Civil Engineering

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Entitlement, where individuals or a group of individuals feel that a measure of debt is owing to them, is a disease that inhibits collaborative effort to achieve success in South Africa, and imposes the millstone of development onto fewer shoulders.

Entitlement holds that government is either the debtor, or that it (or a union) ought to spearhead initiatives for recompense justified by our sense of entitlement – expecting that others are obliged to make real our personal aspirations for wealth, stability and equal opportunity, without having to put hands to the plough ourselves.

During my engagements with ‘other’ civil engineers across the country, there are two perennial issues that surface, the first being the perception that SAICE is an old boys’ club for white civil engineering practitioners. Let me swiftly nail this one down – regardless of demographic persuasion, if you are a civil engineering practitioner in South Africa, SAICE is your home.

The second issue relates to the benefits of membership. What do I get for my subscription? I thought I should nail this one down, too.

A professional civil engineering practitioner who is a non-SAICE member (because SAICE ‘does nothing for me’) has DSTV premium entertainment at a handsome R7 500 per year subscription. But he finds no value in his professional institution – the same SAICE that lobbies on his behalf, that provides technical leadership, learned institution activity, heritage, and which influences the civil engineering pipeline and direction of the industry for R1 700 per year.

The civil engineering profession is only as strong as its institution, and SAICE is famously known as a home for the civil engineering professional – it does what the individual civil engineer cannot do on his own. If you are a civil engineering practitioner, then you should be a member of SAICE. If you are an employer of civil engineers, you should be reimbursing your employees their SAICE membership fees.

At this juncture I could wax lyrical about benefits like the magazine, journal, CPD, professional registration, our lobbying with government, exhorting uninformed officials about what we do, influencing legislation and policies, developing learned institution material (such as standards, contracts and guidelines), promoting our members to the client base, the SAICE bookshop and around 30 other benefits, but I will attempt a unique benefit instead – business leadership development.

Membership of SAICE usually requires engagement in a committee, a structure and/or a project. Participation involves working in a low-risk business administration environment together with civil engineering colleagues (often experts in their field), financial administration and teamwork. This is an ideal opportunity to groom business leaders for the future, at little cost to employers. As young engineers are often earmarked for leadership posts in organisations, I urge you to encourage the civil engineering staff in your employ to join SAICE, and to support them when they participate in SAICE activities, as your organisation and the individual will both benefit from such participation, while the country will benefit from a stronger SAICE which is already dedicated to the upliftment of our people and our profession.

So what do you get for your subscription at SAICE? You get a clean canvas upon which you paint the impressions of what civil engineering should look like and the socio-economic images you envisage society to be.

Civil engineering professionals subscribe to hard work in the intellectual and problem-solving space. SAICE – your institution – needs you. It is unbecoming of us to appear to be succumbing to the philosophy of entitlement.

To all SAICE members who support the cause of civil engineering through volunteerism, and who faithfully pay their subscriptions - thank you for your commitment to the Institution. The profession is moving forward because of your contribution.

Civil Engineering May 2013
ON THE COVER
Aveng Grinaker-LTA Ground Engineering has invested in the tried and tested technology of the casing oscillator in order to support its SICAP bridge piling system and help spread its application to all bridge scenarios. The power of the oscillator is being put to good use installing piles in tough conditions for the Kalagadi Manganese Mine.

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TIPPING POINT
South Africa seems to be perched on a ridge, in a time of challenge and controversy, sitting in the balance between economic success or economic catastrophe. Faced with several challenges, the engineering profession also finds itself at a tipping point, and by the decisions and actions we as engineers take now, history will judge our contribution to the direction in which we steered South Africa. We hope to be remembered for contributing towards tipping the scales in the direction of resounding and sustainable triumph.

For that to happen we need to mass-mobilise SAICE and the South African engineering community, and in strategic fashion restore the value of engineers and engineering in the development of an economy. In solidarity we need to charter the direction of our profession and our future, and paint on the canvass of time the socio-economic images we envisage for society in the next 30 to 50 years. In the final analysis we need to raise awareness.

Civilution encapsulates the tenets of a cause or a mass movement, and it defines an era during which engineers will resolutely reinstate technical, intellectual and strategic leadership. Civilution, therefore, is a time frame – an era. It is the era of engineers in revolution.
The engineers’ revolution is firstly an introspective conversion, where we abandon pessimism and distrust, and regenerate ourselves to become a creative and intelligent part of the solution again, driven by the belief we held in our hearts when we first became engineers – that we can make a difference.

And because engineers are problem solvers, philosophers and strategists, our revolution cannot find resonance in traditional, disruptive conduct. Our revolution must find lodging in the intellectual space. The engineer’s weapon is his pen, and his skill. Let our intellect and our skill carry the weight of our experience and our aspirations. Let us get up and move. Let us as engineers become Civilution manifested.

MAKING Civilution WORK IN PRACTICE
For this struggle to be successful, we must wrestle for dominance in technical creativity, innovative and cost-effective solutions, respect for time and delivery, and engagement with learned institution activities. It is time for us to bring back engineering excellence, ethical business practice and sustainable solutions. This is what we are supposed to be doing anyway, and by returning to this original authenticity, we will also see the restoration of what rightfully belongs to us – esteem, prestige, respect.

Partner with your client – raise the awareness of funding and administrative requirements for successful project completion.

Flee from corruption, and report those that are associated with corruption.

Ensure that all projects are delivered on time, within budget and at world-class standards.

Provide creative and innovative solutions to typical and unique service delivery and engineering problems.

Train and mentor young engineers in a formal and well-defined programme that will see them register as engineering professionals.

Encourage young engineers to start shouldering greater responsibility at an earlier stage.

Prioritise transformation and manage professional entrepreneurial ambitions and expectations.

Provide funding for undergraduate and postgraduate studies to enhance knowledge and innovation.

Engage with your learned society with a view to keep your profession cutting-edge in technical leadership initiatives and activities, thereby maintaining the continuity of the profession and its legacy.

IN CLOSING
We need to recognise that the power is in our hands, and we therefore need to embrace Civilution and participate in its call for engineers to regenerate themselves. Civilution-based projects and events, such as the Civilution Congress 2014 and the Civil Talk debates, are not only excellent regenerating opportunities, but are also ideal occasions for focused networking with decision-makers.

We need to collaborate with our client base (including all spheres of government) to welcome back engineers as vital role players in service delivery and to effect efficient government operations. We expect government to continue making strides in positioning itself as the employer of choice for engineers, and to create a professional and corporate environment within their engineering and service delivery ranks, but we as engineers also need to again start considering career paths in the government sector as a definite option.

Together we as engineers can make Civilution gain momentum and become an unstoppable force for the betterment of society and our environment. Let us live and leave a legacy.

Steven Kaplan
SAICE COO
steven@saice.org.za
A world leader in building materials and a top-ranking player in the cement, aggregates and concrete industries, we contribute to the construction of cities around the world. Our innovative solutions are helping to provide more housing and to make cities more compact, more durable, more beautiful and better connected. The Group employs 65,000 people in 64 countries, and posted sales of 15.8 billion Euros in 2012.

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  - mainline; and
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  - expansion joint sleepers;
  - turnout sleepers;
  - universal sleeper and infrabolt system;
  - LVT (low vibration track) track slabs;
  - 1435 gauge sleepers.
- Maintenance-free railway electrification masts and poles
- Railway culverts
- Level crossings, cattle grids and drain channels

Aveng Manufacturing Infraset - founded on innovation, technical and service excellence.
AVENG GRINAKER-LTA was awarded the contract for the 20 km long rail line for the Kalagadi Manganese Mine near Hotazel in the Northern Cape. The major structure along this route is the bridge over the Ga Mogara River, where Aveng Grinaker-LTA Ground Engineering is responsible for the foundations.

The bridge is a 200 m long, eight-span structure. Due to the varying geology created by an unpredictable calccrete layer, the foundation criteria changes greatly along the length of the bridge. On its east abutment and the first four piers, only dowels into the shallow, thick calccrete layer are required, whereas the remaining three piers and the west abutment require piling that will range between 8 m and 40 m deep. The reason for this change in geotechnical requirement is the varying depth and thickness of the calccrete layer. Where the calccrete is shallow and thick enough, doweled spread footings are used. At the west abutment and Pier 7 the calccrete becomes too deep to excavate for spread footings, but is still thick enough to found on, and thus shallow piles are socketed into the calccrete layer. But under Piers 5 and 6 the calccrete layer becomes too thin to found on and the piles will need to be installed through the calccrete layer and into the underlying bedrock some 35 m deep. Permanently cased auger piles of 900 mm were specified for all the piles.

In order to tackle such a varied and complex undertaking, the Ground Engineering team had to send versatile equipment to the site to install both the shallow and deep piles with the maximum efficiency. It was decided that the “Screwed-In Cased Auger Pile”
system (SICAP) would be the fastest way to install the shallow piles, making use of the speed with which the rotation head of the hydraulic piling rig can install the necessary temporary casings down to the founding levels. In order to install the deeper piles, Ground Engineering purchased a state-of-the-art casing oscillator from equipment manufacturer Soilmec. The oscillator is designed to work in tandem with the piling rig and the SICAP system to ensure that the casings can be installed to the correct level through any obstructions that may be encountered.

The greatest challenge thus far has been on the deeper piles, where it is necessary to install the casings through the 50 MPa, 3 m thick, calcrete layer. It is through this layer that the oscillator proves its value, grinding the casings through with a minimum of fuss. Ground Engineering project manager Jacques van Rooyen comments: “Bridge piles are always a tough challenge and this job has been no different. But, with our skilled site team and the new technology, we are confident of delivering the piles on time and maintaining our two-year quality achievement of not having had a pile fail, a record we are enormously proud of and will go to great lengths to maintain.”

Ground Engineering has been the pioneer of the SICAP system in South Africa, in recent times successfully completing ten bridges in varied geotechnical conditions, and with piles to a maximum of 31 m deep. Working closely with geotechnical design partners ARQ Consulting Engineers, Ground Engineering was able to accurately decide on which contracts SICAP piles could be installed successfully. Now, with the addition of the casing oscillator to its equipment arsenal, Ground Engineering is in a position to take on all bridge contracts efficiently and cost-effectively by marrying the two technologies to ensure that no geotechnical conditions prevent the installation of the necessary piles – while still offering the value inherent in the SICAP system.

Ground Engineering, which has historically not been involved in the bridge piling market, is excited about the prospects that its new equipment will now open up, significantly expanding its already comprehensive service offering. General Manager Wim van Zyl elaborates: “The investment in the oscillator and the necessary ground-engaging tools confirms our commitment to this challenging sector of the market. With the experience we have gained during the recent contracts, we are confident of sustained success in the bridge piling market in the future.”

When completed, Ground Engineering will have installed 23 piles with a combined depth of approximately 400 m on the Ga Mogara Bridge.
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**voestalpine VAE SA (Pty) Ltd**
23 Anvil Road, Isando, 1600, South Africa
Tel: +27 11 928 3700, Fax +27 11 928 3910
sales@vae.co.za
www.voestalpine.com/vaes
RAILWAY AND HARBOUR ENGINEERING

Gautrain State of Good Repair: three years after the first trains were commissioned

With government-owned assets and the sustainability of service delivery a primary objective, the “State of Good Repair” of the Gautrain rapid rail system will in future play a fundamental role in determining its quality and ability to deliver a world-class transportation service. If not managed responsibly, the system could experience major operational and financial challenges that will result in public discontent and possible ridership decline. This article gives a broad overview of a study that was carried out to determine the Gautrain’s State of Good Repair.

BACKGROUND
The Gautrain system comprises a total of 143 km of railway track – 20 km of tunnel track slab and 123 km ballasted. The tunnel section runs from the Portal (close to Marlboro Station) to Johannesburg Park Station, with the first 5 km stretch between the Portal and Sandton being a double-line and the remaining tunnel section linking Sandton to Johannesburg Park Station via Rosebank being a single line, 10 km in length. The ballasted section includes 46.5 km of double-line track stretching from Marlboro to Hatfield via Midrand, Centurion and Pretoria. Another double-line ballasted section of 15 km links Marlboro to the OR Tambo International Airport via Rhodesfield. Ten stations and dedicated bus feeder and distribution services line the route. The route alignment is shown in Figure 1.

The Gautrain system is the first rapid rail train in South Africa, achieving operational speeds of up to 160 km/h and using a standard gauge track width (1 435 mm). Most other South African railways operate on narrow gauge track (1 067 mm).

The project, consisting of the design, construction and financing of the system, as well as on-going operation and maintenance, has brought together government, the private sector, and a host...
of local and international specialists in an unprecedented manner. The Public Private Partnership (PPP) Project has the government of the Province of Gauteng as the client, and the concessionaire – Bombela Concession Company (BCC) – will transfer the system back to the client at the end of the 15-year operating period. The Gautrain project not only addresses a critical transport need in the province, but also meets the government’s objectives of promoting and stimulating economic growth, development and employment creation.

The Gauteng Province has appointed the Gautrain Management Agency (GMA) to oversee the Gautrain Project. The concessionaire (BCC) has subcontracted the operation of the Gautrain system to Bombela Operating Company (BOC), and BOC has in turn subcontracted the perway, wayside and rolling stock maintenance to Bombela Maintenance Company (BMC). Bombardier Transportation supplied the Electrostar Electric Motive Units (EMUs), i.e. the trains that run on the network.

**STATE OF GOOD REPAIR**

Internationally there has been a shift in the focus of service and service delivery sustainability of strategic assets, specifically within asset intensive organisations such as local governments, transits and government agencies. Accounting reform in the South African public sector has been a primary process driven by the National Treasury since 1998. This process fundamentally requires municipalities to comply with generally recognised accounting practices (GRAP), which, from an asset management perspective, focus on how to recognise assets in the financial statements. From a property plant and equipment perspective (GRAP 17) local government entities are required to recognise these assets, based on the useful life and the remaining useful life, in turn based on condition monitoring and/or actual construction date, and to determine their fair value accordingly. A major portion of developing a fixed asset register is the influence of condition on the asset’s fair value.

In recent years the Federal Transit Administration (FTA) in the United States of America also started with a drive in transits, to determine the State of Good Repair (SOGR). As stated on the US Department of Transportation Federal Transit Administration’s website, “Maintaining the nation’s bus and rail systems in a State of Good Repair is essential if public transportation systems are to provide safe and reliable service to millions of daily riders. State of Good Repair includes sharing ideas on recapitalization and maintenance issues, asset management practices and innovative financing strategies. It also includes issues related to measuring the condition of transit capital assets, prioritizing local transit re-investment decisions and preventive maintenance practices. Finally, research and the identification of the tools needed to address this problem are vital. The FTA will lead the nation’s effort to address the State of Good Repair by collaborating with industry to bring the nation’s transit infrastructure into the 21st Century.”

The FTA will use information related to the SOGR provided by transits to determine to whom, as well as how much,
the FTA will support transits through grants, to maintain/renew/replace a transit’s infrastructure assets to an SOGR. This should result in a system that provides sustainable, safe and reliable transport services to the public. To qualify for such grants, transits need to develop a complete asset register, perform a condition assessment on the assets and provide a detailed Transit Asset Management Plan to the FTA to be considered for SOGR grants. Furthermore, the following primary objectives are identified as part of the SOGR initiative to consider reinvestment needs:

■ What are the current physical and service conditions of the nation’s transit assets?
■ How do these conditions compare to an “ideal State of Good Repair”?
■ What is the current investment backlog and what level of investment would be required to attain a state of good repair?
■ How are unmet reinvestment needs impacting service quality and maintenance needs?


CONDITION MONITORING

The condition of railway track is generally determined by either measuring the absolute track geometry, calculating the roughness of the track (in terms of standard deviations) or, more recently, by measuring the response of a design vehicle travelling on the track in terms of the accelerations caused by track irregularities. The Gautrain concessionaire does all three as part of a comprehensive condition monitoring regime. This article, however, focuses only on the former two aspects.

The greatest challenge of condition monitoring is often not the method of obtaining the data, but rather the task of interpreting the vast amounts of data and setting realistic and useful limits to the calculated parameters or indices.

A literature review was conducted to compare the proposed geometric standards for Gautrain with those of international railways that use the same track gauge (1 435 mm) and maximum speed (160 km/h). Comparisons were made with Swedish National Standards [1], Australian Standards [2], Federal Track Standards (USA) [3], Network Rail [4 & 5], British Standard CEN [6] and Japanese Railways [7]. Based on this exercise, the proposed track geometry limits and track quality index calculations were adjusted to find a balance between South African practice and international standards.

TRACK GEOMETRY

Track geometry is measured in terms of the five most common parameters, namely profile, alignment, gauge, cant and twist. Three limits, namely installation, maintenance and intervention, are then specified for each parameter. Exceedences of these limits are used to programme normal and emergency maintenance interventions. Table 1 shows a summary of the concessionaire’s geometry limits. These limits are in line with Network Rail standards [4 & 5].

Track quality

A track quality index (TQI) is calculated for each 200 m section of track, based on a relatively simple weighted sum of different track geometry standard deviations. As before, limits can then be imposed to use the TQIs for classifying the track geometry condition as excellent, good, average or poor.

The formula used by Gautrain incorporates profile, alignment, twist, gauge and cant:

\[
TQI = 0.3\sigma_{PRA} + 0.3\sigma_{ALA} + 0.2\sigma_{TWT} + 0.1\sigma_{SUP} + 0.1\sigma_{GAU}
\]

where

\[
\sigma_{PRA} = \text{standard deviation: Profile Average}
\]
\[
\sigma_{ALA} = \text{standard deviation: Alignment Average}
\]
\[
\sigma_{TWT} = \text{standard deviation: Twist (3 m base)}
\]
\[
\sigma_{SUP} = \text{standard deviation: Superelevation/Cant}
\]
\[
\sigma_{GAU} = \text{standard deviation: Gauge}
\]

The TQI formula [8] gives equal weights to profile, alignment and the sum of twist and cant – two closely related track parameters. Gauge is given a weight of a third compared to the other parameters because of the fact that gauge will not change nearly as much as the other parameters.

Table 1: Gautrain concessionaire’s geometry limits

<table>
<thead>
<tr>
<th>No</th>
<th>Parameter</th>
<th>Measurement length</th>
<th>Installation</th>
<th>Maintenance</th>
<th>Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Profile</td>
<td>10 m chord</td>
<td>-4 ; +4</td>
<td>-10 ; +10</td>
<td>-13 ; +13</td>
</tr>
<tr>
<td>2</td>
<td>Alignment</td>
<td>10 m chord</td>
<td>-4 ; +4</td>
<td>-10 ; +10</td>
<td>-13 ; +13</td>
</tr>
<tr>
<td>3</td>
<td>Gauge</td>
<td>n/a</td>
<td>-3 ; +5</td>
<td>-5 ; +15</td>
<td>-9 ; +30</td>
</tr>
<tr>
<td>4</td>
<td>Cant</td>
<td>n/a</td>
<td>-3 ; +3</td>
<td>-10 ; +10</td>
<td>-15 ; +15</td>
</tr>
<tr>
<td>5</td>
<td>Twist</td>
<td>3 m</td>
<td>4 mm or 1:800</td>
<td>7.5 mm or 1:400</td>
<td>10 mm or 1:300</td>
</tr>
</tbody>
</table>
much as the other parameters, due to being constrained by the concrete sleepers, pads and fasteners. Giving equal weights to all five parameters is considered an accepted method, but this approach does not take into consideration the engineering importance of the different parameters.

The TQI parameter provides all parties (operator and maintainer) with an accurate, overall quality index of the track. The parameter can be used to evaluate the general condition of the track, and for studying time- or traffic-related trends in the deterioration of the track. The parameter is insensitive to single exceedences and can therefore not be used for location-specific maintenance planning.

The following general classification [8] is used to describe the four different track classes:

- \( TQI \leq 1.4 \) : Excellent
- \( 1.4 < TQI \leq 1.6 \) : Good
- \( 1.6 < TQI \leq 1.8 \) : Average
- \( 1.8 < TQI \) : Poor

**THE GAUTRAIN STATE OF GOOD REPAIR: SPECIFIC TO TRACK ASSESSMENT**

A track geometry condition measurement campaign conducted in March 2013 resulted in approximately 600 000 condition records for five different parameters (profile, alignment, gauge, cant and twist). These parameters were used to calculate the track quality index as presented in the TQI formula for the total system, based on a 200 m running average.

The five parameters are measured every 250 mm, and each 200 m section is therefore made up of 800 records. The running average is calculated by means of analysing records 1–800, followed by 2–801, followed by 3–802, and so forth, in an attempt to minimise the averaging out of poor track areas. This calculation provides a statistical representation (cumulative frequency plot) of the system’s overall condition index as presented in Figure 2.

Figure 2 is divided into 3 distinctive areas. The first, shown in green, represents the condition of the Gautrain system that performs within the construction or installation parameters. If a section of track performs within this area, it denotes a condition attribute to the section as being in excellent condition. Track in this area requires no maintenance at the specific point in time (March 2013 measurement campaign). The analysis indicates that the performance of the total system is well within the defined standards. In general it can be said that more than 85% of the system is in excellent condition.

The second portion in Figure 2, shown as two variations of the colour orange, represents the section of line that requires planned maintenance. This can be translated into the distance of the railway section requiring planned maintenance. Planned maintenance is defined as activities that will not disrupt the immediate service delivery to passengers. These activities are planned in advance according to standard processes and procedures developed and implemented throughout the Gautrain organisation. These maintenance sections are recorded as work orders in Gautrain’s work management system, and coordinated with the train operations unit (BOC), where the maintenance organisation (BMC) will apply for work permits to execute the required maintenance at specified locations. The train operations unit, granting these working permits, ensures that the required capacity is maintained, thereby enabling availability of the infrastructure at a required and specified standard. In March 2013, Gautrain’s track geometry condition resulted in approximately 94% of the line performing within the “good” track classification band (i.e. \( TQI \leq 1.6 \)).

The section indicated in red in Figure 2 represents the portion of the line that requires corrective maintenance. Corrective maintenance is required when the geometry of a section of line is above the threshold level, requiring intervention to rectify the problem. It should be stated that these areas have to be investigated and analysed in
detail to determine the root cause(s) of the underlying problem. Furthermore, it should also be noted that some of these areas or sections that perform below the defined intervention thresholds could be built-in defects within the system. For example, a turnout condition performance, utilising the track geometry data, will indicate an area performing below the required standard due to the nature of a turnout’s function and its configuration within the system. This should be taken into consideration when determining the performance of the total system. Figure 2 reveals that in March 2013 only 4% of the total system fell within this category. Compared to world best practice, it is expected that approximately 15-20% [9] of the total maintenance activities will be related to reactive/corrective maintenance.

CONCLUSION
Related to the State of Good Repair, and based on best practice condition assessment data of a transportation facility, it can be expected that some natural deterioration would occur due to utilisation. From the analysis results it is clear that the Gautrain system’s current State of Good Repair is predominantly in excellent condition. It is the opinion of the authors that the system, specifically related to track (superstructure as well as substructure) is performing according to design, is well maintained and that currently, only normal, planned maintenance is required. The system can be qualified “as good as new” after approximately three years of operation from OR Tambo International to Sandton, and after 20 months for the remainder of the network.

REFERENCES
NEW! Now available for AutoCAD 2013
Operational, network and infrastructure selection criteria for tamping machines

INTRODUCTION

There are many different tamping machine models available, each designed for a specific purpose. Applying the wrong machine could mean either under-utilising the machine at an increased cost per sleeper, or the machine being incapable of completing the tamping cycle in the allotted time at an even greater cost in terms of track deterioration. In addition, when choosing a tamping machine for a railway or track section, various operational, network and infrastructure considerations, such as the length of the line, the traffic density, the number of turnouts on the line, etc, must be considered.

SELECTING THE APPROPRIATE TAMPING MACHINE

The following are some of the considerations to be taken into account when deciding on the appropriate tamping machine for a particular line or section:

Calculating the tamping cycle based on traffic throughput

Condition-based maintenance is regarded as the most efficient maintenance strategy for track infrastructure. However, a railway must budget for the maintenance requirements in advance in order to ensure that the necessary machinery is available when required. The tamping cycle must therefore be determined and is especially important when there is a change in traffic or tonnage throughput, axle loading, etc, which will change the status quo. The following is an empirical formula that is often used to determine the expected tamping cycle on freight lines in South Africa:

\[
\text{Tamping cycle in months} = 48 \div \sqrt{\text{annual throughput in MGT}}
\]

If the annual throughput on a particular line is expected to be, for example, 5 million gross tons (MGT, i.e. the total tonnage including the weight of the rolling stock), the tamping cycle will be approximately 21 months if the above formula is used. In other words, the same spot on the line must be tamped again 21 months after the previous tamping cycle. However, one should consider that at lower traffic volumes other external factors may influence the tamping cycle. If the expected traffic is 50 million gross tons, for example, the expected cycle will be approximately 6.8 months.

Calculating the tamping cycle based on axle loading

The above empirical formula for calculating the tamping cycle is based on freight trains with an axle loading of approximately 22 to 26 tons. Dynamic track stabilisation is recommended after any ballast maintenance including tamping. Using the formula with stabilisation may increase the track durability by up to 30%, providing a tamping cycle which will ensure a line of high quality.

For higher axle loadings of 26 to 30 tons the formula may prove to become increasingly conservative, and dynamic stabilisation becomes a necessity. Other external factors, such as climatic conditions and general track conditions, should then also be considered to ensure that the tamping cycle is not too low, causing secondary damage to the track.

For axle loadings in excess of 30 tons, the formula will be inadequate to maintain the line without secondary track damage caused to the rest of the track structure due to poor geometry. We do not have the experience in South Africa of such high axle loadings, but it is certain that the empirical formula would have to be adjusted for an exponential increase in the tamping cycle.

On light axle load lines, such as for commuter trains, the formula may at first seem to be too liberal, but here the train speed needs to be considered. Even small track geometrical defects will have an effect on passenger discomfort. As the speed increases...
to the level of rapid rail links such as the Gautrain, the dynamic effects of small geometric defects increase. As a rule of thumb, the same formula should therefore apply to light axle load commuter lines, with stabilisation becoming a necessity as the train speed increases.

Calculating the tamping cycle based on the length of the line

In practice, various lines sometimes share resources such as tamping machines, in which case the tamping cycle of all the lines that share a machine or machines have to be considered. Double lines also have the advantage that traffic can pass on the adjacent line. To illustrate the influence of the length of line on the type and number of machines required, single lines of 500 km and 1 000 km respectively can be used as examples, together with the above throughput figures of 5 MGT and 50 MGT.

Maintenance planners should always aim to have as few machines on the line as possible, because of their disruptive effect on traffic, especially on single lines where substantial planning and resources are required for each machine, and for each additional machine. Where higher production is warranted, higher-production machines have a lower resultant unit cost of maintenance than lower-production machines. However, the choice will always be between one or more universal tamping machines which can tamp both turnouts and plain track, or two or more tamping machines which can be combined to perform these tamping functions.

Scenario 1: 5 MGT throughput on 500 km line

For the 5 million gross ton (MGT) throughput example, it means that a machine, or a combination of machines, must tamp a total of 500 km in a 21 month period before it theoretically starts at the beginning again. One would expect that a relatively low-production machine would be adequate for such low throughput. A tamping machine with a nominal tamping rate of 16 to 18 sleepers per minute will tamp a minimum of 960 sleepers in one hour. One can expect a maximum of about four working hours per day in a 240 working-day year. The machine will therefore tamp 3 840 sleepers per day. At a sleeper spacing of say 700 mm, it equates to 2.7 km tamped per day, or 54 km per month consisting of 20 working days. The effect of shorter sleeper spacing on heavy haul lines must be considered.

This tamping machine would therefore complete one cycle of 500 km in 9.3 months, which is much less than the required 21 months. Only one machine would therefore be required and a universal tamping machine would provide flexibility in that only one machine would be required for tamping the main line and the turnouts. As turnouts take longer to tamp than main-line, the number of turnouts should be considered. A line of such low throughput is more likely to share resources. Higher-
production machines shared with other lines should therefore be considered, which would provide for lower unit costs of tamping.

**Scenario 2: 50 MGT throughput on 500 km line**

On a line with 50 MGT throughput the 9.3 month cycle will be too long since the required tamping cycle is 6.8 months. A faster machine, or more machines, would therefore be required. Staying with the concept of using one machine, a high-production continuous-action two-sleeper universal tamping machine, such as the 09-Dyna-Cat, may produce up to 32 sleepers tamped per minute (nominal) with integrated stabilisation. The machine will produce 7,680 sleepers tamped and stabilised per day (5.4 km/day or 108 km/month). This machine will therefore have a tamping cycle of 4.6 months, which is less than the required 6.8 months and leaves enough spare capacity for emergencies, turnouts, yards, etc. These are excellent circumstances to ringfence tamping, as ideal unit costs are possible.

**Scenario 3: 1,000 km line and/or high throughput**

For a 1,000 km line with the same throughput as above (50 MGT) and using the same universal tamping machine, the tamping cycle will still be 6.8 months, but a much longer line must now be tamped over this period. Even two machines will not have adequate spare capacity to maintain the tamping cycle of such a long line. A high-production plain-track tamping machine, such as the 09-3X continuous action tamping machine, combined with a lower-production universal tamping machine, such as the 08-16 mentioned before to tamp the turnouts and yards, will have to be considered as one of various scenarios.

**Calculating the tamping cycle based on the number of turnouts and curves on the line**

With the length of the line there are also other network considerations. Curves and turnouts may require a more frequent tamping cycle than plain (straight) track. The more curves and turnouts there are on the line, the more the machine will have to be moving up and down the line to satisfy the tamping cycles of turnouts, curved and plain track. As the line gets longer, one machine may be impractical, even if it is capable of keeping to the required tamping cycle. If emergencies and other sections that require more frequent tamping are also considered, such as those on weak or failing formations, the time the machine will be travelling between working areas may diminish the machine’s production. More machines of lower-production capabilities, spread along the line, may therefore be required.

**Calculating the tamping cycle based on the traffic and maintenance windows**

The above scenarios did not consider the number of trains required to increase the throughput from 5 MGT to 50 MGT. Even if longer trains are used to transport the freight, more frequent trains would still be required. The higher the traffic density, the less time will be available for maintenance and the shorter the maintenance windows will become.

Tamping machines will be required to tamp more sleepers in the shorter windows to keep to the required tamping cycle. Therefore, high-production machines would be required. On a single line more tamping machines cannot always be accommodated, since train slots must be occupied to create a maintenance window, and creating more than one maintenance window will have a severely negative effect on income-producing traffic.

**Calculating the tamping cycle based on the number of crossing loops and whether it is a double or single line**

Double lines are more flexible due to the fact that traffic can pass on the adjacent line. Single lines require more careful consideration of maintenance in general, due to the effect it has on traffic.

On high-traffic-density single lines tamping is often required to take place in-between trains, which means that the machine must vacate the line for oncoming traffic. This requires crossing loops where the train can cross the machine. If these crossing areas are too far apart, the machine may not be able to work for very long before it needs to start vacating the line. Once again, higher-production machines may be required and the travelling speed of these machines will also become important.

**CONCLUSION**

There are many considerations when choosing the appropriate tamping machine for a specific line or section. Unless all the selection criteria are considered, the most cost-effective machine or combination of machines will not be contracted, which may result in excessive costs and track infrastructure damage.

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**INFO**

Pieter van Blerk
Contracts Engineer
Plasser South Africa (Pty) Ltd
pietervb@plasser.co.za
BACKGROUND
With the constantly increasing demand for heavy freight transportation, railways have become an extremely important element in the economic wellbeing of any country, and particularly in a developing country like South Africa. It is thus the duty of track engineers to maintain a continued understanding of the rail track infrastructure. Track designs should be as cost-effective as possible and should be sensitive to the costs associated with the planning, development and maintenance of the track structure. Extensive and continuous research is therefore required to determine the influencing parameters and to maximise the track performance and the lifetime of the track structure.

Deformation of the track structure is a good measure of the structural capability of a track structure or of the expected track performance. This deformation is vastly dependent on the support of the track structure. The ballast support and the foundation of the track structure are therefore key components. Poor support will lead to large deformations, which in turn will accelerate track deterioration. This will increase the maintenance need and therefore the total cost of operating the asset within an acceptable functional condition.

THE PRIMARY OBJECTIVES OF THE RESEARCH
Track modulus is defined as the supporting force per unit length of rail per unit deflection and can be used as an enumeration of track performance. This research was aimed at finding an effective and simple way to determine track modulus and incorporated non-disruptive and mobile measuring techniques. An up-to-date record of track modulus, and thus track performance, will enable engineers to plan optimum maintenance operations and increase the potential revenue of the rail infrastructure.

The objective of this research was therefore to develop a simplified procedure for determining track modulus to provide track engineers with a useful tool to do quick and low-cost track modulus assessments.

TRACK DEFLECTION
Resilient and permanent deformations (deflections) are the two types of deformations occurring in the track structure, and represent the two most important aspects in the design and per-
formance of track formations. Figure 1 illustrates the difference between resilient and permanent deformation.

Resilient deformation (elastic deformation) is the recoverable deflection in the formation while train wheels are passing over the rails. The majority of the deformation caused by vehicle loading is recovered after the train has passed. Permanent deformation (plastic deformation) is deformation that is not recovered, hence it is the total settlement of the track structure over time after repeated loading (Gräbe et al 2005). The structural state of a railway track foundation can be computed by measuring the deflections (deformation) of the track subject to train loads. The state of the foundation will be reflected in terms of stiffness or track modulus (Bowness et al 2006). The focus of this project was on the resilient deformations caused by the wheel loads of passing trains. Permanent deformation is beyond the scope of this study.

As a result of the non-linear load-deflection relationship present in any track foundation, track deflection measurements can easily ignore the initial seating stiffness of the track. Equally important is the potential gap between the sleeper and the ballast, often referred to as a “blind slack”. Both these aspects manifest as initial soft or low stiffness of the track upon first loading, followed by increased stiffness as the load increases (Selig & Waters 1994). When the initial seating stiffness of the track or the possible presence of a slack is ignored in track deflection measurements, inaccurate track modulus and stiffness values are calculated.

**TRACK MODULUS**

Track foundation modulus, commonly referred to as track modulus, is defined as the supporting force per unit length of rail per unit deflection. Track modulus is thus a measure of the vertical stiffness of the track foundation and is related to the vertical deflection of the rail under a specified or known vertical wheel load. A related parameter, track stiffness, is a measure of the vertical stiffness of the whole track structure (effects of rail included).

Track modulus is closely related to track performance as it is a measure of the structural state of the track. The effects of the fasteners, ties, ballast, subballast and subgrade are included in the track modulus.

Track modulus is seldom measured and its magnitude is unknown for most sections of railway track. Track modulus is, however, regarded as an important parameter, and time should be taken to enumerate this parameter. The optimum value for track modulus should neither be too high nor too low. Too high a value (too stiff) would lead to fatigue, fracture and excessive vibrations. A too low track modulus value would cause unwarranted deformations and even permanent deformations (Selig & Li 1994).

Extensive research was done by Selig & Li (1994) to relate track modulus to track response parameters including rail deflection, sleeper deflection and subgrade surface deflection. An increase in track modulus generates a decrease in all deflection parameters.

According to Selig & Li (1994) the track component having the most influence on the track modulus is the subgrade.

A slight increase in the track modulus can be obtained by increasing the ballast or subballast modulus. The overriding factor, however, is the subgrade resilient modulus. By increasing subgrade resilient modulus with a factor of ten, an increase in track modulus by a factor of eight will be achieved. The small
effect of the ballast and subballast on track modulus, compared to the effect of the subgrade, can be attributed to the thin ballast and subballast layers, compared to the relatively thick subgrade layer. The subgrade modulus also varies significantly more than the ballast and subballast moduli.

An increase in the granular layer (ballast and subballast) thickness leads to an increase in track modulus. An increase in subgrade layer thickness leads to a decrease in track modulus. The explanation for this phenomenon is that the subgrade modulus is generally lower than that of the ballast and subballast.

The track foundation layer thickness and the moduli both influence the track modulus individually. There is, however, a greater effect on track modulus when these two factors are combined. The effect of the ballast and subballast moduli on track modulus increases with increasing thickness of the granular layer. The effect of the subgrade modulus on track modulus is equally important, regardless of the subgrade layer thickness.

Better track performance is normally achieved with a higher track modulus. Too high a track modulus will, however, not produce acceptable performance as it would lead to fatigue, fracture and excessive vibrations. The upper limit of track modulus has not been determined yet and many research and field experiments are needed to define a desirable value (Selig & Li 1994). Considering the content of the previous section, the following changes can be implemented to increase the track modulus if too low a track modulus is assumed (in decreasing order of efficiency):

- Increase subgrade resilient modulus.
- Increase granular layer thickness.
- Increase fastener stiffness.

If the track modulus is assumed to be too high, the opposite of the above actions should be taken.
This project focused on the simplified determination of track modulus by measuring deflections without any disruptions to normal railway operations. Transnet Freight Rail (Track Technology) and the University of Pretoria developed a system based on research by Bowness et al (2006) to measure deflections in a non-disruptive manner. This system is called Remote Video Monitoring (RVM).

Several methods have been developed by various researchers for the determination of track modulus. After careful consideration of these different methods, it was decided that an adapted version of the method by Kerr (1998) would be used.

A wagon (car) on two-axle bogies (trucks) as shown in Figure 3 is used to demonstrate this method, which in turn is based on the beam-on Elastic Foundation Method.

The expression for the rail deflection at the left wheel of Truck I (Figure 3), caused by all four wheels, is obtained using the following equation:

$$\delta(0) = \frac{PB}{2u} + \frac{PB}{2ue^{-\beta l^2}} (\cos \beta l^2 + \sin \beta l^2) + \left( \frac{nPB}{2u} e^{-\beta l^3} \cos \beta l^3 + \sin \beta l^3 \right) + \frac{nPB}{2u} e^{-\beta l^4} (\cos \beta l^4 + \sin \beta l^4)$$

Where (from Figure 3)

- $P_1 = P_2 = P$ and $P_3 = P_4 = nP$
- $n$ = factor to relate Truck I and Truck II, obtained by weighing
- $l_2, l_3, l_4$ = lengths between axles
- $\beta = \sqrt{\frac{4}{EI}}$
- $u$ = track modulus
Track modulus, $u$, is obtained by equating this deflection with the measured wheel deflection at the left wheel of Truck I, that is assuming $\delta(0) = \delta_{\text{measured}}$. This gives:

$$\frac{\delta_{\text{measured}}}{P} = \frac{\beta}{2u} [1 + e^{-\beta l} (\cos \beta l_1 + \sin \beta l_1) + n e^{-\beta l_2} (\cos \beta l_2 + \sin \beta l_2) + n e^{-\beta l_3} (\cos \beta l_3 + \sin \beta l_3)]$$

Where:

$\delta_{\text{measured}} = \text{deflection measured using the RVM system}$

Because the mass of the locomotives are known and additional weighing measurements could be avoided, it was decided that only the deflections caused by the locomotives would be analysed. Locomotive loads were assumed to be spread evenly across all axles. A moving train, whose deflections were captured by the RVM system, was assumed to be static at the point where the first locomotive wheel was in line with the RVM target. By making this assumption, dynamic factors were taken into account. The average of the wheel-induced deflections was used in calculations.

After repeated cyclic loading on a railway track, the ballast settles downwards. The result of this is an opening forming between the sleeper and the ballast bed. This opening is referred to as a slack, and the slack is taken up under a small initial load (seating load) before deflection of the structure takes place. Slack effects were taken into account by assuming the slack to be equal to the difference between the expected ballast deflection (affected by ballast modulus and original ballast thickness) and the measured ballast deflection. With these assumptions made, all the parameters in the equation, except track modulus, are known for a given field test. The track modulus can now be solved iteratively.

Figure 4 shows an example of typical deflection measurements using the RVM system.

Once the track modulus had been calculated, the subgrade modulus could be calculated using the equation below, based on the layer of springs method (Kerr 1998). This is, however, just a quick, only fairly accurate, estimation.

$$k_s = \frac{1}{\frac{1}{u} - \frac{1}{k_b}}$$

Where:

$k_s$ = subgrade modulus
$k_b$ = ballast modulus
$u$ = track modulus

**SITE DESCRIPTION**

Tests were conducted at the Bloubank Test Site which is located on the Transnet Freight Rail Coal Line between kilometre 60/16 and 60/17, with kilometre 0/0 at Vryheid and increasing kilometres towards Richards Bay. The RVM measurement instruments were installed at three stations at the test site. The three stations are at 5 m intervals. An averaging effect over the three stations was thus implemented. The three stations are indicated in Figure 5.

**RESULTS**

Answers obtained for track modulus and subgrade modulus are shown in Table 1. The same results are graphed in Figure 6.
Three different methods of addressing the possible presence of a slack were considered, namely:

- Ignoring the slack or seating stiffness in totality
- Calculating the slack using a ballast stress (calculated with GEOTRACK) with ballast modulus = 300 MPa, ballast stress = 400 kPa and the original ballast thickness = 300 mm, where slack = measured ballast deflection – expected ballast deflection
- Calculating the slack as equal to 15% of the measured ballast deflection

Figure 6 clearly demonstrates the effectiveness of applying the different slack effect consideration methods. From previous

| Table 1 Calculated track modulus and subgrade modulus |
|----------------------------------|---|---|---|---|---|---|---|---|
| Test no | Loading | Station 1 | | Station 2 | | Station 3 | | |
| | | Track modulus (MPa) | Subgrade modulus (MPa) | Track modulus (MPa) | Subgrade modulus (MPa) | Track modulus (MPa) | Subgrade modulus (MPa) |
| 1 | 7E | - | - | 39 | 46 | - | - |
| 2 | 7E | 19 | 21 | 33 | 38 | - | - |
| 3 | 11E | - | - | 43 | 52 | 156 | 415 |
| 4 | 11E | 25 | 28 | 45 | 55 | 100 | 167 |
| 5 | 7E | 33 | 38 | - | - | - | - |
| 6 | 19E | 31 | 35 | - | - | - | - |
| 1 | 7E | - | - | 95 | 153 | - | - |
| 2 | 7E | 95 | 153 | 104 | 178 | - | - |
| 3 | 11E | - | - | 125 | 250 | 163 | 468 |
| 4 | 11E | 161 | 452 | 148 | 363 | 119 | 227 |
| 5 | 7E | 97 | 158 | - | - | - | - |
| 6 | 19E | 108 | 190 | - | - | - | - |
| 1 | 7E | - | - | 46 | 56 | - | - |
| 2 | 7E | 22 | 24 | 40 | 48 | - | - |
| 3 | 11E | - | - | 51 | 64 | 182 | 669 |
| 4 | 11E | 30 | 34 | 54 | 69 | 114 | 210 |
| 5 | 7E | 40 | 48 | - | - | - | - |
| 6 | 19E | 37 | 43 | - | - | - | - |

Figure 7: Deflections measured at different stations
measurements at the test site, the track modulus is expected to be approximately 100 MPa – 150 MPa at the three measuring stations. Station 3 is the station with the least disturbance and subsequently the smallest slack. All three methods produce more or less the same track modulus. However, at Stations 1 and 2, a considerable slack is present. The second method, whereby the slack is calculated based on the expected ballast deflection, produces extremely realistic values. The third method slightly increases the track modulus in the direction of the expected value, but not adequately. For small slacks, this method is expected to also produce realistic values.

The average deflection measurements for the three test stations are indicated in Figure 7. The deflections measured in the formation remains constant for the different test stations. This is an indication of constant formation strength beneath all the test sites. The deflections measured on the sleepers, however, differ at the various test stations. These variations could be the result of different ballast conditions or different slack magnitudes at the different stations. Previous testing and disturbance of the ballast at these locations were responsible for significant slack formation at these test stations.

**DEVELOPMENT OF TRACK MODULUS CALCULATION PROCEDURES**

Two tools were developed to provide track engineers with a quick tool to calculate track modulus, namely Track Deflection and Modulus Charts, and a newly developed program, Track Modulus Calculator.

Both the Track Deflection and Modulus Charts and the Track Modulus Calculator, in combination with the RVM method, provide engineers with a quick tool to do a low-cost track modulus assessment. The deflections measured using the RVM method could be used to read off track modulus values directly from the Track Deflection and Modulus Charts. These charts, however, have limited options: only some rail types can be chosen from and slack effects are ignored.

**Track Deflection and Modulus Charts**

Track Deflection and Modulus Charts have been developed for 7E, 11E and 19E locomotives and different rail sections. If the deflection is known, these charts could be used for a quick estimate of the track modulus. It should be noted that the effect of slack was ignored during the preparation of these charts. The Track Deflection and Modulus Chart for UIC-60 kg/m rail is shown in Figure 8.

**Track Modulus Calculator**

The Track Modulus Calculator is an easy-to-use computer program developed to do quick calculations of track modulus and subgrade modulus. The calculations are based on the formulae used in the adapted Kerr (1998) method. Figure 9 shows a screenshot of the Track Modulus Calculator.

The calculator uses as input the vehicle, rail profile, assumptions related to the ballast stress, and lastly the measured sleeper (superstructure) and formation deflections. Most of the popular South African rail types are available to choose from. The user is allowed to choose from a set of pre-defined vehicles, but can also use custom dimensions and loads.

A choice is then given between the four methods of handling the slack or seating stiffness of the track. These methods include:

- Analysis of existing train control and operating systems
- Signalling asset condition assessments and reports
- Feasibility studies
- Operational incident investigations and route cause analyses
- Signalling failure investigations
- Procurement processes and tendering
- Systems design and project specifications
- Construction management
- Maintenance management
- Testing and commissioning of signalling installations

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no slack at all, a fixed slack (in mm), slack as a percentage of ballast deflection and calculated slack value using ballast deflection calculations. The output from the calculator includes the track as well as the subgrade modulus values.

A final advantage of the Track Modulus Calculator is that it displays a warning when unrealistic results are obtained.

CONCLUSIONS
The adapted Kerr method (1998) provides a simple procedure for determining track modulus. The effects of slack can be incorporated by making various assumptions. The calculation of slack as the difference between the expected and measured ballast deflection provides a useful method of ensuring accurate calculation of the track modulus. Depending on the magnitude of the slack, other methods have been proposed to take the slack or seating stiffness of the track into consideration when calculating track modulus.

The development of the Track Deflection & Modulus Charts and the program Track Modulus Calculator, in combination with RVM track deflection measurements, provides track engineers with a tool to do quick and cost-effective track modulus assessments. It is believed that these tools will be useful in the investigation of existing track foundation structures with a view to future rehabilitation or upgrading.

ACKNOWLEDGEMENTS
The authors wish to acknowledge Transnet Freight Rail for allowing the field tests on the Coal Line, as well as the staff of the Track Testing Centre (Track Technology) for providing assistance in carrying out the field work. TLC Engineering Solutions is also acknowledged for the development of the RVM software.

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Intermodal: where to?

With South Africa’s high logistics costs increasingly in the spotlight – and hampering our ability to compete in the global marketplace – the time is ideal for an ‘intermodal renaissance’ that will enable South African companies to leverage the strengths of both road and rail transport.

ROAD CONGESTION, fuel price uncertainty, and toll and environmental issues are further motivators for companies to join the intermodal renaissance at grass roots level, thereby helping to shape a logistics strategy that holds vast, untapped potential. The key to successfully entering these uncharted waters is, however, doing so with the right logistics partner.

Intermodal has been a discussion point for more than a decade, and has been hotly debated by a multitude of organisations and institutions – from government to Transnet to the private sector. In 2007 Maria Ramos in fact commented that growth in major corridors could only be addressed through sustainable intermodal solutions.

Putting intermodal into the limelight again is Transnet’s recent forecast of an increase in its general freight volumes (from 200 to 350 million tons by 2019), along with a 13% hike in its market share in intermodal traffic – taking it to 92% by the end of the decade. Transnet Freight Rail CEO, Siyabonga Gama, was quoted recently citing three commodities that definitely need to be moved by rail, namely agricultural products, chrome and granite. He also indicated that trucking companies are now customers of Transnet, focusing on the movement of goods over ‘the last mile’ to their destination. This is an early indication that logistic service providers are making a move from road to rail in southern Africa. IMPERIAL Logistics’ own intermodal transport strategy embraces the need to convert appropriate products from road to rail transport in southern Africa.

COMBINING THE STRENGTHS OF ROAD AND RAIL

This intermodal renaissance combines the strengths of both road and rail, to offer southern African companies the best of both transport modes. Far from being a threat, as perceived by some, it is an absolute opportunity, even an imperative. Utilising a hybrid form of transportation, intermodal unifies trucks, rail and sometimes cargo ships into one transportation system, utilising intermodal containers, so that shippers do not have to pack and unpack their goods at each stage of the journey.

Intermodal has been a discussion point for more than a decade, and has been hotly debated by a multitude of organisations and institutions – from government to Transnet to the private sector. In 2007 Maria Ramos in fact commented that growth in major corridors could only be addressed through sustainable intermodal solutions. Putting intermodal into the limelight again is Transnet’s recent forecast of an increase in its general freight volumes (from 200 to 350 million tons by 2019), along with a 13% hike in its market share in intermodal traffic – taking it to 92% by the end of the decade.
unpack their cargo each time the mode of transit changes. Intermodal, in a nutshell, improves efficiency and safety.

Rail is more economical and fuel efficient than road transport, with long-haul trains being between three and four times more fuel efficient than trucks, which is one of the reasons Warren Buffet bought all of the remaining shares of BNSF (one of the major Class 1 railways in the USA). When asked at the time why he did this, Buffet responded by stating that trucks have reached the peak of efficiency, while trains have not. Transnet CEO, Brian Molefe, clearly concurs, since he stated in a recent interview that the total supply cost of rail is 23% less than that of road.

Further factors in rail’s favour are its environmental benefits – less noise and air pollution and lower carbon emissions. Recent studies have shown that CO₂ emissions of trucks are up to five times more than other modes of transport. The hybrid transport solution presents unique benefits by combining the cost advantage presented by economies of scale over long haul with superior service qualities of road trucks and their flexibility over short distances. As a result, intermodal can offer competitive rates to customers over several years because of the stability of rail’s cost structure and long-term payback period. With a carbon tax on the cards, the ‘greening of the supply chain’ issue is not just about being environmentally aware. This is also an important, financial consideration going forward.

**LEVERAGING THE BENEFITS OF RAIL TRANSPORT**

Additional benefits of rail transport are lower road maintenance, policing and accident costs. Our growing population is contributing to an ever increasing number of road users, more congestion on our roads, and more strain on our road infrastructure. And while our roads are becoming increasingly congested, it is a well-known fact that general freight rail corridors have excess capacity, while the current investments in the rail industry will also create additional capacity in the next few years.

South Africa is in fact perfectly placed to reap the rewards of an intermodal transport strategy that combines the benefits of road and rail. Our main economic hub is Gauteng, which is some 600 km away from the nearest point of entry. This distance provides an ideal opportunity to leverage the advantages of rail, which yields the greatest economic benefits over long distances, and volume transport.

With South Africa’s high logistics costs a widely acknowledged impediment to our global competitiveness, a move to intermodal transport, and the associated cost benefits, would contribute to turning this around. The total logistics costs in South Africa in 2010 amounted to R339 billion, or 12.5% of GDP (Gross Domestic Product). In Europe and the USA, it accounts for approximately 7% or 8% of GDP. Our high logistics costs, 53% of which are spent on transport, need to be addressed in order for South Africa to compete in an increasingly global marketplace.

According to a recent statement by Transnet’s Molefe, the Transnet Market Demand Strategy will lower the cost of doing business in South Africa by an equivalent of 0.5% of the country’s GDP. The benefits of intermodal clearly outweigh the uncertainties. There has long been consensus on the benefits of rail, but it is time to move from consensus to action. There must be some trade-off between cost, speed and flexibility, but for the right company, and the right cargo, and in collaboration with the right logistics service providers, intermodal is an opportunity to be seized now. Intermodal in southern Africa will benefit the total supply chain.

**COLLABORATION IS KEY TO SUCCESS**

The challenges associated with rail have, in the past, deterred companies from considering this mode of transport, but the success of intermodal lies in collaboration – in particular with a trusted, experienced logistics service provider (LSP). Intermodal transport is complex, so the key is to have multiple parties coordinated by one LSP offering a seamless intermodal solution. This LSP also needs to provide the visibility that has, in the past, been a challenge associated with rail transport.

While the intermodal renaissance is still in its infancy in South Africa, and it will be some years before we see the results of Transnet Freight Rail’s R206-billion investment in rail projects, forward-thinking companies should make the move to intermodal transport now. In order for it to be the complete solution that it has the potential to be, significant investment in our rail and port capacity is a priority, along with an increase in mechanisation, and investment in technology. The tide is turning, and in partnership with the right LSP, companies can make the move to intermodal transport now, thereby spearheading the intermodal renaissance, and leveraging the advantages that rail plus road have to offer.

---

**Table 1**

<table>
<thead>
<tr>
<th>Intermodal Freight Movement and Energy Use in the United States, 2000</th>
<th>Trucks</th>
<th>Waterborne commerce</th>
<th>Class I railroads</th>
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</thead>
<tbody>
<tr>
<td>Number of vehicles (thousands)</td>
<td>2 643</td>
<td>41</td>
<td>20*</td>
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<tr>
<td>Ton-miles (billions)</td>
<td>1 093</td>
<td>646</td>
<td>1 466</td>
</tr>
<tr>
<td>Tons shipped (millions)</td>
<td>4 089</td>
<td>1 064</td>
<td>1 738</td>
</tr>
<tr>
<td>Average length of haul (miles)</td>
<td>717*</td>
<td>607</td>
<td>843</td>
</tr>
<tr>
<td>Energy intensity (Btu/ton-mile)</td>
<td>3 200</td>
<td>508</td>
<td>352</td>
</tr>
<tr>
<td>Energy use (trillion Btu)</td>
<td>3 498</td>
<td>328</td>
<td>516</td>
</tr>
</tbody>
</table>

*Number of locomotives

*717 miles is for general freight (less than truckload); based on data from the Eno Transportation Foundation, the average length of haul for specialised freight (truckload) is 286 miles.
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A new test track at the University of Pretoria

BACKGROUND

The Department of Civil Engineering at the University of Pretoria recently constructed a 30 m long railway test section on the University's Experimental Farm (better known as the “Proefplaas”) in Pretoria. The track will further enhance the university’s research capabilities in the railway environment. The project was made possible with the help of civil engineering students and sponsorship from industry. It was constructed as part of the Workshop Practice module presented to the first year students during the December/January 2012/2013 break. All the first year, and a few third and final year, civil engineering students assisted with the track construction which took approximately one month to complete.

DESIGN AND CONSTRUCTION

The track (30 m long and 4 m wide) was instrumented with various transducers for track substructure monitoring and full-scale railway track testing. Manholes were also constructed next to the track for access to the instrumentation running across the railway track and to control drainage. To keep the instrumentation safe, a control room was constructed next to the track.

The track structure was designed in accordance with Transnet Freight Rail’s 26 ton/axle heavy haul formation specification, similar to the Coal Line formation. The track components used are shown in Table 1. A lateral slope of 1:25 and a longitudinal slope of 1:115 were used for the drainage of the constructed layers. The drainage system was constructed with A10 bidim, a fin drain and geopipe.

The construction of the track was conducted by the civil engineering students. A TLB was used for major excavations and backfilling and a 2.7 ton dynamic roller was used for the compaction of the layer works. The 30 m x 4 m excavation was completed before the students started their work on the track. With their assistance, the trench was cleared and shaped in accordance with the design. This work included two small excavations along the sides of the trench for the drainage pipes. The base of the trench was compacted (Figure 1) and the geotextiles and geopipe were installed as shown in Figure 2.

<table>
<thead>
<tr>
<th>Table 1 Track components used for the construction of the test track</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Component</strong></td>
</tr>
<tr>
<td>Rail</td>
</tr>
<tr>
<td>Fastening</td>
</tr>
<tr>
<td>Sleeper</td>
</tr>
<tr>
<td>Ballast</td>
</tr>
<tr>
<td>Subballast</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Subgrade</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
The layer works were placed after the drainage system had been secured (Figure 3). The subgrade layer material used was sourced from the in situ material excavated at the same site. These layers (A-layer and B-layer) were backfilled in 100 mm increments, whilst removing all large rocks from the layers. The layers were compacted to the correct levels and were continuously monitored by surveying the settlements.

The subballast layer material (SB-layer and SSB-layer) was a mixture of G5 and G1 material, and these layers were also placed
in 100 mm increments. The compacted SB-layer is shown in Figure 4 and the final formation is shown in Figure 5. A 300 mm thick ballast layer was placed on top of the formation (Figure 6). The PY concrete sleepers and 60E1 LHT rails were then placed on top of the ballast and fastened with e-clips. The completed test track is shown in Figure 7.

RESEARCH POSSIBILITIES

The newly constructed test track on the University’s Experimental Farm provides exciting opportunities for further research in railway engineering. The facility will enable students and researchers to investigate railway track foundation behaviour with full-scale measurements, and testing of different components will be possible within a controlled environment. The following topics will be studied during 2013:

■ Full-scale stress and strain tests in a controlled environment
■ The effect of moisture on the strength of the track foundation under loading
■ The evaluation of earthworks specifications under loaded conditions and with different moisture conditions
■ The evaluation of Pencil pressuremeter tests carried out at different depths

Some tests have in fact already been conducted, and permanent instrumentation installed to monitor the condition of the track. Troxler density tests were done on each layer to ensure the compaction and quality of the layers. Light-weight
deflectometer (LWD) tests were also conducted on each layer at 3 m intervals to obtain the E-modulus values of the completed formation layers (Figure 8). Moisture sensors (three per layer) were placed inside each layer and at the surface of the bottom geotextile to monitor the moisture condition of the track Figure 9. To further investigate the moisture conditions, valves to control the flow of water out of the track were installed at the ends of the drainage pipes. This will enable researchers to control the moisture in the formation for studies into the effect of moisture on various other aspects.

Continuous surface wave (CSW) testing was done at the base of the excavation on the in situ material to measure the small-strain stiffness of the track foundation. Pipes were also installed across the track in the middle of each layer and will be used to monitor the deflection and settlement of the track, as well as for the development of new track instrumentation.

CONCLUDING REMARKS
The Chair in Railway Engineering at the University of Pretoria is excited about the opportunities that the new test track facility offers. Students will now have access to a short track section where formation behaviour will be studied and on which newly-developed instrumentation can be tested. The test track has been constructed in such a way that an array of formation and superstructure tests can be carried out to improve understanding of rail track behaviour.
ACKNOWLEDGEMENTS

The following organisations are gratefully acknowledged for their invaluable contributions towards this work:

■ VAE SA (Pty) Ltd for sponsoring the rails
■ Pandrol South Africa for sponsoring the fastening system and thermite welds
■ Aveng Manufacturing for sponsoring the sleepers
■ AfriSam for sponsoring the ballast and subballast materials
■ Geostrada for the soil and laboratory testing
■ Aveng Manufacturing – Lennings Rail Services for the placement of the sleepers and rails
■ University of Pretoria laboratory staff and personnel for assistance with laboratory and field testing

Figure 10: Transverse pipes for future formation layer instrumentation

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INTRODUCTION

Along the mountainous border of Lesotho, between Aliwal North and Barkly East, ran what was arguably the most scenic branch railway line in South Africa. Railway enthusiasts also know the line for the famous set of eight reverses (or switchbacks) that negotiate the difficult terrain of the Witteberge in the southern foothills of the Drakensberg. Although relatively short in length, its overall construction period was unduly long (28 years), spanning from March 1903 to December 1930, and included the puzzling abandonment of an essentially completed and particularly striking section. What circumstances interfered? Because of conflicting explanations, and other questions, a group of five civil engineers visited the disused line during October 2012, seeking answers to their questions. Comprising what came to be known as the 2012 Barkly East Railway Reverses Tour (BERRT), the participants offer these findings, hoping other engineers will visit this remarkable branch line in a magnificent part of South Africa.

LENGTHY CONSTRUCTION TIME

Although only 157 km in length, the line was constructed in four separate sections:

1. Aliwal North to Lady Grey, 64 km, constructed from March 1903 to November 1905. This was a relatively easy section, the only significant obstacle being the first crossing of the Kraai River near Aliwal North.

Figure 1: New railway lines completed in the Cape 1900 to 1909

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Cry, the beloved railway revisiting the Barkly East branch line

Prepared by the 2012 BERRT group:
Johannes Haarhoff, Francis Legge
Mike Johns, Bill James, Johan de Koker
2. Lady Grey to Motkop, 33 km, April 1910 to December 1913. This section was the most difficult, as the line had to cross the Karringmelkspruit, a deeply incised valley. It is here where six of the eight reverses were eventually built. Motkop comprised an insignificant temporary siding, a terminus necessitated by budget constraints.

3. Motkop to New England, 32 km, August 1914 to December 1915. New England was a more substantial terminus, better accessible by road from Barkly East and the surrounding farming country. This section was easy going without difficult obstacles.

4. New England to Barkly East, 28 km, after a 13 year delay, constructed from November 1928 to December 1930. This section crossed the Kraai River for a second time, and required two more reverses.

To the question why construction took so long, a short answer is that each section had to follow a similar, protracted procedure of lobbying, parliamentary authorisation of a desirable “new line”, and then awaiting parliamentary appropriation of the necessary funds (against fierce competition from many rival construction demands and requests). On each occasion insufficient funds were voted to complete the entire branch line – so, to complete the line, a new cycle had to be started. Economic and political conditions in the country also played a role:

- Section 1 was built at a time of national reconstruction following the end of the South African War, when almost every district was clamouring for rail access. Funds were stretched widely.
- Cape rail construction tapered off dramatically after 1905, as shown in Figure 1, and the line was implicated.
- From about 1906, large capital investment by government, which included new rail construction, was inhibited by the pending unification of South Africa in 1910, holding to the well-established principle that projects could only be approved if “those that have to pay have a voice in the expenditure incurred”.

Section 2 of the branch line was the exception to the rule, as it was started only one month before unification after aggressive lobbying by the Barkly East community, based on the fear that their line would never be approved under a new government covering a much larger area of jurisdiction. Of course, the line

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Figure 2: Map of the reverses area near Barkly East; the dashed line indicates the originally planned crossing of the Karringmelkspruit by a high bridge, eventually replaced by a series of six rail reverses (map originally drawn by Bruno Martin, published in Tracks Across the Veld by Boonzaaier in 2008, used with permission)

Manufactured by Westwood Baillie & Co in London in 1884, the three 40 feet (12.2 m) deck sections of the Karringmelkspruit rail bridge first served near Prieska before being moved to their present location in 1912/13

Concrete-lined over its entire 70 m, both portals of the abandoned rail tunnel incorporate one “SAR 1911” keystone; fine sandstone masonry is typical of the area
was absorbed into the South African Railways (SAR) upon unification.

- World War 1 (1914 – 1918) put an automatic stop to rail construction; the SAR had to divert its resources to, amongst other activities, connecting the South African and South West African railways in record time, and transporting troops and war supplies.

- Section 4 was authorised in 1925, when serious doubts were raised about the economic viability of branch lines in general. Critical examination of branch line proposals, coupled with difficult economic conditions, obliged a wait of three more years before construction started.

**CROSSING THE KARRINGMELKSPRUIT**
Between Aliwal North and Barkly East the most severe obstacle is presented by the Karringmelkspruit, east of Lady Grey. Tributary to the Kraai River,
During World War 1 a ship loaded with bridge material en route to South Africa was sunk by a German U-boat. (1978, The Great Steam Trek)

“During World War 1 a ship loaded with bridge material en route to South Africa was sunk by a German U-boat.” (1978, The Great Steam Trek)

The reverses were designed in 1923 by a German woman living in the area.” (1980, Volksblad)

“The reverses were designed in 1923 by a German woman living in the area.” (1980, Volksblad)

“During World War 1 a ship loaded with bridge material en route to South Africa was sunk by a German U-boat.” (1978, The Great Steam Trek)
of more than three months, a fourth temporary bridge restored regular service. During the first part of the interruption, there were no locomotives on the Barkly East side of the break, and some goods (mostly coal and mealie-meal) had to be transported by trolley. May brought more rain, and the mountains were white with snow. Supplies of food, coal and paraffin ran very low in Barkly East. Before its foundations were damaged, the third temporary bridge remained in service just long enough to allow two engines to cross to the Barkly East side of the break. Passengers had to cross the river in a boat at their own risk and goods were hauled across the river using two aerial wire cables. Partial service was thus restored.

One year later, in March 1926, the fourth temporary bridge was washed away and finally a permanent bridge was constructed by 30 July 1926. In exasperation the local newspaper (Barkly East Reporter) cried: “The whole affair has been a glaring example of how not to do things!”

At the other end of the line, 11 km from Barkly East, the Kraai River East crossing posed a similar problem as did the Karringmelkspruit. Approaching from the northeast the line descended steeply to cross the Kraai River at a reasonably low level. As the engineers tried to find a solution to the “difficult nature” of the Kraai River East crossing, construction was delayed three months beyond the promised date. Eventually the crossing was achieved by the use of two further reverses. Reverses have inherent disadvantages of slower average speed and limited train length, but they were adopted due to significant capital cost savings when compared to an alternative longer length of line. Six existing reverses on the branch line might have eased the decision to limit the capital outlay.

**SERVICE FROM 1905 TO 1991**

Finally completed all the way to Barkly East, the official opening of the line took place on 12 December 1930 – “Barkly’s Day of Days”. Starting at 10:00, the train with officials entered the station and the customary bottle of champagne was broken on the decorated locomotive. One of the three national Railway Commissioners, D Hugo, opened the line. Then there followed a public luncheon at 13:00, a fancy-dress carnival at 15:00, free films (“bioscope”) for children at 18:45, dancing in the town hall from 20:00, and free bioscope entertainment for adults from 21:00. Market Square was decoratively illuminated. “It is only once in the lifetime of a town that such an occasion as that which occurred on Wednesday last can be celebrated”, exclaimed the Barkly East Reporter.

By transporting agricultural products to urban areas, and providing rural access to industrial commodities, provision of rail access has always been seen as an instrument of national development. Following this philosophy, many earlier railway lines were approved despite doubts that they would ever pay their way. Branch lines, in general, performed poorly. In 1906, for
example, only two of the then 22 branch lines in the Cape system were profitable if capital redemption was included. Almost at the bottom of the list in terms of profitability was the Barkly East branch line. At the start of construction in 1903, the line had to compete with ox wagon traffic, which was still very much alive and well at the time, until legislation in 1909 removed ox wagons as an economic threat (and a local livelihood). But by the line’s completion in 1930, a new competitor had arrived in the form of motor transport, against which it would steadily lose ground throughout the ensuing 60 years. For economic reasons regular service was finally discontinued in 1991.

THE ACCIDENT OF 1992

On Saturday 10 October, during the 1992 Lady Grey Spring Festival, an entertaining race between train and runners was organised between Melk siding and Lady Grey. Upon the return of the train to Lady Grey, an evidently inebriated passenger illegally entered the cab of the locomotive, pushed the driver aside and pulled the regulator to full speed on a section posted with a 30 km/h restriction. By the time the train entered a sharp curve, speed had increased to 76 km/h and the locomotive and five coaches derailed in a curved cutting. Between the locomotive and the coaches behind, the first coach was crushed, killing five people instantaneously — the Lady Grey station master, his wife, and three children from the area. Four days after the accident the engine driver succumbed. A further 38 people were injured. Subsequently, a monument was erected at the scene of the derailment.

Following this accident, for similar future trips it was impossible to purchase insurance at reasonable rates. However, exactly nine years after the accident, on 10 October 2001, Bushveld Train Safaris ran the ultimately last trip over the line, a commemorative passenger train, after which the line was closed and no further trains were run. Coincidentally, the present BERRT group visited the site almost exactly 20 years after the accident.

A PLACE TO VISIT

Unsurprisingly, the writers highly recommend a visit to this unique part of South Africa’s railway heritage, incorporating, as it does, the only remaining railway reverses (the other two, between Volksrust and Newcastle, and near Van Reenen, were eliminated by subsequent realignment and upgrading). Testament to the local custodians of the line, the Barkly East branch, though long disused, remains intact and complete. Being “lovely beyond any singing of it”, the area will attract further railway enthusiasts and other tourists. Friendly farmers allow, by appointment, hiking along the line which mostly lies close to the main road. Furthermore, two heritage sandstone bridges built in the 1890s, both national monuments, are located close to the railway line. (In addition, celebrated high road passes, rock art, birding opportunities, fly fishing and modern rugged outdoor activities are supported by a range of accommodation opportunities.) Certainly the BERRT group is interested in all possibilities for resurrecting use of this branch line, perhaps by draisines and rail-bikes.

NOTE

Our visit resulted from a suggestion by Mike Johns; Francis Legge provided transport; Johan De Koker proposed preparation of this article; Johannes Haarhoff conducted the research and wrote the draft; with Bill James as picky technical and language editor. A list of documentary sources is available from the BERRT members. Photographs not specifically credited were taken by the 2012 BERRT group.
An overview of technical societies in the railway industry

INTRODUCTION
The railway industry is a multi-disciplinary environment, incorporating a wide range of engineering disciplines, as well as operational and technical skills, and expertise. Within this environment a number of technical societies serve and constantly strive to positively influence the railway industry and its people. This article contains a brief outline of the following technical societies that exist within the railway industry:

- SAICE (South African Institution of Civil Engineering), and specifically its Railway and Harbour Division
- PWI (Permanent Way Institution)
- SASRE (South African Society for Railway Engineering)
- IRSE (Institution of Railway Signal Engineers)
- IHHA (International Heavy Haul Association)

SAICE (SOUTH AFRICAN INSTITUTION OF CIVIL ENGINEERING)
As SAICE and its divisions and branches will be familiar to most readers, this section on SAICE is intended to provide only a brief overview.

SAICE’s mission statement is “to advance professional knowledge and improve the practice of civil engineering”. In support of this mission, SAICE strives:

- to be a learned society for all those associated with civil engineering;
- to enable our members, through consultation and accountability, to provide the community with environmentally and economically sustainable infrastructure;
- to cater for the interests and needs of our members by creating an effective communication channel in a strong, dynamic and stable organisation;
- to provide our members with continuing education in technical, managerial and communication skills;
- to advance and uphold the professional ethics of the civil engineering profession;
- to enhance the recognition of civil engineering as a highly respected profession and a desirable career; and
- above all, to encourage our members to strive for excellence in civil engineering.

The SAICE Railway and Harbour Division focuses on the planning, design, construction and maintenance of facilities for transport via railways, harbours and pipelines. The purpose of the Division is therefore to advance and expand the science and practice of civil engineering in the provision and maintenance of these facilities, and to promote the civil engineering profession in this field. This is pursued by the holding of meetings, a biennial symposium, technical presentations, site visits and social gatherings.

PWI (PERMANENT WAY INSTITUTION)
The Permanent Way Institution (PWI) serves all railway track engineers involved in the design, construction and maintenance of track and infrastructure. It has approximately 3 000 members in the UK and 420 in South Africa. The PWI was inaugurated in Nottingham, England, in January 1884, almost 130 years ago. This was the time when railway construction in South Africa had taken off in the Cape of Good Hope and in Natal. Today South Africa has the largest PWI section outside of the UK.

The PWI publishes a series of textbooks that are widely regarded as a reference library for railway civil engineers. It holds regular meetings through its various sections across the UK and beyond.
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- Railway and Civil Infrastructure Maintenance
- Water supply, Sewer reticulation, Waste water Engineering
- Roads, Structures and other Civil Engineering
- Feasibility Studies
- EPCM services

and holds highly regarded seminars and conferences to complement the regional meetings and to promote lively debate. It publishes a quarterly journal with technical papers, and hosts a comprehensive website with plentiful information available to those who need it.

The mission statement of PWI South Africa is as follows: PWI is a non-profit organisation, which is committed to adding value by promoting knowledge and development through the active involvement of PWI members, thereby assisting in continuous growth of the railway industry. The PWI is not involved with training, but shares knowledge through membership in a structured manner.

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SASRE (SOUTH AFRICAN SOCIETY FOR RAILWAY ENGINEERING)

SASRE was originally the South African Railways (SAR) Engineering Society (established in 1932), and for its first 58 years was run out of the former SAR Chief Mechanical Engineer’s (CME) office. For this reason it attracted members almost exclusively from the mechanical disciplines of the railways. Only SAR employees could become members, serve on the committee and have voting rights. Employees of private companies could only become associate members and had no membership rights. The CME was the Honorary President, his two assistant CMEs were the Vice-Presidents and all former CMEs were Honorary Life Members. Monthly meetings, at which technical papers were presented (and until 1989 were published in the form of an annual proceedings book), have taken place continuously since inception, apart from an interruption in activities during the Second World War. Visits to engineering concerns have also taken place regularly.

When Transnet was formed in 1990 and the SAR became Spoornet, the SAR Engineering Society had to change its name and became the South African Society for Railway Engineering (SASRE). At the same time the CME and the rolling stock divisions of the Chief Electrical Engineer’s (CEE) offices merged within Spoornet (today Transnet Freight Rail) to form a new division called Rolling Stock. SASRE then, for the first time, actively started recruiting members from the electrical engineering discipline.

The railway mechanical workshops (formerly also under the CME) separated from Spoornet and became Transwerk (later Transnet Rail Engineering and today Transnet Engineering (TE)), and SASRE continues to draw many of its members from amongst TE’s Johannesburg- and Pretoria-based employees.

The suburban railway ownership that also used to be part of the old SAR was removed from Transnet and given to the Department of Transport, and became known as the South African Rail Commuter Corporation (SARCC, today the Passenger Rail Agency of South Africa (PRASA)). As some of the Society’s members were part of this exodus from Transnet, SASRE chose to amend its constitution to cater for non-Transnet employees as full members, thereby allowing them to serve as committee members. In 1990, as part of the Society’s renaming, membership was therefore opened to anyone interested in railway engineering, be they from the private sector, government or Transnet. Over the past 20 years SASRE’s committee and the role of president has been occupied by a good mix of members from Transnet and the private sector.

So, whilst SASRE’s history was rooted in the mechanical engineering discipline, an effort has been made over the past 20 years to attract engineers and technical staff involved with the full spectrum of railway rolling stock, be they from the mechanical, electrical, materials, industrial or other engineering disciplines. SASRE continues to hold ten monthly meetings a year at which technical papers are presented. It also arranges visits to engineering concerns, hosts a golf day, an annual awards dinner and organises seminars on subjects of engineering interest. It continues to fulfil its founding constitutional mandate, which is to:

- promote the knowledge, widen the experience and increase the effectiveness of its members;
give members opportunities for discussing railway engineering subjects; and foster the interchange of ideas between members in the various spheres from which the members are drawn.

IRSE (INSTITUTION OF RAILWAY SIGNAL ENGINEERS)
The IRSE is the professional institution for all those engaged in or associated with railway signalling, telecommunications and allied professions. The IRSE has its headquarters in London, in the UK, and is active worldwide. Founded in 1912, the Institution aims to advance, for the public benefit, the science and practice of signalling and telecommunications engineering within the industry and to maintain high standards of knowledge and competence within the profession. The IRSE is a licensed body of the Engineering Council, and IRSE members at the appropriate levels, particularly in the UK, are encouraged to register with the Engineering Council as Chartered Engineers (CEng), Incorporated Engineers (IEng) or Engineering Technicians (Eng Tech).

The Institution publishes its own magazine, IRSE News, which brings members up to date with the latest Institution activities. Regular features include short technical papers, an events diary, membership changes, news about the activities of the IRSE Council and committees, and letters to the editor. The IRSE holds regular technical meetings in London and at major membership centres worldwide. A full report of the meetings is included in the IRSE Proceedings, a journal which is published annually.

The IRSE also holds half-day and full-day seminars designed to brief members on topics of current interest within the industry. An international convention is held every year with several days of presentations and technical visits to gain understanding of railway practice in different countries. About every four years, the IRSE holds an international conference lasting three days, with papers covering a broad range of developments in the science of signalling and telecommunications for railway applications.

IHHA (INTERNATIONAL HEAVY HAUL ASSOCIATION)
The International Heavy Haul Association (IHHA) is a non-profit, non-political organisation organised to facilitate and participate in the development or acquisition and distribution of knowledge germane to heavy haul railroad technology and operations. Membership is open to any heavy haul railroad regardless of country of origin. A heavy haul railroad is defined as one that meets at least two of the following requirements:

- Regularly operates or is contemplating the operation of unit or combined trains of at least 5 000 metric tons.
- Hauls or is contemplating the hauling of revenue freight of at least 20 million gross tons per year over a given line haul segment comprising at least 150 km in length.
- Regularly operates or is contemplating the operation of equipment with axle loadings of 25 tons or more.

The IHHA is dedicated to the pursuit of excellence in heavy haul railway operations, engineering, maintenance and technology. It strives to accomplish this mission through the acquisition of knowledge relevant to this goal by sponsoring and organising international and regional conferences, specialist technical sessions and specialist seminars; by commissioning guideline manuals; by preparing and distributing conference proceedings and technical documentation; and by related activities as recommended by the Board of Directors. The IHHA engages in a continual process of adaptation to ensure it satisfies the demands of state-of-the-art technical information that is relevant in a changing and developing industry.

The IHHA is a worldwide non-governmental, scientific and technological association of heavy haul railways and their advocates, and is incorporated in the State of Missouri in the United States of America as a not-for-profit association.

Based upon the work done by the Melbourne Research Laboratories of the Broken Hill Properties Co Ltd (BHP) for the Mt Newman Mining and Hammersley Iron railways in the Pilbara region of Western Australia, the idea sprang up in 1975-76 to disseminate the knowledge gained in that research programme with other heavy haul railways of the world. After discussions with other countries it was determined that they were not alone in their concerns and problems. Therefore, they sent out invitations world-wide to those railways that were involved in using dedicated unit trains to haul such commodities as coal, grain, iron ore, etc.

Members
The IHHA is governed by a Board of Directors, who are appointed by the member and associate member organisations to conduct the affairs of the association, and by a Chief Executive Officer appointed by the Directors. A Board of Directors Meeting is held annually in one of the members’ country.

The membership of the IHHA consists of national and state organisations, private railway systems, and railway organisations and advocates interested in furthering the exchange of technical information that will benefit the world’s heavy haul rail operations.

At the present time the membership of the IHHA is as follows:

- Australia – private railroads
- Australia – Australian Railway Association (public railroads)
- Brazil – VALE Companhia Do Rio Doce
- Canada – Railway Association of Canada
- China (People’s Republic of China) – China Academy of Railway Sciences
- India – Indian Railways, Ministry of Railways
- Russia – Russian Railway Research Institute (JSC VNIIZhT)
- South Africa – Transnet Freight Rail
- Sweden/Norway – Nordic Heavy Haul Association
- United States of America – AAR Transportation Technology Center
- Associate Member – UIC (International Union of Railways) World Division

ACKNOWLEDGEMENTS
The information with regard to SAICE and the SAICE Railway Harbour Division, the PWI, the IRSE and the IHHA was taken from their respective websites. The information about SASRE is gratefully acknowledged as having been provided by Mr Stuart Scott, the current SASRE Secretary. For additional information about any of these societies please contact the author.
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INTRODUCTION

South Africa has a magnificent 3 000 km coastline, with the Western Cape Province hosting the longest section of approximately 1 000 km. Our coastline supports a myriad of economic activities, such as fisheries, tourism-related developments, recreational facilities and residential development. However, the combination of rapid development and lenient coastal management regulations has resulted in the following “issues of concern” (DEAT State of the Environment Report 2006):

- Increasing uncontrolled coastal development, leading to habitat degradation and changing land-use patterns
- Substantial increase in the amount of wastewater discharged into the marine environment

It is clear there is a need to address the inappropriate exploitation of the South African coastline. The current buzz word is “Integrated Coastal Management” (ICM), but what is ICM? Briefly, ICM “promotes the use of defensible scientific information in conjunction with the principles of cooperative governance in order to achieve sustainable coastal development” (Celliers et al 2009).

The primary aim of this article is to offer a brief, critical analysis of the National Environmental Management: Integrated Coastal Management Act (Act No 24 of 2008), which was enacted on 1 December 2009 in Government Notice 32765 (referred to here as NEM: ICMA), with specific reference to its application to the coastal protection zone (CPZ) within proclaimed fishing harbours (PFHs). The article also aims to consider its effectiveness and associated shortcomings in the context of coastal development within the CPZ of PFHs in the Western Cape.

PRINCIPLES OF COASTAL MANAGEMENT

The NEM: ICMA is informed by the principles of the National Environmental Management Act (NEMA, Act no 107 of 1998, as amended) as adapted for the coastal zone in the nationally adopted White Paper for Sustainable Coastal Development in South Africa (DEAT 2000, cited in Celliers et al 2009). The principles of the NEM: ICMA are summarised in Table 1.

UNDERSTANDING THE COASTAL PROTECTION ZONE (CPZ)

The CPZ forms an integral part of the assessment of development within PFHs. Celliers et al (2009) explains that the CPZ consists of a continuous strip of land, starting from the high water mark (HWM) and extending 100 metres inland in developed urban areas zoned as residential, commercial, or public open space, or 1 000 metres inland in areas that remain undeveloped or that are commonly referred to as rural areas (Figure 1).

There are, however, some provisions to justify certain adjustments to this zone. The CPZ is established to manage, regulate and restrict the use of land that is adjacent to coastal public property, or that plays a significant role in the coastal ecosystem.

PROBLEM STATEMENT

Given the description of the CPZ, a problem emerges for development, since PFHs are always located within 100 m of the HWM. To assess the effectiveness of the NEM: ICMA, Saddler (2008) lists key perspectives from which the criteria for a critical analysis of the effectiveness of such an Act can be derived:

- Effectiveness and performance are interlocking ‘measures’ of success of the NEM: ICMA.
- An effectiveness review asks if the process and elements of approach function satisfactorily.
A performance review focuses on the results and outcomes.

Related concepts include efficiency, fairness and efficacy (Is this the best approach to do the job?).

New attention given to frameworks and measures for undertaking systematic, empirically-based evaluations of effectiveness of the EIA (Environmental Impact Assessment) at different levels and for particular components.

**LEVELS OF EFFECTIVENESS REVIEW**

Saddler (2008) proposed various levels of effectiveness criteria upon which to evaluate EIA effectiveness. This approach has been adapted in this article to consider the effectiveness of the NEM: ICMA:

- **Meta-evaluation** – relative success and utility of the NEM: ICMA as a legislative tool for managing the impact of proposals on the coastal environment
- **Macro-evaluation** – effectiveness and performance of ICM systems established by particular countries or international agencies
- **Micro-evaluation** – role and contribution of the ICM approach and components to specific proposals, value added at specific stages
- **At each level** the anatomy of the NEM: ICMA’s effectiveness can be dissected in relation to institutional, methodological and practical dimensions.

In order to achieve the level of assessment required to arrive at an objective determination of the NEM: ICMA’s effectiveness, the above approach is advisable. However, owing to limited resources, the critical analysis in the following sections of this article is of a subjective nature. Where possible, literature is cited to provide a more objective view.

---

**Table 1. National Environmental Management Act principles as adapted for the coastal zone of South Africa**

(taken from DEAT 2000, cited in Celliers et al 2009)

<table>
<thead>
<tr>
<th>PRINCIPLE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>National asset</td>
<td>The coast must be retained as a national asset, with public rights to access and benefit from the opportunities provided by coastal resources.</td>
</tr>
<tr>
<td>Economic development</td>
<td>Coastal economic development opportunities must be optimised to meet society’s needs and promote the well-being of coastal communities.</td>
</tr>
<tr>
<td>Social equity</td>
<td>Coastal management efforts must ensure that all people, including future generations, enjoy the rights of human dignity, equality and freedom.</td>
</tr>
<tr>
<td>Ecological integrity</td>
<td>The diversity, health and productivity of coastal ecosystems must be maintained and, where appropriate, rehabilitated.</td>
</tr>
<tr>
<td>Holism</td>
<td>The coast must be treated as a distinctive and indivisible system, recognising the interrelationships between coastal users and ecosystems, and between the land, sea and air.</td>
</tr>
<tr>
<td>Risk aversion and precaution</td>
<td>Coastal management efforts must adopt a risk averse and precautionary approach under conditions of uncertainty.</td>
</tr>
<tr>
<td>Accountability and responsibility</td>
<td>Coastal management is a shared responsibility. All people must be held responsible for the consequences of their actions, including financial responsibility for negative effects.</td>
</tr>
<tr>
<td>Duty of care</td>
<td>All people and organisations must act with due care to avoid negative impacts on the coastal environment and coastal resources.</td>
</tr>
<tr>
<td>Integration and participation</td>
<td>A dedicated, coordinated and integrated coastal management approach must be developed and conducted in a participatory, inclusive and transparent manner.</td>
</tr>
<tr>
<td>Cooperative governance</td>
<td>Partnerships between government, the private sector and civil society must be developed to ensure co-responsibility for coastal management and to empower stakeholders to participate effectively.</td>
</tr>
</tbody>
</table>
PROCLAIMED FISHING HARBOURS: A CONTEXTUAL OVERVIEW

The MLRA (Marine Living Resources Act No 18 of 1998, as amended) defines a fishing harbour as "a declared fishing harbour contemplated in Section 27(1)”, which reads as follows: “Subject to subsection (2), the Minister may by notice in the Gazette declare a harbour, or a defined portion of a harbour or a defined area of the sea and the seashore, to be a fishing harbour: (2) If the Minister desires to declare a commercial harbour or a portion of such harbour to be a fishing harbour, he or she shall obtain the prior approval of the Minister of Transport. (3) The Minister may, in consultation with the Minister of Finance, determine the fee payable in respect of the use of a fishing harbour or the facilities available in such a harbour.”

The Western Cape currently has twelve PFHs: Lambert’s Bay, St Helena, Läänepi, Saldanha Bay, Hout Bay, Kalk Bay, Gordon’s Bay, Hermanus, Gansbaai, Arniston, Storms Bay and Struisbaai (DEAT 2008).

CASE STUDY

PFHs are governed by the National Department of Public Works (NDPW), with the assistance of Marine and Coastal Management performing functional management duties.

Anyone familiar with the PFHs in the Western Cape will generally conclude that the infrastructure (buildings, roads, bulk services) is often in a state of disarray. This conclusion is supported by the Fishing Harbours Transitions Project, whereby DEAT and the NDPW initiated an assessment to "unlock economic potential within these harbours, in particular, those options related to tourism and economic development" (DEAT 2008). DEAT (2008) states that the following key factors have been considered in the assessment:

- Economic changes
- Changes in fish stocks
- Impact on local/surrounding community
- Infrastructure development
- Socio-economic impact

Table 2 Case study PFHs and related development applications (2002 – 2013)

<table>
<thead>
<tr>
<th>PFH</th>
<th>Proposed development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hout Bay</td>
<td>Crayfish and fish meal processing plant</td>
</tr>
<tr>
<td>Gordon’s Bay</td>
<td>Crayfish holding and tourism-related facility</td>
</tr>
<tr>
<td>Struisbaai*</td>
<td>Multi-functional retail, fractional ownership and hotel development</td>
</tr>
</tbody>
</table>

*NOTE: The proposed site is privately owned, but within the immediate PFH precinct.

Figure 1: The coastal zone of South Africa (Celliers et al 2009)

NOTE: The term “high water mark” means the highest line reached by coastal waters, but excluding any line reached as a result of (a) exceptional or abnormal floods or storms that occur no more than once in ten years, or (b) an estuary being closed to the sea (NEM: ICMA 2008)
Although the assessment has been concluded, the results have not been made available to the public. It cannot be stressed enough that, inasmuch as development within PFHs is required (by virtue of the fact that the DEAT and the NDPW have initiated the Fishing Harbours Transition Project), the potential exists to impact on the environment, more specifically within the CPZ.

As mentioned earlier, the CPZ criteria applied to urban areas cover a distance inland of 100 metres measured from the high water mark. This essentially means that almost all development within PFHs would result in development within the CPZ as defined in the NEM: ICMA (Section 17, Act No 24 of 2008). This reality results in a host of challenges, since no provision has been made for “harbour infrastructure and/or precincts”. This is the central and most fundamental issue that needs to be addressed with regard to the NEM: ICMA.

**The CPZ paradigm - a constrictive dilemma**

In the context of PFHs, an issue consistently arises when wanting to develop a fishing-related industry, such as a fish processing plant or a crayfish holding facility. This is further extended to tourism-related infrastructure and hospitality services. Table 2 summarises both the PFH and its related development proposals between 2002 and 2013.

The crux of the development dilemma resides with one common characteristic which applies to each of the case studies listed in Table 2. Inasmuch as the harbours in question have been proclaimed as “fishing harbours” in accordance with the MLRA, immense resistance to development from the general public occurred for each development proposed. Ironically, both the Hout Bay and Gordon’s Bay proposed developments are consistent with the very nature and intent of a PFH. It stands to reason that each of the proposed developments warranted an EIA that is more substantive and detailed than a Scoping Checklist and Scoping Report in terms of the Environment Conservation Act (Act No 73 of 1989, GN 1183, 5 September 1997, as amended) or a Basic Assessment in terms of the National Environmental Management Act (Act No 107 of 1998, GN 386, 21 April 2006, as amended).

In undertaking the requisite EIA, public engagement (or opposition) consistently manifested itself as a major hurdle in terms of resolving conflict, which in essence cascaded to the decision-making authorities having to weigh up the respective anticipated environmental impacts with that of fishing-related development within PFHs.

This dilemma continues to prevail, since the NEM: ICMA emphasises the need to ensure public engagement when planning to construct certain types of infrastructure within the CPZ (limited in this case to urban areas, thus 100 metres from the high water mark in a landward direction). The requirement of having to undertake an EIA in terms of Section 63 (1) of the NEM: ICMA is necessary to aid the developer in understanding the potential impacts that the proposed development could have on the receiving environment and vice versa. Also, this approach, in theory, assists the decision-making authority (in the Western Cape: the Department of Environmental Affairs and Development Planning) to arrive
at an informed decision whether to authorise the development or not. It is further noted that, even if an environmental authorisation (formerly known as a Record of Decision in terms of the Environment Conservation Act) is granted, a number of other additional legislated processes may be required, such as the re-zoning of the proposed site, permits for the release of effluents and/or air emissions, and so on.

A constractive dilemma emerges for each of these case studies. In general, development is simply not supported by residents in close proximity to PFHs. Development is halted due to extended EIA processes, which almost inevitably trigger appeals, and in the case studies considered might be followed by an application for judicial review.

### COASTAL MANAGEMENT PROGRAMMES AND COASTAL PLANNING SCHEMES: THE BEGINNING OR THE END?

When considering coastal management solutions, the NEM: ICMA provides two innovative tools which can aid ICM. The first tool is termed a Coastal Management Programme (CMP), which is defined as “the national or a provincial or municipal coastal management programme established in terms of Chapter 6 (NEM: ICMA, 2008)”. Celliers *et al* (2008) state that CMPs are developed in all three spheres of government, as illustrated in Figure 2.

The provincial CMPs must be established to be consistent with the National CMP, and the municipal CMPs must be

### Table 3 Assessment of the effectiveness of the NEM: ICMA (adapted from Sadler 2008)

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>DESCRIPTION</th>
<th>SUBJECTIVE OPINION</th>
<th>RATIONALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meta-evaluation</td>
<td>Relative success and utility of the NEM : ICMA as a legislated tool for managing the impact of proposals on the coastal environment</td>
<td>Yes</td>
<td>Although in its infancy in terms of recorded cases, the legal framework appears to be consistent with international best practice, as well as the South African Constitution and the principles of the NEMA. Section 63 (1) of the NEM : ICMA calls for an EIA which will add value to decision-making for development within the coastal environment and, more specifically, within the CPZ.</td>
</tr>
<tr>
<td>Macro-evaluation</td>
<td>Effectiveness and performance of ICM systems established by particular countries or international agencies</td>
<td>Yes</td>
<td>As stated above, the NEM : ICMA is aligned with international best practice and will go a long way towards protecting development within the coastal environment. However, when considering development within harbours (in this case PFHs), the NEM : ICMA is not clear on how it will address development issues.</td>
</tr>
<tr>
<td>Micro-evaluation</td>
<td>Role and contribution of ICM approach and components to specific proposals, value added at specific stages</td>
<td>Partial</td>
<td>The NEM : ICMA is well structured and resonates consistently within the legal framework of South Africa. The value-adding component, however, remains a point of contention with regard to development specifically within a PFH. The NEM : ICMA could have provided specific requirements for development within PFHs, as they are by design considered a protected area, as opposed to exposed natural coastlines. Value-adding at specific stages is viewed as a critical factor in terms of the effectiveness and appropriateness of the NEM : ICMA. No distinction is provided in the NEM : ICMA to allow for streamlined development applications in this regard. It is a further concern since an EIA will, in most cases, be required. Public Participation will remain the central most significant issue in terms of development within a PFH. Much emphasis is placed on the CMP and CPS tools which, if compiled appropriately, may result in a beneficial effect on prospective development within a PFH. The issue of public participation needs to be controlled and the NEM : ICMA does not allow for a strictly regulated public engagement that meets the development needs within PFHs.</td>
</tr>
<tr>
<td>Dimensional Effectiveness</td>
<td>At each level, the anatomy of the NEM : ICMA effectiveness can be dissected in relation to institutional, methodological and practical dimensions</td>
<td>Yes</td>
<td>Upon review of the NEM : ICMA it seems apparent that well-structured responsibilities have been legislated, which includes cooperative governance from national, provincial through to municipal levels. Methodologically the NEM : ICMA provides for sound consideration of planning and natural environmental conditions, which will prove valuable for coastal development in general, especially for exposed coastlines. However, this seems to rely on the CMPs and CPSs for effectiveness in relation to PFHs.</td>
</tr>
</tbody>
</table>
established to be consistent with both the provincial and national CMPs (Celliers et al 2008). Chapter 6, Part 7, titled “Coastal Planning Schemes”, has reference.

Section 56 (1) defines a Coastal Planning Scheme (CPS) as “A scheme that facilitates the attainment of coastal management objectives by:
(a) defining areas within the coastal zone or coastal management area which may:
(i) be used exclusively or mainly for specified purposes or activities; or
(ii) not be used for specified purposes or activities; and
(b) prohibiting or restricting activities or uses of areas that do not comply with the rules of the scheme.”

Section 56 (3) states: “A coastal planning scheme may be established and implemented for an area within the coastal zone by:
(a) the Minister, after consultation with the MEC and with any authority that is responsible for managing an area to which the planning scheme applies, if the planning scheme applies to:
(i) an area of coastal public property and is established to protect and control the use of marine living resources or to implement national norms or standards…”

CMPs and CPSs appear to be useful tools in terms of reaching the objectives of the NEM: ICMA as defined in Section 2 of the Act (No 24 of 2008). The cornerstone of both these tools includes public participation in accordance with the principles of cooperative governance as set out in the NEMA (Act No 107 of 1998, as amended) (Celliers et al 2008).

Celliers et al (2008) summarise Section 53 (1) of the NEM: ICMA titled “Public participation” as “the public consultation process generally includes three steps, viz consultation with the appropriate government officials (generally the Minister, MEC or municipal official), reasonably accessible publication or broadcasting of intent, and finally, notification in the Government Gazette”. The notice in the Government Gazette must provide sufficient information, in order for the public to submit written representations or objection to proposed actions within a period of 30 days (Celliers et al 2008).

The success of CMPs and CPSs can be viewed from both a proactive/optimistic and a conservative/pessimistic perspective. This is qualified by the reality that development applications within PFHs have been met with significant opposition (Hout Bay – Bluefin Holdings, 2002/5; Gordon’s Bay – ViakorSewe, 2004/5; and Struisbaai – Golden Falls Trading 193, 2006/10) from interested and/or affected parties (I&APs). Involving people in the design and implementation of policies and strategies for environmental management is crucial on both ethical and sustainability grounds (Furtado et al 2000 cited in Holmes-Watts 2008).

Each of the three case studies revealed ‘ethical dilemmas’ consistent with Fuggle & Rabie (2009) – “conflict furthermore arises from diverse needs and perspectives such as: anthropocentrism versus ecocentrism (Barrow 2005 cited in Fuggle & Rabie 2009), or protectionism versus quality of life sentiments.” Quality of life sentiments have resonated consistently throughout the EIAs that were conducted for each of the case studies, which contributes a cautionary optimistic ‘thumbs up’ to public engagement as required by the NEM: ICMA (note, this opinion is reserved within the context of developing within a PFH only).

Owing to I&AP opposition, as confirmed in the aforementioned three case studies, the question remains to what degree development within PFHs will be supported or impeded.

The NEM: ICMA does not specifically acknowledge PFHs as areas that are proclaimed for the purposes of fishing-related activities, and relies on the MLRA, Section 27 (1) to establish a proclaimed fishing harbour. The NEM: ICMA provides two tools to aid ICM, in the form of CMPs and CPSs. However, history shows that public engagement is, for the most part, anti-development. Earlier in this article it was mentioned that a government initiative, the Fishing Harbours Transition Project, is currently under way to upgrade PFHs. However, in light of the requirement in terms of Section 63 (1) of the NEM: ICMA...
that calls for an EIA, public engagement may raise its head as the ‘Achilles heel’.

Although this assumption may be viewed as nonsensical, it appears that in each of the case studies the very essence for which a PFH was created is in many instances being controlled by the general public and surrounding residents as a consequence of the need to undertake an EIA.

Table 1 refers to “Social Equity”, a principle of the NEM: ICMA (as adapted from the NEMA principles), which reads as follows: “Coastal management efforts must ensure that all people, including future generations, enjoy the rights of human dignity, equality and freedom” (DEAT 2000). It is submitted that this principle holds true for exposed coastlines, namely natural coastlines, and not necessarily for PFHs.

Users within a PFH are protected to a large degree from storm surges and/or coastal processes such as tidal fluctuation. Upon review of the NEM: ICMA, it is evident that no cognisance has been taken of fishing harbour infrastructure, which means that any development within a PFH is subject to the same legal process(es) as required for a fully-exposed development within a natural coastal system.

The effectiveness of these CMP and CPS tools with regard to their influence on development within PFHs will be questioned. To date, no CMPs are available, as the NEM: ICMA only came into effect on 1 December 2009, and a period of four years (Sections 44, 46, 48 of the NEM: ICMA) has been allowed for each respective level of government to compile a CMP (NEM: ICMA 2008). Table 3 lists each of the effectiveness criteria, and assesses the degree of NEM: ICMA effectiveness.

CONCLUDING REMARKS

Glazewski (2005) stated that there is a worldwide trend to promote the notion of integrated coastal management in coastal states. In order to achieve integrated coastal management it has been proposed that the following main functions are key: “area planning, promotion of economic development, stewardship of resources, conflict resolution, protection of public safety and proprietorship of public submerged lands and waters” (Cicin-Sain & Knecht 1998, cited in Glazewski 2005).

This article focused on a critical analysis of the NEM: ICMA as it relates to development within PFHs, and the text in bold in the preceding paragraph reaffirms the three key issues that impact on development within PFHs in the Western Cape.

The true challenge posed to development prospects within PFHs remains with the demarcation of the CPZ and the effectiveness of the CMPs and CPSs. In each of the above-mentioned case studies, development within a PFH was met with significant resistance from the public. The key point is that development is hampered within PFHs for the very reason they were created. The answer to the question of whether the NEM: ICMA has missed an opportunity to be effective and successful as it pertains to PFHs, is considered to rest with the application of the CMPs and CPSs.

Fuggle & Rabie (2009) make reference to the phenomenon that “prevailing management efforts are failing to mitigate the impacts of coastal population growth and development intensification”. This reality has spawned the creation of acts such as the NEM: ICMA, and the paradigm shift to ICM has merit. However, the NEM: ICMA falls short of providing adequate insight to development within the PFHs of the Western Cape,

which is considered to be a fatal flaw. This is further exacerbated by the current trend in South Africa to develop within the “urban edge”, thus promoting densification. The result is a conflict between the need to develop within a PFH and the resistance from local residents, who do not support development that will affect the sense of place and heritage to which they have become accustomed.

ACKNOWLEDGEMENTS

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BIBLIOGRAPHY / REFERENCES


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The design and implementation of a framework for assuring the delivery of services on PPP projects

INTRODUCTION

Currently, there is an increasing trend for governments to use Public Private Partnerships (PPPs) as a vehicle for achieving successful outcomes for large government projects. Although the precise reasons for this are often complex, the main motivation is that the PPP model enables governments to transfer almost all project risks to another party, the Concessionaire, which has the capability to perform the necessary work. The downside for the government party (GP) is that it can expect to pay a premium for the Concessionaire’s carrying the increased risk.

The result of the above broad scenario is that the positioning of the parties in a PPP contract (the Concession Agreement) differs fundamentally from the positioning of the parties in normal agreements where the government enlists the services of contractors. In a PPP contract, the Concessionaire’s role is to deliver the project in accord with the requirements of the Concession Agreement, while retaining full responsibility. The role of the government party (GP) is to monitor and report on all factors relevant to project progress without relieving the Concessionaire of any of its responsibilities. Put more simply, this means that, on a PPP project, if the GP considers that the Concessionaire is experiencing problems which are compromising the project’s agreed outcomes, the GP would be ill-advised to become involved to the extent that it does the Concessionaire’s work or tells the Concessionaire what to do, since this risks reducing the responsibilities of the Concessionaire or transferring risk back to government.

Therefore, in these circumstances, the principal role of the GP is one of ‘assurance’. Although this would seem to be a straightforward role, there is scope for many misunderstandings relating to how this role should be performed on PPP projects. It is worthwhile to point out that the assurance conducted by the GPs differs considerably from that performed by the Concessionaire. In particular, the Concessionaire’s assurance staff perform their role with full access to (and knowledge of) the Concessionaire’s systems and processes information. In contrast, the GP’s assurance staff are not in possession of this information and the required information is often not made available by the Concessionaire. This means that the GP’s approach to assurance cannot rely on the standard techniques alone, but must be tailored to match the prevailing circumstances. These include:

■ The requirements of the Concession Agreement
■ The disposition of the Concessionaire in making information available to the GPs which depends on:
  * the Concessionaire’s perception of its risk in making information available,
  * the Concessionaire’s culture, and
  * the history of the relationship between the Concessionaire and the GPs.

The previous two articles discussed the assurance role of the GPs during the development phase of PPP projects. This article covers the operating phase of such PPP projects and presents a framework for assuring the Concessionaire’s delivery of services. Although this would seem to be a straightforward role, since the delivery of services should be capable of relatively easy measurement, the systematic approach proposed in this article provides insights which may escape a more superficial approach.

DEVELOPMENT OF A SUITABLE FRAMEWORK FOR SERVICES DELIVERY

The scope of services

The services to be provided by the Concessionaire during the operating phase of a PPP project are defined in the Concession Agreement. Such services relate to the Concessionaire’s complying with its obligations to operate and main-
tain the system defined in the Concession Agreement. The particular PPP project ‘system’ may involve almost any sector of infrastructural development: for example, it could be a transportation system (rail-, road- or airport-related), a building, relate to power and energy, the mining industry, or involve dams or hydropower. In every case, the Concessionaire would be responsible for providing the services stipulated in the Concession Agreement.

Quite apart from the technical detailed requirements covered within the Concession Agreement, it is also important that users of ‘the system’ receive an acceptable level of service and that the services are available, reliable and safe – on time and at an acceptable cost.

**A generic model for services delivery**

A model often utilised to manage improvement involves the process attributed to Deming:

**PLAN – DO – CHECK – ACT**

Applied to the provision of services by the Concessionaire, this model (the PCDA model) can be detailed as:
1. Plan the delivery of the services.
2. Deliver the services.
3. Check the delivery of the services.
4. Act on any differences between the planned services delivery and the actual services delivery.

**A process approach to the generic model**

Recognising that each stage in this improvement model (undertaken by the Concessionaire) constitutes a process, allows a detailing of the inputs and outputs of these processes.

The framework presented in Table 1 shows the four stages of the Concessionaire’s improvement model for services delivery, each stage being detailed as a process.

![Table 1](image)

**Table 1 A framework for improvement in the Concessionaire’s delivery of services**

<table>
<thead>
<tr>
<th>IMPROVEMENT MODEL</th>
<th>INPUTS</th>
<th>PROCESS</th>
<th>OUTPUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLAN THE SERVICES</td>
<td>FACTORS TO BE CONSIDERED</td>
<td>RESOURCE PLANNING PROCESSES</td>
<td>PLANS</td>
</tr>
<tr>
<td>DELIVER THE SERVICES</td>
<td>PLANS</td>
<td>OPERATING PROCESSES</td>
<td>SERVICES DELIVERY</td>
</tr>
<tr>
<td>CHECK THE DELIVERY OF SERVICES</td>
<td>INFORMATION ON SERVICES DELIVERY &amp; SYSTEM PERFORMANCE</td>
<td>INFORMATION ANALYSIS &amp; EVALUATION</td>
<td>SERVICES TO BE IMPROVED</td>
</tr>
<tr>
<td>IMPROVE THE DELIVERY OF SERVICES</td>
<td>SERVICES TO BE IMPROVED</td>
<td>IMPROVEMENT PROCESSES</td>
<td>ACTIONS TO IMPROVE</td>
</tr>
</tbody>
</table>

**A key observation is that the output of each process becomes the input of each subsequent process, thereby effectively decreasing the framework from twelve elements to nine elements. In terms of the GP’s assurance process, this introduces some obvious rationalisations, the important issue for the common elements being to provide assurance that the outputs of one process are used by the Concessionaire to provide the inputs for the subsequent process.**

**APPLYING THE FRAMEWORK TO ASSURE A CONCESSIONAIRE’S DELIVERY OF SERVICES**

**The assurance rationale**

As far as possible, the Concession Agreement would provide the basis for the services that the Concessionaire is required to deliver and the processes to be used. Where the Concessionaire...
Agreement either lacks sufficient detail or does not cover certain elements of service which are considered essential, ‘good industry practice’ (including the fulfilling of statutory requirements) would provide the basis for the Concessionaire’s processes.

The framework summarised in Table 1 provides a sound starting point for the government’s assurance function, which should address appropriately all stages in the Concessionaire’s processes for delivering services. The strategy utilised would be directed towards the outputs of the Concessionaire’s processes. Only if there is inadequate assurance that the outputs are satisfactory, or if the outputs are clearly unsatisfactory, should further information be required relating to the Concessionaire’s internal processes or to its process inputs.

**The assurance process**

The process by which the GP evaluates the efficacy of the Concessionaire in delivering its contracted deliverables involves four stages:

- **Planning**
  A risk-based Assurance Plan is produced by each GP discipline which identifies what needs to be done to be able to assess that the appropriate system is being used by the Concessionaire to fulfil the Concession Agreement requirements.

- **Gathering information by:**
  - Reviewing the Concessionaire’s systems and reports
  - Attending project meetings
  - Discussing issues with all involved parties
  - Arranging that assessments are performed, when necessary

- **Analysing and evaluating information**
  The information gathered is evaluated to determine what action, if any, should be taken by the GP (through the Concessionaire).

- **Taking action**
  If the GP is satisfied that the Concessionaire is exercising appropriate controls, no interventions are required beyond feedback to the Concessionaire that its systems are working satisfactorily.

  However, if the GP is not satisfied with the performance of the Concessionaire’s systems/controls, the GP must take the necessary action so that the Concessionaire addresses any deficiencies with appropriate urgency.

  In general, the need for action by the Concessionaire may be followed through by the GP according to the urgency and importance of the issue identified.

**Applying the assurance process to the framework**

Applying the GP’s four-stage assurance process to the 12-element framework provides the basis for the GP’s assurance procedures. For each element of the framework (for improvement in the Concessionaire’s delivery of services) the following questions must be asked:

- **How will the GP plan its assurance?**
- **How will the GP gather information?**
- **How will the GP analyse and evaluate the information?**
- **How will the GP take appropriate action?**

For example, if the GP has to provide assurance that the Concessionaire’s identification of ‘Services to be improved’ has been performed in a robust and systematic fashion, it must receive assurance that the identified services show a substantial deviation from what was planned. In order for the GP to feel confident that the identified services fall short of planned expectations, it may be necessary to ask what information was evaluated and how it was evaluated. Such an approach is ‘process-based’, with the quality of the process outputs being dependent on both the quality of the process used and the process inputs. Before pursuing this approach in more detail, there is benefit in first reviewing alternative methods of organising the GP’s assurance procedures in order to determine which method offers most benefits; this is discussed in the next section of this article.

**STRUCTURING THE GOVERNMENT’S ASSURANCE SYSTEM**

**Alternative approaches**

The framework presented in Table 1 gives several possibilities for structuring the GP’s suite of procedures for assuring the Concessionaire’s delivery of services. These alternatives will be presented and discussed in this section.

A suite of procedures can be developed using the 4x3 framework in the following different ways:

- **Service Partitioning**
  This involves the GP’s providing assurance by developing separate procedures to assure each service using the PDCA model in each case.

  In this case, the number of assurance procedures required could be as many as there are services. However, if the assurance procedure for many services is the same, then such services could be clustered and be covered by one procedure.

  This approach has the advantage that each assurance procedure would focus on a particular service or group of services, but suffers from the disadvantage that many procedures may be required.

- **Model (PDCA) Partitioning**
  This involves the GP’s providing assurance by developing separate procedures to cover each stage of the Concessionaire’s PDCA model.

  This could lead to a minimum of four assurance procedures, although, if the details of assurance varied considerably according to the service being assured, there would be a need to segment the procedure to cover differently-handled services. However, this would probably not be necessary since the overarching assurance process is the same in every case. The details that apply to the assurance of different services could then be detailed in attachments to the procedures.

  The issue of potentially clustering services (to which the same assurance approach would apply) would be identified at the GP’s assurance planning stage when services would be clustered into separate modules, and a particular quality assurance technique would be selected for each module.

- **Framework Element Partitioning**
  In this approach the GP would provide assurance using separate procedures to cover each element in the framework. This would lead to the development of at least nine separate procedures because the twelve elements of the framework would be reduced by the fact that the output of one process becomes the input of the next process.

  This approach would handle the clustering of services as discussed for ‘Model Partitioning’.

  Because there are many services under consideration, it is envisaged that attachments to these procedures may be required where further details of specific services could be provided.
Evaluating the alternatives

Alternative methods of partitioning the framework to produce a suite of assurance procedures yield no obvious preferred approach. However, each method possesses its own inherent advantages, and the process of examining the alternatives reveals some important insights.

Although the Model Partitioning results in only four procedures, each procedure could be quite complex if special treatment is required for each service.

The clustering of services, where similar or identical assurance methods are used, leads to rationalisations.

Service Partitioning has the advantage of focusing attention on a particular service. The assurance procedure would answer the question: How would the GP assure (by planning, gathering information, evaluating the information and taking action where necessary) that the Concessionaire had planned, delivered, checked and improved the delivery of that service?

Element Partitioning has the major advantage that it focuses attention on the Concessionaire’s activities required to deliver the services. Furthermore, the GP’s strategy of focusing initially on process outputs (Table 2) provides clarity of purpose that is easily captured within the scope of a particular procedure.

Although the clustering of services would be required to some extent, there are considerable advantages to be realised in addressing the quality of the Concessionaire’s plans, say, to deliver services within the body of a single procedure. Only if the quality of the plans was unsatisfactory would the GP interrogate the quality of the Concessionaire’s planning processes and the inputs to the planning processes.

Table 2 Focusing on process outputs

<table>
<thead>
<tr>
<th>PROCESS</th>
<th>PROCESS OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan the services</td>
<td>Plans</td>
</tr>
<tr>
<td>Deliver the services</td>
<td>Services delivery</td>
</tr>
<tr>
<td>Check services delivery</td>
<td>Services to be improved</td>
</tr>
<tr>
<td>Improve services delivery</td>
<td>Improvement actions</td>
</tr>
</tbody>
</table>

The preferred approach

In discussing alternative approaches to structuring the government’s assurance system, it is clear that each approach has inherent advantages and shortcomings. Although a variety of factors come into play, the preferred approach is often dictated by the natural default of decision-makers. In terms of the above three generic alternatives, it is proposed that Service Partitioning is probably favoured as a natural default, principally because it allows focus on the particular service under consideration.

While this approach has the potential to result in a relatively large number of procedures, subsequent rationalisations could reduce this number substantially.

Therefore, the following phased process is recommended:

1. Draft an assurance procedure for each service – except for services where it is clear that the process of assurance is identical.
2. Review the suite of procedures for potential rationalisations such as:
   a. Where procedures contain a considerable portion of common process, consider producing a single procedure which identifies service-specific differences in practice.
   b. Writing procedures in more generic terms to cover the specifics for individual services; where beneficial, the specifics can always be attached to a procedure as an addendum.
3. Revise the structuring of the suite of procedures and/or the procedures’ content.

Such an incremental, phased approach is often the most practical process, having the advantage that it builds on the most intuitive initial approach with perceptions of subsequent rationalisations being shared by team members with use of the system.

AN OVERVIEW OF THE APPROACH ADVOCATED AND A GENERIC EXAMPLE

When taking a process-driven approach to drafting systems of procedures, it is easy to become confused. Thus far, we have discussed the Concessionaire’s deemed four-stage model of services delivery (PLAN – DO – CHECK – ACT), with each stage in the model constituting a process with inputs and outputs. This leads to a 4x3 framework for the Concessionaire’s services delivery.

The government’s assurance process also consists of four stages (PLANNING – INFORMATION GATHERING – EVALUATION – ACTION), which are applied to the Concessionaire’s provision of services. As mentioned earlier, there are several ways in which procedures may be drafted, although covering each service within one procedure is favoured as a first step.

It therefore seems appropriate to provide a practical example, albeit generic, of how a procedure for assuring the Concessionaire’s delivery of a particular service may be drafted (see Table 3). It is hoped that this example will lead to valuable insights which will remove any potential confusion.

SUMMARY

A process has been explained for the government’s development of procedures to assure the Concessionaire’s delivery of services. The process involves:

1. Identifying the scope of services according to the Concession Agreement.
2. Modelling the Concessionaire’s process of services delivery using Deming’s model for improvement. The model consists of four sequential stages and has been applied to the Concessionaire’s Delivery of Services:

   PLAN ➔ DO ➔ CHECK ➔ ACT

3. Recognising that each stage in the Concessionaire’s improvement model constitutes a process, enables the drafting of a framework. Each stage of the model has been outlined as a process conducted by the Concessionaire, the outputs of each process becoming the inputs of the next process.
4. Drafting the government’s assurance procedures (using the process outlined in the government’s Assurance Strategy and applying it to the framework):

   PLANNING ➔ INFORMATION GATHERING ➔ EVALUATION ➔ ACTION

The following three alternatives for producing a suite of assurance procedures have been explained:

1. Service Partitioning
2. Model Partitioning
3. Framework Element Partitioning

The Model Partitioning approach appears to result in the least number of procedures, although there are other advantages to using the Service Partitioning approach. Although the approach used
should be that which the users of the procedure consider most useful, the writer of this article favours the Service Partitioning approach.

A generic structure has been developed for the government’s suite of assurance procedures, and comments have been provided which highlight important considerations.

In particular, before proceeding to write a procedure, it should be decided how the services may be partitioned.

### Table 3 Proposed structure for a government procedure to assure the Concessionaire’s delivery of a particular service

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PLANNING</strong></td>
<td>Produce an Assurance Plan (refer to March 2013 edition of Civil Engineering) for the service. This involves determining the probability that the Concessionaire will not provide appropriate assurance that the service will be delivered, and the quality technique to be used by the government.</td>
</tr>
<tr>
<td><strong>INFORMATION GATHERING</strong></td>
<td>Information on the process outputs of the Concessionaire’s PDFA model should be the focus of the government’s attention. This information relates to:</td>
</tr>
<tr>
<td>Service plans</td>
<td>- The plans should explain how the Concessionaire has used available resources to achieve the services.</td>
</tr>
<tr>
<td></td>
<td>- The resources include:</td>
</tr>
<tr>
<td></td>
<td>- Assets</td>
</tr>
<tr>
<td></td>
<td>- Human Resources</td>
</tr>
<tr>
<td></td>
<td>- Systems</td>
</tr>
<tr>
<td></td>
<td>- Services from utility providers.</td>
</tr>
<tr>
<td>Reports on service delivery</td>
<td>- Deliver all services to the satisfaction of all stakeholders.</td>
</tr>
<tr>
<td></td>
<td>- Such services cover all elements of the total services experience.</td>
</tr>
<tr>
<td>Improvements required</td>
<td>- Identify items where there is a difference between planned and actual services delivery.</td>
</tr>
<tr>
<td>Improvements implemented</td>
<td>- Implement the Change Management Plan once all suitable approvals have been obtained and all relevant stakeholders have been informed.</td>
</tr>
<tr>
<td></td>
<td>- Once the changes have been implemented, revise relevant documentation.</td>
</tr>
<tr>
<td></td>
<td>- Check the effectiveness and efficiency of the changes implemented and inform stakeholders of the impact on the services (as outlined above in Table 2 and supporting text).</td>
</tr>
<tr>
<td></td>
<td>Such information may reside within reports, audits, meetings, specifications, quality system documents; the Concession Agreement (CA); interactions with the Concessionaire’s team members; the government’s audits; and surveillance information.</td>
</tr>
<tr>
<td></td>
<td>Suitable techniques for gathering the information should have been identified in the Assurance Plan. The procedure should also explain how the information will be gathered and who is responsible for performing the various tasks.</td>
</tr>
<tr>
<td><strong>EVALUATION</strong></td>
<td>The information gathered will then be analysed and evaluated to determine whether the government is comfortable with the assurance it receives that the Concessionaire is performing its role appropriately.</td>
</tr>
<tr>
<td></td>
<td>- If the government is not in a position to assure that the Concessionaire is performing its role appropriately, the reasons for this need to be identified. The reasons could be one or several of the following:</td>
</tr>
<tr>
<td></td>
<td>- The assurance information made available by the Concessionaire is inadequate due to missing, inaccurate or conflicting information.</td>
</tr>
<tr>
<td></td>
<td>- The assurance information received from the Concessionaire is appropriate, but compliance problems exist which require action from the Concessionaire. If this is the case, the government would require further assurance from the Concessionaire that it is taking appropriate action to address, and prevent recurrence of, the problems.</td>
</tr>
<tr>
<td></td>
<td>Resulting from the analysis and evaluation of the information, any identified issues will be pursued through the Concessionaire – the emphasis always being on leveraging convincing action from the Concessionaire. If the issue relates to the lack of sufficient information to provide the assurance required, the Concessionaire is required to provide the information. If the issue relates to a real problem which the Concessionaire is experiencing, the Concessionaire is requested to inform the government what it is doing to address the issue and to provide evidence of successful remediation or removal of the risk.</td>
</tr>
<tr>
<td><strong>ACTION</strong></td>
<td>Should the assurance received (that the Concessionaire is performing its role adequately) be inadequate or negative, the government will address these issues, through the Concessionaire, using the approach described in its Assurance Strategy (refer to January/February 2013 edition of Civil Engineering). Less serious issues should be addressed at regular meetings, with more important and urgent issues ultimately involving senior management and being escalated to contractual letters.</td>
</tr>
<tr>
<td></td>
<td>In accord with the government’s assurance strategy, should the above approaches prove inadequate, the government may require further information (process and inputs) on the relevant Concessionaire process.</td>
</tr>
</tbody>
</table>
Let's go for more kilometres between engine overhauls.

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How do we do it? Delo® ISOSYN® products utilise our special ISOSYN® Technology, which combines premium base oils, high performance additives and Chevron formulating expertise to provide superb diesel engine parts protection that rivals synthetic performance. All at an outstanding value. Delo® products with ISOSYN® Technology help provide extended service protection, maximise engine durability and minimise operating costs. Learn how Delo’s family of products can help you go further, visit www.deloperformance.com.
The engineer and the future

The Southern African Institute of Steel Construction (SAISC) recently held its SteelFuture Conference where engineers from across the globe convened to discuss the future of the steel industry. The papers presented and the ensuing debate were intense and naturally of an exceptionally high standard.

THE ONE CONCEPT that is ubiquitous at nearly every forum on the future, is sustainability. It is a broad concept that circumscribes how we should utilise our social, economic and natural resources so that we can “satisfy our own needs without compromising the ability of future generations to meet theirs”. That is the message Reidar Bjorhovde, one of the fathers of modern structural steel engineering in the US, and a speaker at the SAISC Steel Future Conference, hopes to convey to the world.

First and foremost sustainability is about keeping us and our children safe from immediate dangers that arise from natural or human-made disasters. These can range from earthquakes to arson, and can cause tremendous damage to society. Sustainability is also about choosing materials that are economically accessible and flexible to work with. Moreover, we must be able to pass these materials and technologies on to future generations without degrading their usefulness. Finally, sustainability requires that our immediate social wellbeing, and our use of materials and technology, should not compromise the most important public good that we have – the natural environment.

Therefore a great deal of research is required to come up with solutions that can satisfy our sustainability needs. And whenever we achieve such solutions we need to standardise them so that they are widely accessible. Ongoing efforts in both of these arenas fall squarely on the shoulders of the best and brightest engineers around the world.

RESEARCH

We now know that Charles Clifton’s research efforts at the University of Auckland in New Zealand (to make buildings safer from the effects of fire) are bearing fruit. Not only is the behaviour of a building on fire better understood, but protection is now much more economical. He says that the new ‘Slab Panel Method’ allows structural steel buildings to be designed and built without the need for wasteful passive fire protection on secondary steel beams. Such floors achieve fire resistance by turning the slab from a one-way system into a two-way slab during a fire. Significant developments have been made, and New Zealand is now leading in the use of radiation shielding to protect structural steel in buildings. It is possible to protect structures by blocking troublesome infrared photons very cost-effectively.

According to Bjorhovde, research in the production of steel is now focused on achieving ever higher strengths and elevating the performance of the material by making it more ‘weldable’ (lower carbon content) and tougher (more ductile through continuous casting and smaller crystalline structure). High-yield strength plates of 650 MPa are presently available for high-rise columns and special connections, but it is also fascinating to hear about the need for low-strength (150 MPa), high ductility steel for use in energy dissipating fuses of earthquake resistant applications.

The fact that modern metallurgy allows for steel to be recycled in electric arc furnaces minimises iron ore mining activities and avoids the use of energy-consuming and polluting processes such as the blast furnace. Colin Hautz from Arcelor-Mittal Europe says that steel makers are actually going the extra mile and reducing the impact on the climate,
not only at the production phase, but also by researching and developing building sub-systems that will help to satisfy stringent future requirements – such as that of the EU – to have homes that are energy positive by 2020.

All of these research efforts can help to make the world a safer place while lowering costs and reducing the impact on the natural environment – all primary concerns of sustainability. Thus, much of Bjorhovde’s and Clifton’s work also involves taking the promising results of such research and collating them into standards in order to make them accessible to design engineers. Without the application of research results in real projects, it is practically impossible to satisfy our sustainability needs.

**STANDARDS**

Standards are vessels of knowledge about materials, and the ways of engineering them into useful products. They aggregate and turn complex data into accessible and rational methods of design and construction. When they relate to safety critical materials, such as structural steel, they are also commonly incorporated into laws and regulations as minimum requirements for what is deemed to satisfy jurisdictional requirements. Renewed focus on sustainability has forced standards, beyond hosting knowledge and acting as legal benchmarks, to facilitate quick standardisation of new innovations without lowering overall performance.

Therefore, when Clifton sought to standardise novel fire-related design approaches for New Zealand, he says that he used as his basis the Eurocode documents, which include a comprehensive approach for how to accomplish such standardisation. According to Roger Pope, who works with the British Constructional Steelwork Association, this makes the Eurocode set of standards unique in how broad, deep and harmonised they are. Richard Liew, who is a professor at the National University of Singapore, supports this view and says that Singapore has given itself only two years to make the transition in full from an older standard that was based on British standards to the Eurocodes for structural design and construction.

Despite the UK having adopted the Eurocode, Pope reveals that only a fifth of British engineers actually use the standard, because it is too complex for everyday use. This explains why many British practitioners and academics are now exerting significant pressure to simplify Eurocode requirements using design guides and software. In contrast, Bjorhovde and Ed Whalen, the president of the Canadian Institute of Steel Construction, say that North American standards are far more concerned with serving practitioners than researchers, software developers and innovators. Not unlike those of New Zealand, researchers and software developers in North America use Eurocode standards when they find it necessary, but standard writers there have avoided burdening design engineers with its complexity.

This leaves many countries that lack sufficient resources to develop their own standards with two competing standard development methodologies to choose from. South Africa, for instance, is in the process of deciding whether to adopt the North American or European approach for standards relating to the design of steel structures. Participants of the Steel Future conference asked the guest speakers to comment on this matter. The responses surprised many. Without exception the speakers think that requiring Eurocode compliance in South Africa would impose considerable burden on designers without the commensurate benefits.

From the ensuing discussions it is possible to conclude that the vast majority of structures in South Africa are designed and built using standard methods and technologies. Therefore the savings that can be derived from using the Eurocode are limited. In fact there are concerns about how much resources South Africa can practically devote towards the development of design aids, software and human capital that have the requisite advanced engineering competence to absorb the Eurocode in the near future.

As the debates intensified during the engineering session at the conference, important comments in support of South Africa adopting the European steel standards were made. For instance, if South African firms wish to provide services to European, or any other, customers who require compliance with the Eurocode, then adopting other standards could disadvantage South Africans. However, counterpoints were also made about how South Africans who wish to pursue work in Eurocode-oriented markets can learn the Eurocode irrespective of the standard that is adopted in South Africa.

The reality for most countries, Bjorhovde points out, remains the adoption of a mixed approach. The Indians, Chinese and various other Asian and Latin American countries have done exactly that. Most African and Middle-Eastern countries are yet to adopt an approach. According to his global survey no single standard today is comprehensive enough to encompass all elements of design and construction. It so happens that the Europeans and North Americans frequently use each other’s standards. For instance, while American standards are better developed for seismic design, European standards are commonly referenced in relation to fire design.

It may make sense for South Africa to evaluate its choices on a case by case basis. For instance, as things stand, the loading code SANS 10160 is based on the European EN1991, whereas the steel design standard SANS 10162-1 is based on the Canadian CSA S16. Taken at face value this appears inconsistent. However, when considering how much more accessible S16 is at this time compared to its European counterpart EN1993, working to harmonise the European loading approach with the Canadian steel standard may end up consuming less resource than simplifying EN1993 for South African everyday use.

**THE FUTURE DEFINED**

The speakers at the engineering sessions of the SAISC Steel Future Conference see a future for design and construction that is defined by advances in research and standardisation, the ultimate goal being to achieve sustainable societies, economies and natural environments. While research and development efforts generate sustainable solutions, standardisation makes the solutions accessible to designers and contractors who apply them to real projects.

As South Africa attempts to expand its industrial base and promote exports into a fast-growing and urbanising Africa, these lessons are invaluable. Sitting in one room listening to, and interacting with, speakers of this calibre – and on such pertinent issues – is a rare event. We hope that South African researchers, standards developers, design engineers and contractors have made copious notes – we’ll need them to frame our future.
Innovative RCS Rail Climbing System
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Frank Colucci,
General Superintendent,
Sergio Vaclotto,
Project Supervisor:
"We decided to use PERI RCS in this project for three reasons: Safety for workers and for the traffic below, productivity to achieve one floor pour in 5 to 6 days and schedule improvement to avoid lost days due to wind or weather conditions."
WITH THE RESOURCE boom happening across Africa, the need for efficient infrastructure networks has become increasingly important. In particular, rail systems capable of operating optimally with minimal downtime or need for maintenance would provide enormous value to the mining sector.

Given the high costs of developing this infrastructure a key focus needs to be on increasing its service life, thereby slowing depreciation and allowing the investment to reach its full potential.

For many years the focus has been on improvements in the rolling stock, signalling systems and traffic control. Track technology, however, has changed little over its history. The introduction of concrete sleepers and continuously welded rail has certainly had a big impact, but the ballast bed itself has changed little.

BALLAST BED MAINTENANCE COSTS

"Economic studies by Wheat & Smith into British rail infrastructure showed that more than one third of the total maintenance expenditure for all railway networks that operate on ballasted track goes into substructure." (Advanced Rail Geotechnology – Ballasted Track by Buddhima Indraratna, Wadud Salim & Cholachat Rujikiatkamjorn)

What has been observed over the last few decades is the physical and financial impact of poor track geometry brought about by ballast degradation and settling. Poorly aligned track leads to higher dynamic stresses on the critical track components, such as the rail, sleepers and fastening

Figure 1: Padded sleeper after 190 million load tons showing indentations in the Sylomer® without any perforations

Improving efficiencies, increasing track availability and lowering life cycle costs
systems. But more than that, poorly aligned track also leads to the need for speed restrictions and the risk of derailments.

The cycle of ballast degradation is a vicious one. Poor track geometry leads to higher dynamic forces in the wheel-rail interface, resulting in wear and tear that accelerates as time goes on. Tamping helps the immediate issues of track geometry, but it is also a mildly destructive process that becomes less and less effective over time.

**DEFINING TRACK ELASTICITY**

The implementation of defined track elasticity through under-sleeper pads, sub-ballast mats and elastic rail pads has been clearly shown to slow the damage to ballast. By improving track elasticity the distribution of the high load and dynamic stresses has been greatly increased, leading to lower point loads in the ballast and dramatically slowing degradation. In turn, this leads to improved track geometry that lasts longer, requires less maintenance and increases the service life of the track.

Companies such as Getzner Werkstoffe have been at the forefront of developing materials capable of surviving these loads. Polyurethane elastomers such as Sylomer and Sylodyn have been in use around the world for forty years in environments ranging from street trams, to passenger metros, to the incredible stresses of heavy haul.

**UNDER-SLEEPER PADS (USP)**

Under-sleeper pads are pads that are fitted to the bottom of a sleeper. The polyurethane material can be applied during sleeper manufacture by way of an assembly mesh, or to existing sleepers through gluing.

In the track structure, the PUR (polyurethane resin) material deforms to the ballast stones, increasing the contact area between the bottom of the sleeper and the ballast from 9% (for a well maintained and stabilised track) up to 35%. The resulting effects are a reduction in ballast stone stresses by over 70%. The improved load distribution leads to a 100% increase in the length of interval between tamping cycles, and has also been shown to increase the track service life by a minimum of 25%. Professor Peter Veit and Associate Professor Stefan Marschnig from the Technical University of Graz have in fact shown that track service life increases up to a massive 60%, leading to a dramatically slower depreciation of the service life.

### Table 1: Track service life and tamping cycle comparison with and without USP

<table>
<thead>
<tr>
<th>Axle load and configuration</th>
<th>Without USP</th>
<th>With USP</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 ton UIC60 R260 rail concrete sleeper</td>
<td>service life = 29 years tamping interval = 1.5 years rail life = 700 MGT</td>
<td>service life = 46 years tamping interval = 3 years rail life = 700 MGT</td>
</tr>
<tr>
<td>32.5 ton UIC60 R260 rail concrete sleeper</td>
<td>service life = 20 years tamping interval = 1 year rail life = 500 MGT</td>
<td>service life = 32 years tamping interval = 2 years rail life = 500 MGT</td>
</tr>
<tr>
<td>25 ton UIC60 R350HT rail concrete sleeper</td>
<td>service life = 29 years tamping interval = 1.5 years rail life = 1 150 MGT</td>
<td>service life = 46 years tamping interval = 3 years rail life = 1 150 MGT</td>
</tr>
<tr>
<td>32.5 ton UIC60 R350HT rail concrete sleeper</td>
<td>service life = 20 years tamping interval = 1 year rail life = 800 MGT</td>
<td>service life = 32 years tamping interval = 2 years rail life = 800 MGT</td>
</tr>
</tbody>
</table>
initial investment. To support this even further, a recent two-year study by the UIC showed the incredible value offered by under-sleeper pads.

**SUB-BALLAST MATS (SBM)**
Sub-ballast mats take the principles of the under-sleeper pads a step further. Traditional sub-ballast mats are between 15 mm and 19 mm thick, allowing for greater deflection in the track structure. Where USPs would allow for 1 mm to 2 mm deflection due to limited thickness, SBMs allow for deflections of up to 3 mm. This again improves the load distribution within the ballast bed, but also allows for improved structural vibration absorption. Reducing structure-borne vibration has the benefit of lowering damage to bridges and the transition zones leading onto them.

Additionally, integrating rail systems into densely populated city environments also has issues related to health and safety, and lowers the value of property adjacent to the track. By absorbing the structure-borne vibrations, disturbance to offices, apartments and homes is greatly reduced, leading to an improved quality of life for citizens and less impact on property values.

**RAIL PADS**
Not all track sections are exposed to the same levels of load and stress. While under-sleeper pads and sub-ballast mats are of enormous value to tight radius bends, turnouts, bridges, tunnels and transition zones, more cost-effective solutions, such as elastic rail pads are of great value on sections of track that experience lower stresses.

In one example from South America, the implementation of elastic rail pads stopped the rail fractures that were being experienced on a monthly basis. Due to the high 33-ton axle load, and traffic of 140 million tons per annum, the rail was under extreme stress. The rail pads were installed in October 2011 and since then not a single rail fracture has occurred.

Rail passenger health is also a concern. By improving track elasticity the rolling stock and passengers experience a smoother ride, resulting in a more comfortable travel environment, better working conditions for rail staff and less wear and tear on rolling stock components.

**CONCLUSION**
It has been shown by the Technical University of Graz that the life cycle costs of a rail network are made up of: depreciation + operational disturbances + maintenance costs. For rail operators, the better their network functions, the better (more) they can deliver to their customers, and hence the more money they make. The slower their investment depreciates, the more profitable they become. Improved track elasticity ticks all these boxes.
THE SUBTECH GROUP has been involved in most of the port construction projects that have taken place in South Africa in the last ten years. The company offers a full range of marine construction services, including marine piling and piling support, scour protection, confined dredging and capital dredging support, underwater demolition, underwater concreting, preparation of caisson beds and caisson placement, installation of subsea cables and pipelines, bathymetric survey and geotechnical services. This range of services provides clients with multiple solutions to harbour development projects, as illustrated in the examples below.

**2007 TO 2010: PORT OF DURBAN - HARBOUR ENTRANCE WIDENING**

Sub-contracted to the Group 5 / Dredging International Consortium, Subtech carried out all of the marine and diving support for construction operations, as well as substantial stand-alone portions of work, including demolition of all the old marine construction services par excellence

Removal of the old sub-aqueous tunnel from beneath the Durban Harbour entrance channel

An aerial view of the Berth 28 site in the Port of Richards Bay, with Franki pile working off the Subtech barge Jumbo on the left; on the right is the barge Punt 30 which Subtech supplied to transport concrete and other materials to the piling operation

The Moma Sands export jetty – exposed to the oceans’ moods and in need of rehabilitation

The Subtech barge Imvubu on its way to Moma with the new berth sections
entrance channel structures, offshore disposals, scour protection and other related works. In conjunction with T&T Marine the company also carried out extensive dredging operations in confined areas, including dredging the footprint of the new north groin.

2009 TO 2010: PORT OF RICHARDS BAY - BERTH 208
Sub-contracted by Stefanutti Stocks, Subtech supplied all of the marine services and support for the construction of the new chemical berth. This included the Subtech barge, Jumbo, set up as the piling platform with spuds and crane bearers for Frankipile to work off. Subtech’s main portion of the work followed the piling, where the company was responsible for the complete process of handling and placing in position on the pile caps around eighty 70-ton precast concrete beams, as well as precast deck panels. For this operation Subtech designed and built the specialised lift barge Inyathi, with derricks and winches for the marine transport and placing of each beam. In addition to the technical aspect of the project, the placing operation also had to be coordinated with the tides.

2010 TO 2011: MOZAMBIQUE - MOMA SANDS EXPORT JETTY REHABILITATION
Sub-contracted by Group 5, Subtech was responsible for the complete operation of transporting all of the new jetty sections to site, removing the damaged berth structure, and installing the new berthing structures on either side of the jetty. This was an extremely challenging project. Due to the project being located on a remote, open coastline with restricted access, the work required careful planning in its design and execution, with particular attention to the
construction methods. The client also stipulated that the berth had to remain operational during the construction period. All work was undertaken entirely off a floating plant, which required exceptional planning and preparedness, as most of the work could only take place during short good-weather windows, due to the site being so exposed to the ocean.  

2010 TO PRESENT: PORT OF DURBAN - ISLAND VIEW BERTH UPGRADES

Transnet Capital Projects (TCP) is in the process of rolling out extensive upgrades to many of the berths at Island View. This process has been on-going since 2010, with Subtech involved in many portions of the work, some contracted directly to TCP and others through various sub-contract agreements working for Stefanutti Stocks, WBHO and Esorfranki, to name a few.

2011 TO PRESENT: PORT OF DURBAN - CONTAINER TERMINAL SCOUR PROTECTION REHABILITATION

Contracted directly by Transnet, Subtech is in the process of upgrading the rock scour protection beds to all 15 of the Pier 1 and 2 Container Terminal Berths. The scope calls for the placement of 50 kg to 200 kg rock scour protection in a minimum 800 mm thick layer to specified levels and accuracy. In addition the work has to be carried out using water-based plant and equipment, and all activities have to be coordinated with the Berth Planning Department so as not to disrupt port activities. With limited occupations of working berths the Subtech teams are often required to work around the clock. The operation involved a bathymetric ‘in-survey’ by Subtech’s survey department to determine areas that require trimming and levelling prior to rock placing, as well as quantities and dumping grid. After dumping, rock levelling is carried out using an 85 ton long-reach excavator mounted on a spud barge, with a final ‘out-survey’ being conducted to check levels prior to handing over the berth. Since the start of the operations in January 2012 some 67 000 tons of rock have already been dumped.

OTHER PROJECTS

Other works undertaken in recent years include the deepening of the West Quay in the Port of East London, the placing of the new rock revetment at the Port of Coega, restricted dredging operations for the extension of the iron ore terminal berth in the Port of Saldanha, maintenance dredging and clearing of the Coega sand bypass system, the installation of the new 3.2 km long sea outfall pipeline for Mhlathuze Water, and all of the fibre optic cable landings around the southern African coast.

ADEQUATELY EQUIPPED

As can be seen from the photographs, Subtech’s assets include tugs and barges, cranes, rigging and mooring equipment, dredging equipment, underwater concreting and demolition equipment, etc. Underlying all of these services is the company’s key diving ability.

Subtech is a member of the International Maritime Contractors Association (IMCA) and is ISO 9001:2000 accredited.

Subtech is approved by the following classification societies:
LAFAEGRE COMMITS TO BUILDING BETTER CITIES

LAFAEGRE SOUTH AFRICA recently announced the repositioning of the international Lafarge Group’s global master brand to reflect the increasing shift to urbanisation taking place throughout the world. The new brand signature ‘Building better cities’ pledges Lafarge’s commitment to help create sustainable cities and rural developments that are desirable environments for all people. The new brand signature is more than a slogan – it conveys both the force of the Group’s ambition and of its strategy.

Urbanisation is one of the biggest challenges of the 21st century. By 2050, 70% of the world’s population will be living in towns and cities, compared with just over 50% today, resulting in two billion more city dwellers. To cope with this burgeoning urban landscape, development at an unprecedented scale will be a major challenge for the whole construction industry, including in South Africa where more and more people are migrating to towns and cities, requiring housing, hospitals, schools and offices, together with the associated infrastructure to connect and service cities, such as roads, airports, water and power utilities.

As a world leader in building materials, the Lafarge Group, together with its partners, will be a major contributor to the creation of enhanced urban environments. Lafarge South Africa is in a position to provide solutions for more housing in cities, more compact cities, more durable cities, better connected cities, and more beautiful cities. A strong presence in all its construction-related business lines (cement, aggregates, readymix, plasterboard and fly ash) will accelerate this growth, and the expertise developed for cities will also be utilised to improve development of South Africa’s rural towns and villages.

Country CEO of Lafarge South Africa, Thierry Legrand, says, “Innovation in the building materials industry is of paramount importance. Concrete is no longer simply concrete. Quality and innovation make a huge difference to cost and ease of building. At Lafarge we believe we can make that difference, and more than ever we want to develop innovative solutions to help build better cities.”

In line with its aim to provide more housing in cities, Lafarge is involved in Cape Town’s Happy Valley housing development, where the structural frames for 1 200 affordable houses are being built with Lafarge readymix concrete pumped into custom-made steel shutters. The remaining parts of the structures are completed with bricks. Lafarge South Africa’s local readymix team proposed using readymix mortar as the solution, enabling the customer to meet his schedules. As a result of the consistent high quality of the product and the increased productivity, the contractor decided to switch to Lafarge readymix plaster as well.

Also in line with its ‘Building better cities’ philosophy, Lafarge South Africa is offering space-efficient solutions for the construction of dwellings, commercial and retail facilities, and leisure infrastructure, thereby supporting the development of more compact cities. The 75 000 m² super-regional Mall of the North retail development, for example, brought first-class city shopping to Polokwane in the Limpopo Province. Lafarge Gypsum’s 6.4 mm plasterboard was used extensively throughout the project, providing an ideal solution for quality and space-efficient interior finishes. The unique construction of the plasterboard ensures a cleaner cut and easier handling, with reduced risk of breakage on site, while the superior finish reduces paint costs for customers.

By providing materials for the upgrading of transport infrastructure, the company contributes towards improved mobility for all people and the development of more connected cities, as with the Gauteng Freeway Improvement Project (GFIP), which comprised the upgrading and construction of 561 km of roads and major interchanges. Ash Resources supplied its classified fly ash products DuraPozz® and DuraPozz@Pro™ to the major readymix concrete producers who were involved in the GFIP.

With the dramatic escalation in urbanisation, efficient stormwater management is an increasing challenge to reduce the risk of flash flooding and sustain natural water cycles. Lafarge recently introduced the highly acclaimed Hydromedia™, a fast-draining concrete pavement solution which provides rapid stormwater removal from streets, parking surfaces, driveways and walkways. By furthermore focusing on the strength and longevity of structures, and by taking full account of environmental concerns, particularly the energy efficiency of buildings and the reduction of CO₂ emissions, Lafarge is able to help develop more durable cities.

Lafarge South Africa encourages innovation, in combination with architectural expertise, thereby helping to create visually bold solutions. For example, for the recently completed Podium landmark building in Menlyn, Pretoria, its Agilia™ Vertical readymix concrete supplied the aesthetic and architectural solution for the façade of this attractive building. The architect specified high-quality, patterned off-shutter finishes on all vertically exposed concrete walls. The use of standard concrete was out of the question. The exceptional fluidity of the unique self-compacting Agilia™ concrete allowed it to flow easily through the reinforcing without the need for vibration, and produced exceptional finishes – a splendid example of helping to provide citizens with more beautiful cities, thereby generating a sense of pride and place.

C&CI SERVICES

THREE OF SOUTH AFRICA’S leading cement producers have stepped in to fund the establishment of a new company to preserve the vital education and consulting services previously provided by the Cement & Concrete Institute (C&C).
AfriSam, Lafarge and Sephaku are now financing the operations of The Concrete Institute which, from 2 May this year took over most of the major services previously provided by the C&CI. The C&CI had to close down at the end of April 2013 following the withdrawal of funding.

The Concrete Institute will offer vital concrete technology services to the construction industry, including education and training, consulting, publications, and a comprehensive information centre, which is one of the largest and most respected sources of information on concrete in the southern hemisphere.

According to Bryan Perrie, former MD of the C&CI and now in charge of The Concrete Institute, all the courses listed in the C&CI’s School of Concrete Technology 2013 Training Programme are still being offered. “We are hoping to expand the curriculum by including even more courses. The Concrete Institute has also taken over the responsibility for running the comprehensive and highly-respected Advanced Concrete Technology course which was under way when the C&CI closed.

“There was widespread dismay within the building and construction industries when the C&CI was forced to close its doors. With the new support of new cement producer, Sephaku, as well as the continuing support of AfriSam and Lafarge, we are confident that The Concrete Institute will be able to provide the services which made the C&CI an industry icon over the past 75 years.”

NEW REPORT HIGHLIGHTS FINANCIAL VALUE OF GREEN BUILDINGS

A COMPREHENSIVE REPORT recently released from the World Green Building Council (WorldGBC) highlights that there are numerous compelling benefits from green buildings.

The report, The Business Case for Green Building: A Review of the Costs and Benefits for Developers, Investors and Occupants, examines whether or not it is possible to attach a financial value to the cost and benefits of green buildings. Today green buildings can be delivered at a price comparable to conventional buildings, investments can be recouped through operational cost savings, and, with the right design features, a more productive workplace can be created.

“This report synthesises credible evidence from around the world on green buildings into one collective resource, and the evidence presented highlights that sustainable buildings provide tangible benefits and make clear business sense,” says Jane Henley, CEO of WorldGBC. “From risk mitigation across a building portfolio and city-wide economic benefits, to the improved health and wellbeing of individual building occupants, the business case for green building will continue to evolve as markets mature. Indeed, we have already seen this momentum grow globally, where...
in more and more places, green is now becoming the status quo."

“This latest global research further reinforces and supports the findings in our own publication, The Rands and Sense of Green Buildings, which sets out the economic case for green building in a clear, incontrovertible manner based on local evidence and tangible case studies. It dispels the myth that green building is more expensive, lists the benefits of green building and provides the local proof of these,” explains Green Building Council of South Africa (GBCSA) CEO, Brian Wilkinson.

Key findings include:

- **Design and construction costs:** There has been an overall trend towards the reduction in design and construction costs associated with green building as building codes around the world become stricter, supply chains for green materials and technologies mature and the industry becomes more skilled at delivering green buildings.

- **Asset value:** As investors and occupiers become more knowledgeable about and concerned with the environmental and social impacts of the built environment, buildings with better sustainability credentials will have increased marketability.

- **Operating costs:** Green buildings have been shown to save money through reduced energy and water consumption, and lower long-term operations and maintenance costs. The energy savings alone typically exceed any cost premiums associated with their design and construction within a reasonable payback period.

- **Workplace productivity and health:** There is an emerging body of evidence suggesting that the physical characteristics of buildings and indoor environments can influence worker productivity and occupant health and wellbeing, resulting in bottom-line benefits for businesses.

- **Risk mitigation:** Sustainability risk factors can significantly affect the rental income and the future value of real estate assets, in turn affecting their return on investment. Regulatory risks have become increasingly apparent in countries and cities around the world, including mandatory disclosure, building codes and laws banning inefficient buildings.

The report concludes that, by greening our built environment at neighborhood and city scale, the green building industry can deliver on large-scale economic priorities, such as climate change mitigation, energy security, resource conservation and job creation, long-term resilience and quality of life.

“We are optimistic that reviews of this nature will continue to influence the strategies of many astute property investors, owners and developers, and that the economic business case will be the key driver in ensuring that green building becomes the accepted standard for all property projects,” concludes Wilkinson.

The report was produced in partnership with PRP Environmental along with the following sponsors: Skanska, Grosvenor, and the Abu Dhabi Urban Planning Council/Estidama.
**SUPPORT WITH NEW ECSA REGISTRATION PROCESS**

Graduates enter the workplace with big expectations – their qualifications allow them to enter the world of engineering and become professionals. But with the announcement from the Engineering Council of South Africa (ECSA) that a new registration process is in place, many questions are being asked. This is the first of several articles in which the SAICE Candidate Academy addresses this topic and provides answers.

**What does ‘professional’ mean?**

BusinessDirectory.com says that a professional is (1) "a person formally certified by a professional body or belonging to a specific profession by virtue of having completed a required course of studies and/or practice and whose competence can usually be measured against an established set of standards" or (2) "a person who has achieved an acclaimed level of proficiency in a calling or trade."

**How do I become a professional?**

Becoming registered as a professional is done in two stages. For purposes of registration, the time spent at a tertiary institution is referred to as Stage 1, which leads to graduation. Once graduates enter the workplace, they start with Stage 2, which can lead to professional registration. The responsibility for achieving professional registration lies mainly with the graduate, supported by the employer and assisted by a mentor, supervisors, line-managers and peers.

**Where do I begin?**

To begin the process of working towards registration, you need an ECSA-accredited qualification. If you have not studied in South Africa, the first step is to apply for assessment of your qualification by ECSA (remember that ECSA accreditation is not the same as SAQA accreditation).

You will have to follow the ‘rules of the game’ as laid down by ECSA – available on the ECSA website (www.ecsa.co.za). Some of these rules have changed recently and care must be taken that you follow the rules applicable to your situation.

**Do I follow the legacy route or the new route?**

Graduates who have just finished their studies must follow the new route. By the time they have completed their candidacy phase, the new route will be well established. For candidates who have been working for a number of years, it is your decision which route to follow – the legacy route or the new route – but you cannot mix the two routes of registration. If you want to register in terms of the legacy route for engineers, the old rules apply, i.e. com-
plying with policy statement R2/1A and the associated Discipline Specific Guidelines. If you want to register in terms of the new route, you need to satisfy the 11 outcomes called for in the new policy document R-01-P and competency standard R-02-PE.

What is the difference between the legacy route and the new route?
There are various differences between the two methods of registration for different categories of registration. In the legacy system some disciplines completed training and experience reports, and projects reports, and attended interviews, whilst others only completed training and experience reports. In the new system all applicants must complete training and experience reports, and an engineering report, and all engineers will attend an interview. The requirement for writing two essays after the interview, which was applicable for civil engineers, falls away in the new system.

The registration process for technologists and technicians has changed over a period of time and the forms already call for demonstration of the outcomes.

What if I do not have the required qualification, but have extensive experience as a technician or technologist?
It is important to be able to prove that you have been working (for the number of years required by ECSA) on the level you are applying for. ‘Outcomes-based’ forms B18 and C18 have been introduced for technologists and technicians respectively to demonstrate that experience at the level of registration has been acquired over a period of time.

Future articles about registration
In our next instalment, we will discuss the registration process and the changes in the rules of the game. If you have any questions on this article, please do not hesitate to contact us (contact details at the end of this article).

NEW COURSES
In the joint venture between SAICE and Consulting Engineers South Africa (CESA), we are offering the following new courses (please refer to the calendar at the end of this article for dates and locations for the next four months):

**Getting Acquainted with Fixing and Anchoring Technology (1 CPD credit)**
Fixings form a very important part of most construction projects. In almost every project it is required to connect steel to concrete, timber to brickwork, and steel to steel – to name just a few materials.

In all cases, the loads to be carried by the fixings must be calculated to enable the fixing engineer to specify the appropriate fixing. There are different types of fixings available, of which the most common are:

- Friction anchors
- Undercut anchors
- Chemical anchors

The design of single anchors and groups of anchors has become a
specialist discipline which is generally not covered at universities or universities of technology. Numerous factors, such as concrete strength, anchor spacings and edge distances must be taken into consideration when designing a group of anchors. This can be done manually, using first principles, but specialist software is also available to assist the designer.

Some typical applications where fixings are used are illustrated in Figures 4–6.

Getting Acquainted with Road Construction and Maintenance (3 CPD credits)
We have added this new course to our roads offering. It is presented by Theuns Eloff, Blng (Civil), who also presents the Pavement Rehabilitation and Maintenance courses. This new course covers some of the content that is offered in those courses, but focuses on the construction of roads.

Getting Acquainted with the Fundamentals of Procurement and Tendering (2 CPD credits)
This is a new and essential course which is long overdue. Procurement, and especially tendering, is rife with mismanagement, misconduct and malpractice. Apart from corruption and fraud, various other factors influence the current poor procurement systems. Due to the complex legal framework and involvement of many role players, most public entities are confused about what is required of them during the development process. The course is set up to assist these entities in their struggle towards better procurement and tender processes. The course is designed to be a proactive, feel-good learning experience, improving the understanding and workings of procurement and tendering. By completing various activities, participants will get a better feel for pricing a tender. The activities are particularly useful for newcomers, but are also a great refresher for more experienced individuals. The presenter is Theuns Eloff, Blng (Civil), who also presents other course for the Candidate Academy.

Getting Acquainted with Water Resource Planning (2 CPD credits)
This exciting new two-day training course provides attendees with a basic insight into the water resources planning process and covers a range of aspects such as data sources and processing, hydrology, water resources systems modelling, water allocation and intervention planning. The course is aimed mainly at young professionals in the water sector, but would benefit anyone with an interest in water resources planning, including employees of national, provincial and local government, water services authorities, bulk water suppliers and large water users, as well as engineers, hydrologists and environmental practitioners.

Figure 7: Geosynthetics are used widely, but are not covered in depth at undergraduate level.
The course will offer an ideal opportunity for engineers, technologists and students in relevant fields to gain exposure to geosynthetic products and design principles for their use in containment, roads, walls, slopes, drainage and erosion control measures.

The course sections will be based on the book *Designing with Geosynthetics* (6th Edition) by Dr Robert M Koerner. Presentations will be customised by GIGSA to include local practice and products. An introduction to geosynthetics will be followed by sections on geotextiles, geogrids, geocomposites for drainage, geomembranes, geosynthetic clay liners and erosion control products.

The course will be structured over two days, and will include theory and design examples. A range of geosynthetics samples will be available for delegates. The electronic version (e-book) of Dr Koerner’s book will be included in the course.

### CONTACT DETAILS

For registration or more details, please contact Margie at margie@ally.co.za. In-house courses are also available at a reduced fee per person; contact Marthelene at saice@ally.co.za for more information.

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### CANDIDATE ACADEMY COURSES JUNE - SEPTEMBER 2013

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*NOTE: this course will also be presented in Durban (17–18 October) and Cape Town (7–8 November)
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SAICE welcomes Steven Kaplan

SAICE IS DELIGHTED TO welcome Steven Kaplan as Chief Operating Officer. He has only been with us since 2 April this year, but has already become a trusted member of the National Office staff.

Steven is a graduate of the University of Cape Town, holding a BSc (Hons) in civil engineering. He brings with him around 30 years of consulting engineering experience, which includes an impressive track record of 25 years of project management. With this methodology in mind he hopes to enhance SAICE’s internal organisation processes and infrastructure, which will allow the Institution to continue growing and fulfilling its mission. Along with this, he is particularly determined to contribute to SAICE’s Civilution goal.

Steven has built up his experience working in infrastructure projects (with particular focus on the construction and project management sector), one of his highlights being his role as project manager on the Gautrain Rapid Rail Link (Hatfield Station) in 2006 and 2007.

He is a highly focused and positive person who strives to motivate his team with his strengths of good communication and leadership.

We at SAICE look forward to working with Steven and helping him achieve his goals, one of which is the Civilution aim of motivating engineers of all disciplines to conduct business differently, with a view to achieving an improved society.

In his spare time Steven enjoys walking and hiking trails.

Steven’s contact details:
011 805 5947
steven@saice.org.za
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ECSA Case Studies: Number 3/2012

ECSA (Engineering Council of South Africa) has prepared five case studies arising from the contravention of ECSA’s Rules of Conduct for Registered Persons. These case studies are offered to the engineering fraternity as advisory notes to minimise the risk of recurrence. Civil Engineering will be publishing these case studies over five editions – herewith the third of these case studies. The first and second case studies in the series appeared in the March and April 2013 editions of Civil Engineering (pages 75 and 76 respectively).

Inadequate design and lack of monitoring lead to collapse of staircase

THE PROJECT
The project: a new staircase in an existing building, to provide public pedestrian access between two floors.

BACKGROUND TO THE CASE
The new owners of an existing building in a city centre required to improve pedestrian access between two floors of the building, to accommodate public assemblies. The lower floor consisted of an auditorium with seating to be accessed by members of the public from the floor above. A firm of consulting structural engineers was engaged to design two large staircases, one on each side of the auditorium. Each staircase led from the auditorium floor level to the floor above through an opening cut into the upper floor structure. One was a mirror image of the other. A registered professional engineer of the firm was put in charge of the assignment.

Shortly after the staircases had been completed and the building had been taken into use by the owners, one of the staircases collapsed onto the floor of the auditorium. The staircase was in use at the time, and some 80 persons were injured, but there were no fatalities. The collapsed structure was removed and replaced with a new structure. The other undamaged staircase had to be modified considerably to make it safe.

ECSA appointed an expert to investigate the structure and report to the Investigating Committee if prima facie evidence existed of any contravention by the engineer of ECSA’s Rules of Conduct, arising from the collapse. Evidence was established and the engineer was charged. The engineer pleaded guilty and in a settlement agreement agreed to pay a fine of R20 000.

DETAILS OF THE PROBLEM
Each staircase was constructed with steel stringers and treads carrying granite panel inlays. The stair comprised a first flight ascending to an intermediate landing, a second flight to a 6 m long walkway, a third flight to another intermediate landing and a longer fourth flight to the upper floor. The vertical distance between floors was 6 m and there was a change in direction at each intermediate landing. At the bottom the stair rested on the auditorium floor structure. The walkway and flights 3 and 4 were supported by hangers fixed to the floor above, which was a mirror image of the other. A registered professional engineer of the firm was put in charge of the assignment.

By arrangement between the consulting engineer and the steelwork subcontractor, the final detail design and preparation of shop drawings for fabrication were carried out by the subcontractor and approved by the engineer.

The expert’s investigation revealed a number of faults:

a) The walkway had to be lengthened by 1.4 m to agree with the General Arrangement drawings.
b) The placing of the hangers on site did not correspond with the positions on the drawings.
c) Fewer hangers were installed on site than shown on the drawings.
d) As a result some hangers were carrying heavier loads than designed for.
e) This was aggravated by too low a design load on the stair being used to design the hangers (4 kN/sq.m instead of 7 kN/sq.m).
f) The subcontractor elected to weld the lower ends of the hangers to the top flanges of the channel stringers of the walkway instead of using a bracket detail shown by the engineer.
g) The coffered slab construction of the upper floor structure prevented the use of the engineer’s fixing detail for the tops of the hangers. A row of three or four bolts held an inverted channel beam to the underside of the coffer rib with a cantilevered end from which the hanger was suspended. This was a very unsatisfactory solution as it placed bending in the beam about its weak axis and severe tensile forces on the bolts nearest to the cantilevered end.

The collapse of the staircase was triggered by failure of a number of hangers at their connections, simultaneously and in sequence while the stair was carrying a load of pedestrians.

Further faults were noted in the investigation at the openings cut into the existing floor structure to receive the fourth stair flight. The engineer had specified galvanised mild steel strengthening plates anchored and epoxyed to the underside of the slab, to compensate for the weakening...
brought about by the new opening. The plates installed were red oxide coated (reducing epoxy adhesion) and not all plates were continuous, with butt joints being unconnected or not welded together. Some plates moreover had been fixed into a weak concrete/rubble infill which had been placed to make up for over-break. These latter faults did not, however, cause the stair to collapse when it did.

The design calculations by the engineer were generally correct, but did not take into account the coffered slab construction of the upper floor, which led to the failure of the inadequate fixing of the hangers to the floor. The investigation found the engineer to be seriously at fault in not ensuring that the construction of the staircase was done in compliance with the specified requirements and details.

While the engineer is not responsible for errors and poor workmanship of the contractor, it is inconceivable that the engineer would have approved of the defects if he had seen or been informed of them. It follows that the engineer did not inspect, or failed to notice, or negligently approved the numerous incorrect actions of the contractor, and it was these actions which led to the collapse.

In response to ECSA's investigation the engineer pointed out that the construction monitoring duties had been delegated to two members of his staff, both of whom were qualified with BSc Eng degrees, and each having at least five years' experience. It transpired that these persons were Candidates for ECSA registration. Since their involvement did not shift any responsibility from the engineer, no action was taken against them.

The engineer was charged with contravening the following ECSA Rules of Conduct:

Rule 3(1)(a) in that the engineer failed to discharge his duties to his client effectively with skill, efficiency, professionalism, knowledge, competency, due care and diligence;

Rule 3(3)(a) in that the engineer failed to have due regard and priority for public health, safety and interest;

Rule 3(5)(c) in that the engineer failed to provide work or services of quality and scope, and to a level which is commensurate with accepted standards and practices in the profession.

The engineer pleaded guilty to the charges, in particular the contravention of Rule 3(5)(c). A settlement agreement was reached, with a fine of R20 000 being imposed by ECSA.

WHAT LESSONS CAN BE LEARNED?

Lessons to be learned are chiefly in the area of construction monitoring by the engineer and construction by the contractor:

**Lessons for the engineer:**

1. Notwithstanding the contractor's responsibility to construct the works in accordance with the contract specifications and requirements, irrespective of the engineer's approval, the engineer remains responsible for monitoring the contractor's work in a professional manner, with due skill, care and diligence, if monitoring is included in his agreement with his client.

2. This responsibility remains with the engineer even if the duty is delegated to a subordinate person. In particular, if such a person is a Candidate Engineer, Section 18(4) of the Engineering Profession Act requires that a Candidate "must perform work in the engineering profession only under supervision and control of a professional of a category as prescribed". This in effect extends the responsibility of the engineer.

3. Shop drawings for steelwork fabrication prepared by a subcontractor must be examined by the engineer, to confirm that sections, key connections, leading dimensions and method of erection comply with the engineer's design.

4. When alterations to existing structures are involved to accommodate new structural elements, the engineer must ensure he is fully informed as to the nature and dimensions of the existing structure and that strengthening measures designed by him are correctly fabricated and installed.

5. The engineer should ensure that bolt fixings, epoxy resin-based connections and surface preparation are correctly done, according to his details.

6. No reliance should be placed on the contractor by the engineer to alert him to any need to alter his details or his design due to unforeseen conditions on site – the engineer is obliged to keep himself familiar with all conditions on site which could pose a risk to a successful installation.

**Lessons for the contractor/subcontractor:**

7. Be aware that the constructing parties carry full responsibility for their materials and workmanship meeting requirements, including rectification of defects, irrespective of the extent of construction monitoring being exercised by the engineer.

8. Ensure the design information, erection procedures and fabrication details to be furnished by the engineer are sufficient for their purpose, without the contractor having to make assumptions or misinterpretations.

9. Advise the engineer immediately of any discrepancies in dimensions or inconsistency of details, to be resolved by an engineer's clarification or instruction.

10. Ensure all fastenings and fixing bolts are correctly positioned and installed in sound parent material, without cutting or re-drilling, which could weaken the connection.

11. Do not provide any alternative fixing methods or fabricate any modifications to the structure or connections without confirming the need for them and approval thereof by the engineer.

12. Ensure that all materials, fixings and connections shown by the engineer are installed, with any article being omitted (say due to lack of fit) brought immediately to the engineer's attention.
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