr>
<td>2</td>
<td>Construction procurement strategy for implementing the infrastructure plan in the medium term</td>
</tr>
<tr>
<td>3</td>
<td>Strategic brief setting out the package information for a package</td>
</tr>
<tr>
<td>4</td>
<td>Concept report setting out the integrated concept for the package</td>
</tr>
<tr>
<td>5</td>
<td>Design development report setting out the integrated developed design for the package*</td>
</tr>
<tr>
<td>6A</td>
<td>Production information which enables construction or the production of manufacturing and installation*</td>
</tr>
<tr>
<td>6B</td>
<td>Manufacture, fabrication and construction information for construction*</td>
</tr>
<tr>
<td>7</td>
<td>Works completed in accordance with requirements</td>
</tr>
<tr>
<td>8</td>
<td>Works handed over to user complete with record information</td>
</tr>
<tr>
<td>9A</td>
<td>Updated asset register</td>
</tr>
<tr>
<td>9B</td>
<td>Completed contract or package order</td>
</tr>
</tbody>
</table>

*Stages 5 and 6 are not needed in the maintenance of infrastructure*
The CIDB IGS permits the undertaking of groups of activities in parallel or series, and results at the end of each stage in a predetermined deliverable (a tangible, verifiable work product) and a structured decision point, which enables decisions to be made to determine if the project should continue to its next stage with or without any adjustments between what was planned and what is to be delivered.

The CIDB has developed a Standard for the Delivery and Maintenance of Infrastructure using a Gateway System which establishes the work flow associated with the system and enables responsibilities to be allocated.

A key innovation in the CIDB IGS is the introduction of the procurement planning stage which requires that a construction procurement strategy be developed for the implementation of an infrastructure plan at a portfolio level (see Figure 3).

Strategy in the delivery and maintenance of construction works may be considered to be the skilful planning and managing of the delivery process. It involves a carefully devised plan of action which needs to be implemented. It is all about taking appropriate decisions in relation to available options and prevailing circumstances in order to achieve optimal outcomes.

Construction procurement strategy is the combination of the delivery management strategy (decisions relating to the meeting of needs through a Public Private Partnership, an implementing agent, another organ of state’s framework agreement, outsourcing or own resources and the packaging of projects), contracting arrangements and procurement arrangements for a particular procurement. An outcome of this process is the identification of packages (works to be delivered under a single construction works contract or a package order issued in terms of a framework agreement) and contracts for professional services.

Such strategies:
- can significantly reduce the number of contractual relationships that an organisation needs to enter into to manageable levels, commensurate with their staff compliment, without compromising empowerment objectives while introducing efficiencies in the delivery process
- enable long-term collaborative relationships to be entered into which can:
  - lead to efficiencies and improvements over time in terms of project costs, time for delivery, quality of construction, health and safety performance, environmental performance and key performance indicators (KPIs) relating to broad based black economic empowerment, contractor development, job creation and poverty alleviation
  - provide flexible construction capacity to undertake projects over a term which ensures that allocated budgets for a programme of works are spent
  - enable early contractor involvement to integrate projects in order to achieve higher value and less waste
  - facilitate a higher degree of project integration, innovation and value-based contractual arrangements that reward performance through non-adversarial collaborative relationships.

The CIDB, in collaboration with National Treasury, has developed Practice Guide No 2, Construction Procurement Strategy, as part of the IDM Toolkit. This guide provides a step by step procedure with decision trees to facilitate the development of a construction procurement strategy in response to a set of organisational objectives.

INFRASTRUCTURE DELIVERY MANAGEMENT SYSTEM (IDMS)

The IDMS, which was developed by the CIDB in collaboration with National Treasury and others, forms the backbone for the management of the delivery and maintenance of infrastructure, as illustrated in Figure 4. The CIDB / National Treasury IDM Toolkit 2010 provides a documented body of knowledge and set of processes that represent generally recognised best practice in the delivery management of infrastructure.

The IDMS, which encompasses the Infrastructure Gateway System and the Construction Procurement System, is structured in such a way as to embed government’s budgeting and expenditure cycles into the planning, delivery and operation and maintenance of infrastructure. These cycles are embedded into the Toolkit’s three key delivery processes, namely (see Figure 4):
- Portfolio Management — the iterative processes of identifying objectives, planning and intelligently grouping...
projects into infrastructure programmes and monitoring and controlling the roll-out of these programmes or projects

- **Project Management** – implementing the projects identified in the planning processes
- **Operation and Maintenance** – where assets are operated, maintained and ultimately disposed of.

Two important documents that are developed annually to manage and report on the projects identified in the planning process are the *Infrastructure Programme Management Plan (IPMP)* and the *Infrastructure Programme Implementation Plan (IPIP)*.

The IPMP, which strengthens client oversight and needs to be aligned with the adopted construction procurement strategy, should as a minimum:

- identify the objectives of each programme
- identify the scope and time schedule of the programme of projects
- provide details of the projects budgeted for implementation in the Medium Term Expenditure Framework (MTEF) period (three-year planning horizon)
- outline the construction procurement strategy (execution strategy)
- identify and describe the client support structures which need to be consulted during, or who need to participate in, aspects of the delivery cycle
- provide a time management plan for the programme, i.e. the baseline against which progress towards the attainment of milestone target dates can be measured
- provide the projected budget and cash flows (cost plan for the programme) which will enable planned and actual expenditure to be compared in different categories of spend, and revisions to the budget to be approved, and multiple project budgets to be managed and rolled up to infrastructure programme level
- document the key success factors and the key performance indicators which need to be measured, monitored and evaluated
- identify the major risks and how such risks are to be mitigated/managed (risk assessment and management plan)
- indicate how client quality requirements and expectations are to be met
- document a communication plan which determines the lines of communication and includes, as necessary, the following key activities:
  - **Communications Planning** – determining the information and communications needs of the stakeholders, i.e. who needs what information, when will they need it, and how will it be given to them
  - **Information Distribution** – making needed information available to project stakeholders in a timely manner
  - **Performance Reporting** – collecting and disseminating performance information, including status reporting, progress measurement, and forecasting
  - **Administrative Closure** – generating, gathering and disseminating information to formalise phase or project completion
- identify quality management requirements.

The IPMP, which is prepared by the ‘planner’, indicates the allocation of the MTEF budget to the projects to be implemented over the MTEF period. As such it creates an alignment between planning and budgeting. This enables an MTEF project list to be generated so that the planning and design processes can start timeously to ensure expenditure in financial year budget projections.

The *IPIP*, on the other hand, should as a minimum:

- provide for each package of which the concept report has been accepted:
  - a high level summary of the most recent package information (project execution plan (PEP))
  - the assigned resources for implementation and responsibilities
  - the current cash flow forecast
  - the milestone dates (key deliverables) for implementation of each project
  - key performance indicators, targets and the means of quantification/measurement
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the controls and measures which will
address health, safety, environmental
and other project risks
■ outline requirements for projects and
packages that have not progressed beyond
stage 4 of the IGS
■ enable a financial report to be generated
which:
■ lists the packages associated with a
programme or project which have been
finalised during the last two years pre-
ceeding the MTEF period together with
actual expenditure
■ shows the following for packages being
implemented during each year of the
MTEF period:
■ budget for the year
■ actual expenditure to date
■ remaining budget for the year
■ forecast expenditure for the re-
mainder of the year
■ forecast over/under expenditure for
the year
■ indicates expenditure in relation to
projects which have not progressed
beyond stage 4
■ enables ‘Actual versus Planned’
expenditure and time lines to be
compared at a package or programme/ project level.
The IPIP is prepared by the ‘implementer’
and focuses on managing package scope,
time and cost.

THE FRAMEWORK FOR DELIVERY
MANAGEMENT

The IDMS establishes the processes, pro-
cedures and methods which need to be
applied in the delivery of infrastructure and
maintenance projects and presupposes that
an organisation has in place a well-devel-
oped construction procurement system. It
needs to be institutionalised and operation-
alised within an organisation, failing which
it will remain as a useful tool and set of best
practices which should be employed – a
‘nice to have’.

In order for it to become an integral part
of an organisation, the following questions
need to be answered:
■ What are the different responsibilities of
the person commissioning the work and
the person responsible for implementing
the works at each gate?
■ What are the primary design and delivery
activities and responsibilities?
■ How are KPIs/progress monitored and
reported on?
■ How is quality assured in the delivery
process?
■ How are major capital works evaluated
prior to making an investment decision?
■ What are the project and programme
arrangements?
■ How are contracts administered and how
is payment effected?
■ How are occupational health and envi-
ronmental safety managed?
The answers to these questions need to be
documented in an organisation’s delivery
management framework, which not only
establishes the planning, design and de-
ivery management processes, procedures
and methods, but also sets out the:
■ services required to develop an end of
stage deliverable
■ minimum requirements for the content
of end of stage deliverables
■ governance arrangements to manage and
control the processes
■ organisational decisions which deal with
issues such as assessing the quality of the
end of stage deliverables and reporting on
progress and key performance indicators.

This document, read together with an
organisation’s Infrastructure Programme
Management Plans (IPMPs) and
Infrastructure Programme Implementation
Plans (IPIPs) for portfolios of projects across
a medium-term expenditure framework
and documented construction procure-
ment system, will enable an organisation to
develop its organograms, staffing require-
ments, training programmes, monitoring
and reporting systems and its approach to
audits.

ACKNOWLEDGEMENTS

This article draws upon material produced
for government’s Infrastructure Delivery
Improvement Programme (IDIP), a capacity-
building programme of the South African
government designed to address problems
relating to the planning and management of
public sector infrastructure delivery. (IDIP is a
partnership between the National Treasury,
the National Departments of Public Works,
Education and Health, the Development
Bank of Southern Africa (DBSA) and the
Construction Industry Development Board
(CIDB)). IDIP III has set a target that all infra-
structure planning at a portfolio and package
level (IGS stages 1 to 4) in provincial depart-
ments will be IDMS compliant during the
2013/14 financial year.

Information on the IDMS, the IGS and
construction procurement may be found on
the CIDB website:
www.cidb.org.za/procurement/delivery/
infrastructure_improvement/default.aspx
Evolution, Environment and Engineers

INTRODUCTION
This article is a pilot to explore the issues and to seek as much comment, challenge and other input as possible to assist in developing a formal approach to the subject. It dates back to the 32nd PIANC Congress in Liverpool in May 2010 (Permanent International Association of Navigation Congresses). The closing plenary session took the form of a debate on the PIANC environmental initiatives in harbours and in navigation. From the floor I pointed out that all the main fields of engineering are firmly rooted in proper scientific theories. An appropriate scientific basis would be Charles Darwin’s theory of evolution by natural selection.

The ideas propounded here introduce a new way of thinking, and new uses of modern mathematics. This is an article for and about engineers. To this end I will identify engineers as professionals educated in the classical sciences who inevitably have mud on their boots and grease on their hands.

BASIC CONCEPTS
The following are a few basic concepts that we need to understand clearly if we are to venture into the world of evolution. I am offering these from a pragmatic, engineering perspective – they are only intended to be valid in an engineering context.

Proposition 1: Reality
Figure 1 shows the dimensions of reality in a graphic format. The red plane maps all possible perceived reality. Our life experiences are only a small part of this total reality. Our awareness is like a spotlight, instantaneously illuminating the small patch that our current perceptions capture. The green plane maps all things real but imperceptible, such as the very small that needs a microscope, the very large that needs a telescope, or the imperceptible parts of the electromagnetic spectrum. They are things that can be detected by our instruments or by deduction from things we can observe. The blue plane maps all things real but non-existent. In the last shape on the right
in Figure 2 the centre of gravity (CG) occurs in empty space – the CG is real but non-existent.

Dimensions are another example. These are imaginary frames erected in space from which to map reality. Reality is constant, independent of our frames, but the mapping we produce depends on our choice of reference frame.

**Proposition 2: Time**

Time is a measure of change and, conversely, change is a measure of time. Change implies pattern and such changes involve the flow of energy, changes in entropy and changes in information. We detect change by changes in the perceived pattern – and our perception of time is always limited to an arbitrarily prescribed system of patterns.

**Proposition 3: Infinity**

Infinity deals with numbers and measures. These are entities and fool us into seeing infinity as an entity. It is not. It is a process. Specifically it is the implication of a counting algorithm that has no halting statement. The implication can only be realised if the algorithm is run on a computing machine where at least one of the operating algorithms does have a halting statement, e.g. on a pocket calculator the statement that says: “battery flat – halt”.

**Proposition 4: Causality**

Newtonian science is founded foursquare on the concept of causality. Figure 3 illustrates domino tumbling – line up a row of dominoes standing on end then trip the first so it trips the second that trips the next in a causal chain reaction right down the row. The upper sequence in the figure illustrates simple chain causality, but a common variation is simple bifurcation. If then there is a strong correlation between B and C, and A is not visible, a naive observer may well conclude that B causes C. Hence, *all causality is fundamentally stochastic*. It only expresses some variable probability of contiguity between observations of any two events. Classical science assumes a contiguity probability of 1, but generally it has a fractional value!

**Proposition 5: Some computational issues**

The classic reductionism of science leads to two organisational poles:

- **Alienated**: Independent and non-interacting systems:
  
  \[
  f_1(x_1) = y_1 \\
  f_2(x_2) = y_2 \\
  \vdots \\
  f_n(x_n) = y_n
  \]

- **Reticulated**: Multiple, enmeshed and simultaneous interaction between diverse systems or groups of systems:
  
  \[
  f_{11}(x_1) + f_{12}(x_2) + \ldots + f_{1n}(x_n) = y_1 \\
  f_{21}(x_1) + f_{22}(x_2) + \ldots + f_{2n}(x_n) = y_2 \\
  \vdots \\
  f_{m1}(x_1) + f_{m2}(x_2) + \ldots + f_{mn}(x_n) = y_m
  \]

The alienated is what you get when the reticulated is reduced to a diagonal matrix – nought everywhere except on the diagonal.

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- Mechanical & structural tubing for bus frames
- Sheet metal for bus bodies
- Tubing for handrails

**LOGISTICS**

- Floor plates • Cross members • Drop sides
- Rave rails • Bin liners • Under-run bars
- Products used in the manufacture of truck bodies

**Services**

- Cutting • Punching • Primer painting
- Drilling • Bending • Precision slitting
- Precision blanking
- In-house customised fabrication
Another problem is the computational explosion. Consider a jobbing workshop where \( n \) different jobs must be cycled through processes on \( m \) different machines. The number of ways of scheduling the work is given by \((nm)^n\). For the case where \( n = m \):

<table>
<thead>
<tr>
<th>( n )</th>
<th>( n! )</th>
<th>((n!)^n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>2.2 \times 10^2</td>
</tr>
<tr>
<td>5</td>
<td>1.3 \times 10^2</td>
<td>2.5 \times 10^{10}</td>
</tr>
<tr>
<td>7</td>
<td>5.0 \times 10^3</td>
<td>8.3 \times 10^{25}</td>
</tr>
<tr>
<td>11</td>
<td>4.0 \times 10^7</td>
<td>4.1 \times 10^{83}</td>
</tr>
</tbody>
</table>

In this situation, computation is impractical and nobody ever bothers to attempt it.

**Proposition 6: The scientific method**

The scientific method is the search for truth and the practice of scepticism. It is also an aggressive invasion of reality and uncompromised accounting. It was Galileo who first held that “nature is written in the language of mathematics”. Newton added his Rules for Reasoning (“we are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances”, etc).

Certainly, the corpus of modern science is far too vast for any individual to comprehend. By and large, science grows by a process of evolution beyond the control of any individual. The result is the Jungian idea of a communal consciousness – the idea that the total scientific knowledge, across all our minds and all our books and journals, is a dynamic, constantly changing ecology of information.

**ORIGINS OF THE SCIENTIFIC CONCEPT OF EVOLUTION**

Three names stand out in the establishment of the modern theory of evolution: Jean Baptiste de Lamarck: the inheritance of acquired characteristics Charles Darwin: natural selection of random mutations Herbert Spencer: survival of the fittest

Lamarck appears to have intended the transmission of characteristics acquired by parents during their lives to their offspring, and in this he was shown to be quite wrong. If, however, his concept is moved from the real individual organisms to the real but non-existent, either the morphotype or the genotype, then it becomes valid. It describes the persistence of acquired changes to these ‘types’.

Darwin’s natural selection is brilliantly fuzzy and intuitive. It applies to real individuals – to the random fluctuations in morphology between parent and child integrated over the whole population. Darwin confirms this with the following observation: “Natural selection can act only by the preservation and accumulation of infinitesimally small inherited modifications ...” This leads to the doctrine of *natura non facit saltum* – nature does not make jumps.

Herbert Spencer was a railway engineer turned philosopher who couldn’t stop being an engineer and poking his nose into the mechanics of natural selection when he stated: “This ‘survival of the fittest’, which I have here sought to express in *mechanical terms*, is that which Mr Darwin has called ‘natural selection’ or the preservation of favoured races in the struggle for life.”

He was hopelessly wrong. It only applies if each attribute can be assessed independently and all the assessments added by superposition, but superposition does not apply when all the attributes are interconnected. A better sound bite for Darwin’s theory is: Optimisation under conflicting constraints.

In his autobiographic essay, Darwin has the following comment: “According to my judgment happiness decidedly prevails, though this would be very difficult to prove. If the truth of this conclusion be granted it harmonises well with the effects which we might expect from natural selection.”

**STABLE, NON-EQUILIBRIUM THERMODYNAMICS**

As far back as the late 19th century the idea of thermodynamic principles was adopted to understand the erosion–deposition behaviour of rivers. By the mid 20th century this was formalised by Prigogine’s concept of non-equilibrium thermodynamics. In unbounded systems, energy is continually flowing through the system and there is always an energy gradient within the system. It can never reach an equilibrium condition. However, in its passage through the system, energy is degraded; there is an increase in entropy, caused by interaction with the system. The structure of the system is adjusted and the system reaches a stable condition when the rate of increase of entropy is constant throughout the system in time and space. The components of the system are shown in Figure 4. They are:

- Structure: the physical form of the system
- Function: the interaction of the structure with the flow of energy through and around it and the concomitant changes in entropy
Fluctuation: random motions of the elements of the structure induced by the function and in turn causing fluctuations in the function.

An hydraulic analogue was described by George Annandale in 1986 in his paper on the thermodynamics of reservoir sedimentation. He used the rate of dissipation of energy, friction and turbulence, effectively a measure of power, as an hydraulic analogue for rate of change of entropy.

The process of river evolution shown in Figure 5 is a very simple example of the process. The method has been applied to beach morphology by Per Bruun who assumed a uniform rate of energy dissipation per unit area of sea bed, and by Robert Dean who assumed uniformity per unit volume of water. Both got the same result which, when compared to actual beach profiles, gave a function of:

\[ h = Ax^{\frac{2}{3}} \]

**MODEL-FREE SYSTEMS**

A computational system that exhibits evolutionary processes in optimisation is the technique of neural networks, so named because it mimics a simplified version of the biological networks of a neuron. In 1993, Shaw described the application of the technique for managing the balancing of storage tanks in sewage works. These networks consist of large numbers of highly interconnected nodes. In general, each input to each node carries a biasing value. The resulting output is the sum of the biased inputs. In general, the behaviour of the net is a function of the field of bias values. Training of the net is the process of causing the bias values to change to yield to some required relation between input and output. The process of setting the bias values is made part of the system and it is not computationally feasible to run an audit trail through the process. The key concept is model free – there is no computation specific algorithm to the bias field.

This is a highly structured system that performs an evolutionary function despite a very coarse grain structure. It is stable despite the failure of any one connection. These systems are capable of outperforming algorithmic computation on complex functions.

**BIOLOGICAL MORPHOLOGY**

All organisms interact with their environment, not only externally between the organism and its environment, but internally between the internal substructures. It is only the physical organisms that interact and the interaction only influences their physical morphology.

All organisms exist in interbreeding communities commonly described as species. No two individuals are identical. These morphological fluctuations exist in time as well as space, and the thermodynamics will adjust the morphotype to maximum stability. It will adjust the morphotype to a position where the fluctuations average out and both the morphotype and degree of variation about the morphotype remain constant.

Now we come to the tricky part, the part that led Spencer astray and generations of British academics, particularly Dawkins. The process is a complex system of complex interactions. It is reticulated. The interactions cannot be described as independent, which is an essential requirement for Spencer’s survival of the fittest. For the last few decades there has been a dawning of awareness of this issue of complexity with a revival of the use of natural selection in preference to survival of the fittest. The transition does not appear to have been easy. There are still people using the term fitness and doing handstands trying to explain what it means. The correct concept is the stability of the morphotype of a species subsisting in an environment far from thermodynamic equilibrium.

Normally natural selection acts as a homeostat keeping the morphotypes of individual species targeted on the particular attractor of the ecological niche it inhabits. However, in doing so, it is constantly refining the internal fit of its various components, the physiological and behavioural substructures, to each other. When next the time comes to change, evolution morphs a more efficiently coordinated suite of physiologies.

Evolution is non-teleological. It does not try to reach any specific goal. Any solution will do. Consider the giraffe – its long neck allows it to browse the tops of trees, but the elephant is another, quite different solution to exploiting this niche.

Evolution is versatile. It can produce forms that mediate in the process itself. Certain structural forms have evolved that lend themselves to morphing into a wide variety of shapes, all retaining a potential for operational efficiency that the thermodynamics can mediate.
DNA
All biological organisms are built from cells that contain DNA, but DNA codes for proteins; it does not code for morphology or behaviour. There is a fundamental disconnect between the two. Although many characteristics, generally at a biochemical level, can be traced directly to a protein, by and large there is no direct correlation between DNA and gross morphology.
It will help, in trying to understand these concepts, to get some sense of scale. The total number of genes in the DNA of a human cell is around 30,000 and the number of base units to encode this, in the order of $10^{10}$. So, too, is the number of cells in the body. Displayed as an array on a TV screen (cells x base units), the screen would need to be in the order of 1,000 km on a side.

One way or another, DNA acts as a biological hologram. Illuminate an optical hologram in the appropriate manner and it reinstates the original light waves. In this way a single-celled seed or egg is a biological hologram. As it grows, so DNA constructs complex organic morphology as a highly complex waveform. Hence, in principle, the correlation between DNA and morphology should be intractable. However, given the reliability with which it does the job, perhaps the pattern of information of viable organisms exists in a more tractable island.

REACTION DIFFUSION
Alan Turing first published the principle behind this nearly two years before Watson and Crick deciphered DNA as a process of reaction diffusion. Turing’s model is not exactly the same as real DNA, but it illustrates the principle of biological waveforms. He assumed two different substances on a substratum, each having its own characteristic rate of diffusion and, depending on concentration, each able to suppress or stimulate the production of either itself or the other. Depending on how these various laws are set up, initial random perturbations can be made to adopt a regular waveform with a fixed wavelength.

PALEY’S WATCH
Paley’s comparison of a watch to a biological organ such as an eye or a flower has led to considerable confusion – a failure to distinguish between design and manufacture. The complexity is not in the manufacture, but in the design. Darwin has shown that the design of the eye and the flower is the result of evolution. Dava Sobel has done the same for the mechanical, specifically Paley’s watch.
She has made an in-depth study of the 18th century watchmaker, John Harrison, and his lifetime struggle to perfect the chronometer – his struggle to develop a design that satisfied the required function. Paley’s watch would have been a descendent of Harrison’s work. What she has unearthed is a process of evolution. In her account, we can actually watch the progress of this evolution. However, in her book, it was quite clear that she was not aware of this evolutionary aspect. When I wrote to her, she very graciously confirmed this and then went on to support the evolutionary view and my interpretation of her work.

Engineering design evolves. No one man, not even Henry Ford, ‘designed’ the motor car. The design of the modern motor car has evolved. The whole of engineering and science, although they have no equivalent of DNA, also evolve. As Newton said, he could do what he did because he stood on the shoulders of giants!

HARDY CROSS
The advent of OPC (Ordinary Portland Cement) led to reinforced concrete, an explosion in the use of statically indeterminate structures and a computational crisis in structural design. The analysis involves a large set of simultaneous equations that, before computers, were often computationally intractable. A pragmatic solution developed by Prof. Hardy Cross allowed a simple computational method
of successive approximation that involved a half carry-over factor. It converged quite rapidly.

Is sex a Hardy Cross process? In reproduction, each individual contributes a 50% carry-over to its progeny of the particular suite of alleles of genes it has received from its parents. This then creates a new mix of alleles to start the next iteration of the gene pool. Judging by experience with the Hardy Cross method, the process can track a changing stability field very rapidly.

**GAIA**

Perhaps the best description of our environment, the biosphere of the earth, comes from James Lovelock and his *Gaia* hypothesis. Lovelock is an atmospheric scientist and his idea grew out of his recognition of the following:

The atmosphere is a stable system far from equilibrium. It has a high concentration of free oxygen in a stable association with biological volatiles. This could only exist if the whole system is a vast homeostatic environment. In this system, the atmosphere acts as a mediator between the radiation, incoming from the sun, and re-radiation back into space, and the biological processes on earth that constantly regenerate the chemical balance of the atmosphere.

Lovelock’s champion, Lynn Margulis, writes: “Far from being fragile ….. planetary life is highly resilient … Gaia displays a physiology that we recognise as environmental regulation.”

**PUNCTUATED EQUILIBRIUM**

This term is due to Stephen Gould and strictly should be *Punctuated Stability*. Notwithstanding Darwin’s doctrine of gradualism, the earth has been subject to periodic catastrophes, commonly of extra-terrestrial origin, although the process of gradualism, of itself, as shown in Figure 6, can achieve the same result. These lead to mass extinctions and a rebuilding of the biosphere from the remnants. It does not compromise Darwin’s concept of evolution, although bad catastrophes can jump the main line progress onto a different track.

**ICE AGE AND MODERN HUMANS**

The earth has been cooling since the age of the dinosaurs, 65 million years ago, and for the last 2 to 3 million years we have been in an Ice Age. This is an age of oscillation between glacial and interglacial with a periodicity of about 100 000 years.

Generally there is a long, slow cooling to full glacial, with a sudden warming to a brief interglacial of a few thousand years, then the start of the next cycle. Currently we are in an interglacial and approaching the start of the next cycle.

The evolution of humans took place in Africa during the Ice Age and fully modern humans appeared by the end of the glacial cycle before last – arguably as beachcombers in the coastal fynbos centred on Cape Town. They escaped into the rest of the world during and shortly after the last interglacial.

The onset of permanent warming without significant setbacks started around 12 000 years ago, and with it the first domestication of plants and animals – the agricultural revolution. It was the start of settled village life and a symbiotic relationship between humans, plants and animals. By about 5 000 years ago, this had developed into what we now call civilisation – characterised by large public works. It was also the start of the ‘three Rs’ – *writing* to record who owed what, *arithmetic* to record how much and *religion* to make sure they paid! In other words, society had begun to differentiate into specialised occupations and the interchange of goods and services.

The exponential growth of humanity, as a global phenomenon, had begun – not just humanity, but the exponential advances in technology. All this growth, both in population and built infrastructure, has been fed by energy: the grains, the energy crops; then, as technology advanced, fossil fuels. M inflable mineral concentrations are another major energy source. The natural concentration is a saving on the energy needed to extract them. These are all finite resources and will be depleted.

The situation is not much better with biological (renewable) resources. Colin Clark unified the natural growth model with the discounted cash flow model. He has shown that, if growth rates of the resource are high and interest rates low, it pays to conserve a stock. If the growth
rates are low and the interest rates are high, it pays to treat a biological stock like an ore body and mine it to extinction. The population of a seed stock inoculated into a finite food (energy) source will grow and decline as shown in Figure 8. The indications are that humanity is currently about halfway up the log growth phase. The big question is what will happen later on if we continue to follow the curve.

However, given three aspects – the supply of energy, the human quest for happiness and human technical ingenuity – in the context of evolutionary dynamics, I consider that speculation on future scenarios is computationally intractable.

The call for sustainable exploitation is understandable, but there is no system, at the energy levels demanded by modern society worldwide, that will not have significant impacts. Already there are complaints about wind power. More important though, alternative sustainable sources are likely to have much lower yield to input ratios than we have been used to over the last century. To maintain a particular per capita standard of living will require a much higher investment of infrastructure per capita.

**ECOLOGICAL ENGINEERING**

The exponential growth of humanity has impacted and altered much of the surface of the earth and there has been an ‘environmental’ backlash, with genuine, emotive (albeit often unscientific) reactions from the common man on the one hand, and considered opinions of professional conservationists and environmentalists on the other hand.

The core activity of the latter is the establishment and management of nature reserves. Looked at this way it is clear that they too are engineers. As a provisional suggestion, shall we call this field *Ecological Engineering*?

In all seriousness, I suggest that they be invited to recognise this, organise themselves properly and apply for ECSA (Engineering Council of South Africa) membership. They certainly qualify in the sense that they operate in the natural environment at an engineering scale, and their field ranges from high academic research based on established biological sciences, through all professional levels to the management of raw labour in the bush. Once they are formally recognised as engineers, the conceptual segregation between them and other engineers should disappear and leave only the normal interdisciplinary differences.

**EVOLUTIONARY BACKGROUND**

In simplistic terms, as engineers, if we are to take the lead in global environmental
management, we need to understand the mechanics of evolution and to develop techniques that are based on an application of evolutionary processes. The individual elements, the individual structures, remain at the mechanistic level. We continue to build our structures and machines mechanically. It is the large-scale integration that must conform to the thermodynamics. Evolutionary systems are scale-dependent. The more finely grained the system, the more smoothly the process works, the less disruptive jerks in the process.

Notwithstanding the naive emotional reactions of every one of us, we need to be non-conservative towards our built environment and start seeing it, from both an emotional and an economic perspective, as transient in its form – morphing like a species in an evolving ecology – to accommodate the vast anthropogenic changes taking place in the world. On the positive side, constant change like this offers excellent opportunities to undo previous environmental disasters – for instance, inappropriate coastal development. In the longer term, it allows the evolution of the global built infrastructure and concomitant cultures to track a changing world.

However, notwithstanding the above, when using evolutionary systems – essentially model-free systems – one cannot pre-specify the kind of answer needed. The system seeks dynamic stability. It finds the questions as much as the answers. At a practical level, De Bono’s Lateral Thinking is a simplistic model-free method.

**HUMAN INTELLIGENCE**
Humans differ from anything that has gone before in their intelligence, in particular in our ability to invent new technology and to change the nature of the game. Of course, that does not mean that we can evade evolution. Evolution is always the ultimate arbiter.

Our intelligence is a function of our brains. Contrary to popular belief, these are not unique, just the pinnacle of a design that has been evolving for millions of years. But we still don’t know how it works. In particular we do not know how the phenomenon of consciousness arises. Currently brain sciences tend towards two poles. The regionalists focus on regions of activity within the brain as it performs different tasks, while the globalists maintain that all activity is distributed throughout the brain, arguing that even lack of activity in some parts is part of a global pattern.

It is clear that the only physically real activity in our heads is the incredibly complex electro-biochemical activity of the neurons, and the dominant problem is explaining the “Cartesian Theatre” of consciousness.Crudely, it amounts to the impression of a little man inside our heads watching the input of our senses on a large screen. It captures the impression we experience, but is clearly false since it leads to an infinite regression of littler men inside even littler men! Following the globalist approach, there is no Cartesian centre of consciousness. In other words, mind, the expression
of consciousness, is a real-but-non-existent implication of brain activity. The ultimate challenge in identifying the globalist paradigm is to solve the mind and consciousness problem.

An excellent interpretation of the globalist approach to mind has been developed by Edward de Bono – if you can stomach his excruciating oversimplification! He used this approach to develop his technique of Lateral Thinking. It works by an evolutionary process of random variation. Essentially, it is a model-free process. It does not ‘solve’ a problem; it yields unanticipated but viable proposals.

In my discussion above of the hologram function of DNA, I was essentially raising the same globalist approach. To my mind it is beginning to look as if there is a major paradigmatic concept out there that nature is exploiting that we have not yet been able to visualise. Provisionally, let us use J C Smuts’ term holism for this paradigm. I think he would be quite happy to allow that usage. I strongly suspect that human society in a built environment is starting to activate a similar system.

Daniel Dennett, in discussing our linear sense of the flow of time, argued that mind follows the sequential computing of the Von Neumann architecture. This approach can be modified by taking the idea right back to the fundamental Turing machine. It has an input/output tape – the machine modifies the input so that the output is the answer. It also has a programme tape and a machine state tape. The latter is reset with each step of the programme and acts as a bias. The action of the programme will be different depending on the current machine state value. If the mind acts as a super Turing machine, then emotions are the machine states of the mind!

It comes back to the brain-mind problem. Brain operates on an as yet unidentified globalist paradigm – holism. By contrast, mind operates like a computer.

As Louis Liebenberg put it: “A fully modern brain had evolved at a time when all humans were hunter-gatherers. Yet the same brain that has been adapted for the needs of hunter-gatherer subsistence, today deals with the subtleties of modern mathematics and physics.”

Mind does not exist in isolation. Minds grow from and exist in communication with other minds to form a ‘real but non-existent’ evolving ecology of group consciousness.

Group consciousness, culture, grows out of the biosphere but is completely alien to it. It is not ‘life as we know it’. It is something quite different – a ‘psychosphere’ perhaps, the key to the dawn of the ‘anthropocene’?

Our minds take to Euclidean shapes, and in particular straight-line ones, like a duck to water and it shows in our preferences for property boundaries. From a different point of view, this is precisely what naive environmentalists dislike about engineers.

LEGAL ROAD BLOCKS

In attempting to develop a rational, engineering approach to the global environment, we need to be aware of severe limitations imposed by the law. These are limitations, often of recent provenance, driven by the natural inclinations of our minds that try to mimic the simplistic, post-Newtonian, mechanistic view of the world. An excellent example is the legal interpretation of the High Water Mark (HWM) and hence the Seashore.

The seashore is a strip of finite width that is fuzzily defined and there are many real physical processes linked to this strip. There are no physical reasons preventing the erection of beacons in this zone and proclaiming straight line property boundaries. But this would severely compromise all those processes and attributes of the seashore. Legal sources generally go back to:

- The swash line on a tideless shore under heavy storm attack (Justinian 533 AD)
- Very high tides in protected waters (Hale 1666 AD)

Both of these show an excellent understanding of the reality of the seashore in their respective regimes, of human behaviour that is appropriate to that regime and a pragmatic application of that understanding. They also permit conceptual superposition on open oceanic shores subject to both storms and tides. Unfortunately, over the last 200 years leading British jurists have mistranslated the original Latin texts and confused it with an incorrect understanding of Hale.

As a result, South African law has attempted to define the HWM with a corrupted concatenation of Justinian and Hale that is useless garble! The 2008 ICZM (Integrated Coastal Zone Management) does recognise the special nature of the seashore, but is crippled by this corrupt definition of the HWM. To make matters worse, engineers and land surveyors attempt a literal interpretation of the HWM definition and try to ‘discover’ procedures for locating the mark.

Colonial French practice tackled the problem head-on. It introduced the idea of the Cinquante Pas Géométriques – 50 double paces of five large French feet – in effect 81.2 m as a shoreline reserve. This was imported into South Africa as the ‘Admiralty Reserve’. The idea is good, but fails if not properly enforced.

In large measure the problem can be laid at the door of the legal profession – from politicians to judges to solicitors to bureaucrats who do not manage their profession in an environmentally responsible manner.

There is a new branch of law forming – environmental law, but to the best of my knowledge, it is concerned with law that imposes environmental constraints on the rest of the community. In the current situation, this is completely misdirected. At this stage its sole concern should be the environmental relevance of the whole of the law – all those issues that arise in matters of no apparent environmental impact, such as tender procedures, that in fact ultimately and cumulatively do have an enormous impact.

GLOBAL WARMING

The most prominent environmental issue before us is global warming. Currently we are burning around a cubic mile of oil a year and a like amount of coal. That is an enormous amount and has led to the view that it must be affecting the atmosphere. In turn, this has generated the theory of anthropogenic global warming, corroborated by small observed increases in temperature worldwide over the last century, and predictions of much greater changes over the next century.

The deliberations of the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC) have unfortunately been allowed to become politicised and emotional. The overriding impression is of a fear of apocalyptic change. The swarm of fanatics that accompany the movement do not help impressions.

An economist friend of mine once remarked that the 20th century had been the worst for Europe since Attila the Hun. In fact, it was Eurasia-wide and by far the
The core terror was the judicial murder of the order of 100 million people. And this all traces back to mechanistically thinking idealists in the 19th century thinking they knew how to initiate a better world – fundamentally the same sort of thinking that is going around now.

At issue here are the words of Lyn Margulis on the manifestos of the environmentalist for saving the world:

“Life is a planetary level phenomenon and the Earth has been alive for at least 3 000 million years. To me, the human move to take responsibility for the living Earth is laughable – the rhetoric of the powerless. The planet takes care of us, not we of it. Our self-inflated moral imperative to guide a wayward earth or heal our sick planet is evidence of our immense capacity for self-delusion. Rather, we need to protect us from ourselves.”

The key idea here is that we cannot, should not and need not presume to protect the biosphere from anthropogenic impacts. All we should be concerned with is protecting ourselves from the impacts such changes have on us.

The politicisation of the global warming initiative is currently focusing on what can be done to reverse the trend. The approach is classically legalistic, focusing narrowly on carbon emissions and enforcing mechanistic ‘remedies’. But one cannot legislate nature, human nature included, and I cannot see that a few irritating ‘carbon taxes’ will suddenly stop the burning of fossil fuel. This will only happen over the course of the coming century as these fuels run out, as costs change and alternatives take over and introduce their own suite of problems.

The only way is to use model-free, evolutionary processes. Our research initiatives need to be focused on this radical new way of thinking and recognise that we cannot impose preconceived ideas.

Almost the entire suite of built environment over the whole world has been built in the last century. I would expect this century to be able to do at least the same, and in the process adapt to the new climate regimes – and lead to cultural changes as great as those of the last century. A brief reflection of the last five centuries suggests that the rate of change has not changed much over that period. If it continues at the historical rate of the present developmental level, it should be quite sufficient to address the problems of global warming.

All this implies that civil engineers need to take the lead in moulding the world and the societies in which we will live. To do this we need an over-arching paradigm based on Darwin’s natural selection, and we need to abandon any preconceived ideas of what the solution and the future should be.

In the meantime, for those who still fear global warming, who fear change, and those who still worship the Ice Queen, may I recommend C S Lewis’s The Lion, the Witch and the Wardrobe?

NOTE
References and full text are available from the author on request.

Civil Engineering May 2012
African marine civil engineering

STEFLNUTTI STOCKS MARINE (a division of the Stefanutti Stocks Structures Business Unit), specialises in all types of marine civil engineering structures, often including both design and construction services.

Over the last two years Stefanutti Stocks Marine has continued to thrive in a challenging economic environment. With the current trend of increased economic development taking place in Africa, the company has won and successfully completed numerous marine and harbour construction projects outside of South Africa, operating in such remote areas as Malongo in Cabinda, Angola, and Pepel near Freetown in Sierra Leone. Contracts have also been executed in Tanzania and Walvis Bay recently. Although logistically very challenging, careful and detailed planning ensured that these projects were completed on time and within budget.

The Malongo Dock Expansion Project, in Cabinda, Angola (R600 million), was completed in the final quarter of 2010. This project was a design and construct contract for Chevron, preceded by a front end engineering and design contract also secured by Stefanutti Stocks Marine. An ‘overhand’ construction technique was used, working directly out to sea, whereby one works with the crane progressing along the front of the construction works, with materials being ferried up to the crane from land along the newly completed section. Activities involved pile driving for the dock structure, sheet piling for the wave wall, and installation and concreting of precast concrete panels. All precast work was undertaken in Cape Town and shipped to Angola to ensure a high degree of concrete quality and conformance to durability requirements.

The Pepel Marine Works near Freetown in Sierra Leone (R154 million) was completed in December 2011. This was a joint venture (JV) with Bam International. The design and construct project involved the construction of two new mooring dolphins, refurbishment of the existing jetty and the installation of 27 navigational aids some 25 km downstream from the work location. The JV made use of a 300 t piling barge to drive the 65 m long piles used to form the structure of the mooring dolphins. Working in a tidal river (with currents in excess of 2 m/s), and during the peak of the rainy season during a fast-tracked project, proved to be a challenge, but this was overcome with the combined experience of the JV team.

Other recent projects outside of South Africa include Walvis Bay in Namibia (new fenders, scour protection and deepening of berths) and Tanzania Ports Authority (new navigation aids at the ports of Tanga and Dar es Salaam). Stefanutti Stocks Marine has also been kept busy here at home in South Africa with multiple large-scale expansion and refurbishment contracts currently taking place in the ports of Cape Town (in the Ben Schoeman Dock), Durban (in Maydon Wharf and Island View) and Richards Bay (at Berth 208). Contracts in Saldanha Bay (for mooring hooks and access platforms) and Durban (Island View Berth 2) have recently been concluded.

The recent expansion experienced in work load has seen Stefanutti Stocks Marine bulk up its staff complement and acquire new specialised plant, such as modular and single pontoon barges and ancillary equipment like crawler cranes and marine piling installation kits. Further anticipated growth will see more investment in staff and equipment to keep up with demand and expansion.
projects expertly executed

Construction of Malongo Dock in Cabinda, Angola, where an ‘overhand’ construction technique was used, with the crane progressing along the front of the construction works.

Aerial view of the completed Malongo Dock.

Work under way at the Pepel Marine Works in Sierra Leone.

Cape Town’s Ben Schoeman Dock – one of a number of South African projects in which Stefanutti Stocks Marine was involved.
LEADING THE RAIL REVOLUTION

THE RAIL DIVISION of consulting engineering and project implementation firm Hatch is currently managing various rail projects in the Northern Cape, ranging from specialised investigations to complete Engineering, Procurement and Construction Management (EPCM) services for some of the largest mining projects in South Africa. The company’s experience and expertise in the infrastructure component of major mining and industrial projects around the world have resulted in the group being awarded specialised investigations and major EPCM projects with mining majors such as Kumba Resources and Assmang. The majority of the projects and investigations that Hatch is either working on currently, or has recently completed locally, are located in the Northern Cape – a major mining area.

KUMBA RESOURCES

In 2008, the Hatch rail group was appointed by iron ore miner, Kumba Iron Ore, to carry out a complete EPCM service for the rail infrastructure for the nine million tonnes per annum (mtpa) Kolomela Iron Ore Mine, which included more than twenty kilometres of private siding rail infrastructure.

Hatch Global Director for Rail and Transportation, Henk Bester, says that the balloon layout that was proposed by Hatch and adopted by Kumba, incorporates a 50 kV AC electrified siding with yard automation, as well as centralised traffic controlled (CTC) signalling outside of yard precincts, which are controlled by Transnet Freight Rail (TFR) Saldanha.

“Features within the private siding include a layout that allows a complete 342-wagon distributed power (DP) train to be loaded within the time specified by TFR, as well as being able to accommodate a 114-wagon swingset on separate lines. These wagons are loaded by Kumba with a private diesel locomotive,” explains Bester.

He adds that overhead line equipment around the load-out station allows for the movement of electric locomotives through the non-electrified load-out section by using a combination of track switches, thereby ensuring safe movement throughout the load-out. Other features of the siding include a locomotive maintenance workshop, as well as an automated system for weighing and reporting payloads between Kumba and TFR.

Hatch Rail, as part of the larger Hatch EPCM contract for the complete materials handling and mining infrastructure Kolomela project, recently reached a milestone of 16 million lost time injury (LTI) free hours – a South African first in mine safety.

In addition to its work at Kolomela, Bester says that Hatch is also currently executing the Sishen Western Expansion Project (SWEP) on behalf of Kumba Iron Ore. The SWEP project requires a deviation of the TFR main line away from the future mining activities of Kumba’s Sishen Iron Ore Mine.

According to Bester this project entails a complicated mini-Gilloolys-type interchange of lines that would have to cross the TFR domestic and export lines, negotiate tricky topography, as well as incorporate departure gradients and sight distances for the long main line trains.

TATA STEEL, ASSMANG AND UMK

Hatch is currently assisting diversified miner, Assmang, on an EPCM basis with the rail infrastructure required for its Khumani Iron Ore Mine, which is located 60 km north of the Beeshoek mine and adjacent to Kumba’s Sishen Iron Ore Mine. Bester says that Hatch has already completed the construction work linking Khumani Mine’s rail infrastructure with the TFR domestic rail network.

Features of the Khumani rail infrastructure project include the following:

- State-of-the-art yard automation complete with detection and mini CTC
- Refuelling using environmentally friendly and safe self-contained fuel facilities
- 50 kV AC and 3 kV DC separation controls
- A diesel locomotive workshop, and a rail layout that allows simultaneous entry and departure of 342-wagon DP trains
- In-line weigh-in-motion complete with automatic vehicle identification system (VIS)
- TFR and Assmang interface design for train control

Bester says that Hatch recently reached one million LTI free hours on this project, which is set for completion during 2012.

In addition to the Khumani project, Hatch has been assisting Assmang with options for loading manganese and incorporating the mines of Gloria, Nhwaning and Black Rock into a seamless integrated system for export. Bester says that Hatch has also assisted the mining house with a procurement strategy for new diesel locomotives, including the specifications of these locomotives.

Meanwhile, as part of a more specialised service, Hatch assisted manganese miner, United Manganese of the Kalahari (UMK), in an audit of the UMK Mine’s existing rail infrastructure, as well as compiling a maintenance philosophy for the next five years. Bester says that included in this service is a quarterly maintenance audit ensuring quality control and assisting the mine with contract administration.

Hatch has also been assisting Tata Steel with investigations linking the Sedibeng Iron Ore Mine, which is 20 km north of Postmasburg, with the TFR domestic and export lines, as well as with options of connecting the mines with the existing TFR rail network. Hatch is furthermore assisting various new entrants, for both iron ore and manganese export options, with private rail layouts to join the TFR rail network.

IN BRIEF

Hatch is carrying out specialised investigations and large rail projects in the Northern Cape’s extensive mining area.
Consulting       EPCM Services       Technologies       Operations Support

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FOR MANY YEARS South Africa’s railway industry has been characterised by sporadic capital growth spurts followed by relatively long periods of stagnation. This trend is hopefully set to change following President Jacob Zuma’s address on 9 February 2012 when he voiced government’s commitment to upgrading the country’s infrastructure, with specific reference to a number of key focus areas in the rail domain,” says Johann Rauch, recently appointed General Manager for the rail sector at consulting engineering company, GIBB. Johann is well known in SAICE circles as a previous chairman of the SAICE Railway and Harbour Division.

“Historically, the railway industry experienced a tremendous growth phase in the late 70s and early 80s with the establishing of the coal export line to Richards Bay and the iron ore export line to Saldana Bay. By the late 80s there was rail network expansion linked to capital investment and the last new rail commuter coach was purchased in the late 80s.”

Activity in the sector started to pick up in 2006 when construction commenced on the Gautrain project and in late 2007 when the first tenders went out for the upgrading of existing stations, construction of new stations and various other commuter rail infrastructure upgrade projects prior to the 2010 FIFA World Cup. “This upgrading saw the start of significant investment into the rail infrastructure by the Passenger Rail Agency of South Africa (PRASA),” says Johann.

According to him, President Zuma’s announcement heralds an important turning point for rail engineering and associated industries. “Not only will the new infrastructure investment contribute positively to the lives of people who rely on trains for transport, but it will present opportunities for job creation, economic growth and social upliftment.”

Johann, who has more than 32 years of experience in railways, was introduced to the industry through his father, Hein Rauch, who headed the Geotechnical Department in Transnet before he retired in 1991 and who was a keen model train hobbyist. “I was fascinated by my father’s model train collection. As a family we frequently travelled by train to various parts of the country when going on holiday. Most of our holiday trips, however, were to Cape Town on the then Trans Karoo.”

Johann graduated with a Bachelor of Engineering (Civil) from the University of the Witwatersrand in 1979. As a South African Transport Services (SATS) bursar, he joined the organisation’s structural design office in 1982 where he gained exposure to the various engineering divisions at SATS.

“At the end of 1982, I was transferred to the construction unit where I spent four and a half years working on various projects, notably the doubling of the Johannesburg-Durban freight corridor, the construction of the Nataalspuit cartage depot, and the doubling of the Welverdiend corridor.”

This experience allowed Johann to register as a professional engineer in 1985. In the same year he was promoted to personnel engineer at Spoornet with responsibility for all civil engineering staff and the recruitment and granting of bursaries to prospective civil engineering graduates and technicians.

Johann believes the current shortage of skilled engineers in the country is mainly due to the cyclical nature of capital funding available for infrastructure investment. This resulted in skills being lost to international projects and other areas of economic activity other than engineering. “We trust that the recent announcement by the President will curb this trend. On a positive note, however, I believe there has been a recent increase in the rate of up and coming engineers in the system, but it will take a few years for them to be at a level where they can contribute to the industry in a significant way.”

In 1991, after graduating with a Masters in Business Leadership from UNISA, and after five years in human resource development, he moved to Transnet Housing (SATS had become Transnet in 1990) as project manager involved in the planning and development of low- and medium-cost housing developments located largely on Transnet land.

With his heart set on getting back into rail, he left Transnet in 1997 and joined the South Africa Rail Commuter Corporation (SARCC) as manager of railway planning. “I was involved in interesting planning projects that entailed the linking of new railway lines onto the existing rail network, largely necessitated by the emergence of new residential developments,” says Johann.

In 2000 he was promoted to senior manager of station and railway projects, which entailed the development of commuter railway stations. “This job allowed me to do planning, but also to move into the next level of engineering projects – design.”

His next move was to GIBB in 2003 as director of rail where he got his teeth into the execution side of the business. Since then, he has worked on several key projects, growing the GIBB rail business into a strong team able to respond to railway needs in both the passenger and freight rail markets.

Instrumental to this growth was the Gautrain Rapid Rail Link Project. “Since joining GIBB, I’ve worked on roughly 90 projects of which Gautrain was initially the largest. It has since been overtaken by the PRASA Rolling Stock Financing and Procurement Project,” says Johann.

This year he was appointed General Manager (rail sector), as part of the company’s transition to a sector-based organisational structure. He believes in the engineering credo that engineers are there to improve the quality of life of all citizens of the country, and is enthusiastic about the prospect of an improved railway infrastructure that will enhance public transport options for South Africans.

“This change is long overdue and presents exciting new challenges for the industry and the country, and I feel privileged to be part of it.”

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INFO

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CMA ADOPTS FRESH APPROACH TO AWARDS FOR EXCELLENCE

COINCIDING WITH ITS 40th-anniversary celebrations, the Concrete Manufacturers Association (CMA) has announced that its 2012 Awards for Excellence competition will be run on an entirely new basis.

Unlike in the past when the competition categories were product-based, this year the emphasis is on the core values and standards on which precast concrete products and applications are measured, and the new award categories reflect this. These are as follows: Aesthetics, Sustainability, Community involvement, Technical excellence, Innovation, and Vintage.

Besides the new categories, the number of awards has been halved from 36 to 18. Moreover, the three-tiered structure comprising regional awards and ceremonies, national awards and five trophy awards has been dropped. It is being replaced by a single, streamlined ceremony in which trophies are awarded to the overall winner of each category. In addition, three commendation awards per category will be made.

CMA director, Hamish Laing, says each category is open to entries from any construction project, on condition that one or more precast concrete product that had been manufactured by a CMA member has been used in its implementation.

“Entries will be judged on the contribution that precast concrete elements make in one or more of the competition’s categories. In other words, the same project could be entered for more than one competition category. For example, a township paving project could be entered into several if not all six categories.”

Laing says the standards on which the award entries will be judged this year will be as high if not higher than they always were, and awards will only be made if the quality of entries meets competition criteria. In instances where standards are not sufficiently high, awards will be withheld.

Commenting further, Laing says that an awards entry book will not be published this year. Instead all entries will be posted on the CMA website and on Facebook. As in previous years a winners’ book will be published and distributed immediately after the Awards function, which will be staged jointly with the Association’s 40th-anniversary celebrations, on 3 November at the Indaba Hotel in Johannesburg.

“The event presents an outstanding opportunity for all professionals involved in the manufacture and application of precast concretes to establish themselves as trendsetters in their specific disciplines and to gain national recognition for their achievements,” concludes Laing.

The deadline for entries is 29 June 2012 and judging, by construction-related professionals, will take place in July. Award entry forms and competition rules can be downloaded from the following address: www.cma.org.za

INFO
Hamish Laing
Director CMA
011 805 6742

011 345-0700
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SAICE CONSTRUCTION
AWARD FOR 2012
The conditions for this award are as follows:
1. The SAICE Construction Award supersedes the Basil Read Award. The Award is for peer recognition and may consist of a Gold Medal and/or up to two Bronze Medals, which are presented annually to a member of the Institution who is employed in or associated with Civil Engineering Construction and who, in the opinion of the South African Institution of Civil Engineering (SAICE), Project Management and Construction Division (PMCD), has made an outstanding contribution or rendered significant service to Civil Engineering Construction, normally within the previous two years.
2. Nominations and motivations are invited annually from individual members, Branches or Divisions and are to be submitted in the first instance to the SAICE Project Management and Construction Division, which will pass its recommendation to the SAICE Executive Board for approval.
3. The PMCD will take into account the achievement of a candidate/s in one or more of the following fields when considering its recommendations:
   a. Direct control of an engineering construction unit which achieves an exceptionally high production, coupled with a concomitant reduction in cost.
   b. Development of engineering techniques which have made a major contribution to the efficiency of a significant part of the construction process, or engineering or management techniques which will significantly impact the construction process, e.g. reduction in cost, saving in time, improved ergonomics.
   c. Overcoming extreme physical obstacles encountered in the execution of construction work.
   d. Solving unexpected and difficult problems encountered on a construction project, including the development and implementation of imaginative and practical design solutions.
   e. Methods leading to significant simplification or improvement of construction organisation and planning.
   f. Contributions resulting in a significant improvement of the image of construction.
   g. Leadership or innovation in the implementation of socio-economic development, environmental applications or occupational health and safety regulations.
   h. Entrepreneurial leadership and/or management in the development of a construction unit or organisation.
This list of considerations is not exclusive and motivation for the Award need not be confined to these fields of endeavour.
4. In the event of no suitable candidate being proposed, the PMCD may withhold its recommendations in any one year. Bronze medals may be awarded in a year in which no Award for the Gold Medal is made.

SAICE YOUNG CONSTRUCTOR’S AWARD FOR 2012
The conditions for this award are as follows:
1. The SAICE Young Constructor’s Award runs in parallel with the SAICE PMCD Construction Award. The Award, in the form of a commendation and prize, is presented annually to a young member/s (under 35 years) of the Institution who is employed in or associated with Civil Engineering Construction and who, in the opinion of the South African Institution of Civil Engineering (SAICE), Project Management and Construction Division (PMCD), has made a significant contribution or rendered innovative service to Civil Engineering Construction normally within the previous two years.
2. Nominations and motivations are invited annually from individual members, Branches or Divisions and are to be submitted in the first instance to the SAICE Project Management and Construction Division which will pass its recommendation to the SAICE Executive Board for approval.
3. The PMCD will take into account the achievement of a candidate/s in one or more of the following fields when considering its recommendations:
   a. Individual leadership/management of an engineering construction unit which achieves high production coupled with a concomitant reduction in cost.
   b. Innovation in the development and implementation of engineering techniques which have made a significant contribution to the efficiency of part of the construction process or engineering or management techniques.
   c. Overcoming physical obstacles or solving difficult problems encountered in the planning and execution of construction work.
   d. Contributions resulting in a significant improvement of the image of construction.
   e. Leadership or innovation in the implementation of socio-economic development, environmental applications or occupational health and safety regulations.
   f. Personal contribution towards the safety of co-workers.
   g. Significant contribution to the development of individuals or the organisation.
   h. Achieving peer-recognition internally or externally to their contribution in construction.
This list of considerations is not exclusive and motivation for the Award need not be confined to these fields of endeavour.
4. In the event of no suitable candidate being proposed, the PMCD may withhold its recommendations in any one year.

SUBMISSION DETAILS FOR BOTH AWARDS
Deadline 30 July 2012
Number Nominations need not be limited to one submission
Address Chairman, SAICE PMCD Division
Private Bag X200
Halfway House, 1685
e-Mail secretary@saicepmd.co.za
Clause 3.1.1 of the By-Laws reads as follows:

“Every candidate for election to the Council shall be a Corporate Member and shall be proposed by a Corporate Member and seconded by another Corporate Member.”

Nominees accepting nomination are required to sign opposite their names in the last column of the nomination form. Nomination for election to Council must be accompanied by a Curriculum Vitae of the nominee not exceeding 75 words. The CV will accompany the ballot form, and the format of the CV is described in Sections A and B. According to a 2004 Council resolution, candidates are requested to also submit a focus statement. Please see Section C in this regard.

Section A: Information concerning the nominee’s contribution to the Institution.
Section B: Information concerning nominee’s career, with special reference to civil engineering positions held, etc.
Section C: A brief statement of what the nominee intends to promote / achieve / stand for / introduce / contribute, or preferred area of interest.

Please Note: Nominations received without an attached CV will not be considered.

Closing date: 31 July 2012. Acceptable transmission formats - email, fax and ordinary mail. All nominations are treated with due respect of confidentiality.

If more than 10 nominees from Corporate Members are received, a ballot will have to be held. If a ballot is to be held, the closing date for the ballot will be 31 August 2012. Notice of the ballot will be sent out using two formats, i.e.
1. By e-mail to those Corporate Members whose electronic address appears on the SAICE database, and
2. By normal surface mail to those members who have not informed SAICE of an e-mail address.

M Pillay
Chief Executive Officer
April 2012
## NOMINATION FORM 2013

### 10 Corporate Members

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Please fax, e-mail or post this form, plus the CV of the nominee, to SAICE National Office, for attention Memory Scheepers, by 31 July 2012

Fax: 011 805 5971 | e-Mail: memory@saice.org.za | Postal address: Private Bag X200, Halfway House, 1685
DURING 2011 the Institute of Municipal Engineering of Southern Africa (IMESA) celebrated its 50th anniversary. One of the permanent outcomes of this event was the launch of Reflections 2011 – an IMESA journey through time compiled by Professor Johannes Haarhoff of the University of Johannesburg.

This attractive book is a laudable contribution towards the efforts to record our South African engineering history and heritage, and is indeed a collector’s item. It is a publication that should be read by all civil engineering practitioners, especially by municipal engineers. It should also be compulsory reading for students in engineering since it relates the development and value of a professional society and its members who have diligently served our country and its citizens over such a long time.

The municipal engineering profession is at the heart of the wellbeing of our modern society. Not a day goes by without input and contribution from this profession to ensure our safety, our nourishment, our existence and our health.

It was once said that engineers, and civil engineers in particular, are the ‘invisible’ people. We seldom see or meet the engineers who make sure that we have water and streets, and sewage and garbage disposal, although these services themselves are highly visible and tangible. Reflections 2011 therefore tells the story behind the story and highlights the achievements of a small group of dedicated individuals and the professional society by means of which they organised themselves.

As is mentioned on the cover, Reflections 2011 is a journey through time, a tale of history and of heritage – a reminder of how our engineering profession changed the world for the better.

The book also contains some bittersweet those-were-the-days kind of memories – when the Town and City Engineers were still in charge, and how that era was the time of individuals in engineering commanding respect. Many of them became household names and their legacies are there for all to see. The book also lists the presidents and other office bearers of IMESA, thereby providing not only a trip down memory lane, but also a concise reference of the people who had served IMESA so well.

Author Professor Johannes Haarhoff is well known to many of us. This work of note is another achievement in a row of historical publications from his pen. His skill as researcher-engineer-writer is well demonstrated in this book and ensures an enjoyable read. In addition, Gavin Clunnie, current chair of the Northern Provinces Branch of IMESA, together with a professional editing team, produced a publication in a class of its own – a book that will increase in value over time.

I sincerely recommend that, as engineering professionals, we should not only acquire this book to read and to reflect on, but also to use as a living testimony of what our profession has achieved. The book is a lesson and a guide for the future, that should point the way for politicians and communities on who to engage to ensure sustainable service delivery for South Africa – the often unsung and unseen, but the most valuable resource that a country can wish for, namely the municipal engineering profession.

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QUALITY IS OUR FOUNDATION
MOVING ON FROM SABS 1200
(Civil Engineering January/February 2012, p 20)

Let me make it clear that I agree – SANS 1200 has been long overdue for a rewrite. However:

The ongoing use of 1200 is not only about the measurement and payment provisions in Clause 8 of 1200 that practising engineers and contractors are familiar with. It is also about the practical ease of use that follows from the logical and consistent layout of Clauses 1 to 7 in 1200.

Granted, the SANS 2001 series starts with the consistent sequence of headings Scope, Normative References and Definitions, but these are followed by the globular heading “Requirements” which, in the case of 2001-CC1, is followed by the more globular sub-heading “General”. The Requirements are followed by the slightly-less-vague heading “Compliance with the requirements”. So, where do you look for things like permissible time from batching to placement, types of tests and frequency of slump tests, etc?

If one wants a ready reference for permissible tolerances, frequency of testing, construction procedures and similar, the layout of SANS 1200 wins hands down. If there has been resistance from industry to the adoption of 2001, this may have something to do with it.

More could be said, but in the interests of brevity I will stop here: While I agree that 1200 is a bit moth-eaten (and has been for a while), to me 2001 is not the model answer and possibly also needs a re-think.

Pieter Zietsman, Pr Eng
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AMEC
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CLIMATE CHANGE EDUCATION
(Civil Engineering January/February 2012, p 33)

Dr Nimpuno’s article ‘Climate change education’ cannot be allowed to go unchallenged.

For a start, readers should be aware that climate change theory is no more than a monumental scam intended to suppress the economic competitiveness of the developing nations of the world in order to ensure the continued economic supremacy of the developed nations of the West.

Readers should also note that Dr Nimpuno did not produce a scrap of evidence demonstrating the adverse consequences of climate change here in South Africa. The simple reason is that no such evidence exists. Nor did he refer to the publications and studies by South African civil engineers on this subject during the past 30 years.

Why is it that the climate alarmists refer to remote regions of the world when quoting ‘proof’ of human-caused climate change? These include the reduction of the polar bear populations of the Arctic regions and the equally false melting of the ice in the Antarctic. In-between are the claims that the Himalayan glaciers will disappear by 2035 when the date should have been 2350. It was also claimed that the snows of Mt Kilimanjaro near the equator are melting as a result of the increasing greenhouse gas emissions in Europe when the global movement of energy is in the opposite direction.

There is abundant evidence of these false claims. I deal with this whole climate change scam in my comprehensive technical report, “Climate change and its consequences – an African perspective”. It can be downloaded from the website of the Department of Civil Engineering of the University of Pretoria. The report consists of eleven chapters (337 pages), eight appendices (216 pages) and seven PowerPoint presentations (452 slides). The set of slides is available on request. In my view, this report should be distributed to students.

Our responsibilities as civil engineers are to improve the quality of life of the poor and disadvantaged people of our country, not to spend time, effort and money propagating this wholly unscientific and groundless climate change fallacy.

Prof Will Alexander
Professor Emeritus
University of Pretoria
alexwjr@iafrica.com
Focus on SAICE courses: Training in railway technology and bridge maintenance

Three courses prepared and presented by Ed Elton (Pr Eng, FSAICE) cover various aspects of rail technology and bridge maintenance. The two rail courses are both two-day courses, each crediting the delegates with two CPD (Continuing Professional Development) points towards retaining their professional registration with the Engineering Council of South Africa (ECSA), while the one-day bridge maintenance course is worth one CPD point.

The courses are presented in lecture format, with adequate time for in-depth discussion by the delegates.

Course presenter Ed Elton has extensive experience in the fields of railway engineering and bridge maintenance, and for the past 15 years has been involved in technical training.

SUMMARY OF THE THREE COURSES

Railway Transport
This course discusses the various components and aspects of transport on rail. The basic railway infrastructure of the track, control systems for safe passage of trains, overhead traction equipment, rolling stock required and methods of train operations are covered.

Completion of the course should enable the delegates to have a greater understanding of the complexity of railway transport. This understanding will result in a better informed decision-making process when technical and operational issues are discussed and decided upon.

The Basics of Rail Track Engineering
This course explores and discusses the various components of the track formation, from the wheel contact on the top of the rail to the subgrade level. In addition to the discussion on track components, various other aspects are discussed, such as: track drainage, track mechanisation, continuous welded rail, clearance distances, vehicle profiles and track geometry.

Completion of the course should enable the participants to have a firm foundation of the concept of track engineering. It should also enable participants to be more effective maintainers of the track infrastructure and, if involved in design, to avoid basic defects in track infrastructure.

Bridge Maintenance
This one-day course was developed in response to the increasing importance of repairs and maintenance to steel and concrete bridges as this asset group ages. Aspects that are covered in the course include common defects of bridge structures, repairs to steel and concrete bridges, paint systems for steel bridges, coatings to concrete bridges and aspects of a bridge maintenance system.

Completion of this course should empower delegates to deal with the challenges of bridge maintenance.

INFORMATION
For booking details, please refer to the SAICE Training Calendar 2012 on page 80.
### SACPCMP Notice

Please take note that Board Notice 54 of 2012, in terms of Section 13(k) of Act No 48 of 2000, regarding the Continuing Professional Development Policy, was published in the Government Gazette of 3 April 2012 (No 35222 page 3).

Commencement Date: 1 April 2012
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