GROWING FORWARD TOGETHER: IS YOUR ETHICAL COMPASS BROKEN?

BERRT 2019: A CELEBRATION OF SA BRIDGE ENGINEERING

OVERVIEW: DESIGN OF VERTICAL GRAVITY SEA AND QUAY WALLS
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Progressive steps to move on from the age of Covid-19: Thinking out of the box

INTRODUCTION
It is unclear at this stage when economic activities will return to full normality. However, as the saying goes, extraordinary times call for extraordinary measures. Thinking out of the box is what is required of us. Two areas that the country could focus on are infrastructure development and maintenance. My mind is particularly preoccupied with the level of railway infrastructure maintenance which can be done during this lockdown period by the two big rail operators in South Africa (Transnet and PRASA), and by the exciting possibility of high-speed trains (HSTs) as a further job-creating opportunity.

TRANSNET
The various stages of the national lockdown provide opportunities to our rail operators to carry out extensive maintenance on the network due to reduced train movement, something which is practically difficult during normal day-to-day train operations. The concept of a maintenance shutdown, which was introduced on the Sishen Saldanha Iron Ore Line (1998) in keeping with the Kumba iron ore mine annual shutdown (later also introduced on the Richards Bay Coal Line), can be fast-tracked during the current window period of low train movement.

PRASA
A 12-car train on the PRASA network (metro system) has the capacity to carry 1 600 passengers, compared to a rapid-rail network (Gautrain) which has a theoretical capacity of 800 or 1 200 passengers for an 8 or 12-car configuration respectively. A well-oiled PRASA system should serve as the backbone of an integrated transport system in South Africa. The 2 200 km PRASA network, shared approximately in the order of 60%, 25% and 15% between the Gauteng, Western Cape and KwaZulu-Natal regions, requires intensive maintenance, as alluded to by PRASA’s Administrator, Mr Bongisizwe Mpondo. With many operating lines now temporarily closed, a shutdown philosophy should be considered.

NEW INFRASTRUCTURE DEVELOPMENT
For about 510 brand-new civil engineers (excluding technicians) who completed their studies at South African universities and are entering the industry in 2020, the timing could not have been worse. After all, another cohort of about 650 first-years have started their studies this year, joining a civil engineering student population of about 3 620 at the six main universities, and they are all aiming to graduate in four to five years’ time. Nothing will excite these new graduates more, including those from the universities of technology, than getting involved in designing and building new infrastructure. Infrastructure development in South Africa should be one of the priority areas to kick-start economic recovery. We can reasonably expect that an increase in infrastructure development will lead, *ceteris paribus* (all else being equal), to an increase in employment and a reduction in the unsustainably high unemployment rate. The time has come for all stakeholders to think outside the box.

One such area is the design and construction of HSTs (250–350 kph) connecting major cities around the country, e.g. Johannesburg–Cape Town, Johannesburg–Durban and Johannesburg–Polokwane. Expansion of the Gautrain network is another priority.

In countries like France, China and Japan the introduction and operation of HST systems has been an economic game changer. However, rather than building 10 000 km in ten years, as has been done in China, South Africa can quantify its own realistic pace to achieve its own integrated public transport objectives. Determining the demand for the system, and executing planning, funding and affordability studies can start now, or be refined, as this is likely to be a 15–50 year project. It was encouraging to hear Mr Alec Moemi, Director General of the Department of Transport, advocating the need for HST systems in our country in support of President Ramaphosa’s dream of HSTs “... passing through Johannesburg as they travel from Cape Town to Musina, and stopping in Buffalo City on their way from eThekwini back to Cape Town.” (SONA 2019) This is a dream I totally buy into.

CONCLUSION
With over 122 000 jobs created during the Gautrain construction project, as an example, one of the ways to create jobs is to unleash infrastructure projects to the consulting engineering and construction industries. Engineers, technologists and technicians, and every person in the supporting work force will be elated, and their families will be happy, and the economy will thrive.

We need to rethink the “it will be difficult” or “we are not ready for it” mentality. The vehicle to achieve any goal or objective is to “start”. We need to start hunting like a pack of lions. To succeed we need to get used to pushing the envelope and get better at doing things in a sustainable manner.

One acknowledges that this will require the buy-in of every stakeholder – internal: employees, unions and executive leadership, and external: government, regulators, suppliers, voluntary associations, funders, media, lobby groups, environmentalists, etc. I dream to see this project materialise before I go on pension in fifteen to twenty years’ time.
And now the storm-blast came, and he
Was tyrannous and strong:
He struck with his o’ertaking wings,
And chased us south along.
– Rime of the Ancient Mariner
Samuel Taylor Coleridge

The good ship SAS Civil Engineering and Construction has battened down the hatches in the stormy waters of the South African economy. Through the driving rain of business rescues, the typhoon of Covid-19 and the fog of recession, safe passage is not clear even to the keenest-eyed navigator. To compound the challenge, the rising tide of the need for new infrastructure and upkeep of the old breaks against the rocks of insufficient skills. At the centre of the maelstrom bobs a need to redress the wrongs of the past whilst still keeping afloat in the midst of the turmoil.

So where do we begin?
In times like these there is a danger of trying to put out every fire as it occurs, being reactive rather than proactive. There is also a danger of being so desperate as to throw caution to the wind and quickly compromise on professional and ethical business practices whilst securing work. A recent economic crimes report1 revealed that, whilst South Africa has seen a drop in the rate of reported economic crime (including fraud, corruption and bribery), we are still ranked third behind China and India.

The place to start tackling this massive challenge is at the beginning. We should put “first things first”. This means resetting our ethical compass and returning to verify our foundations to ensure we can build on them. We need to reflect on what we are doing and whether we are doing it in the right way. This not only means delivering efficient design, reliable construction or disciplined operations and maintenance, but also behaving ethically and in good faith with clients and one another.

We need to reflect on what we are doing and whether we are doing it in the right way. This not only means delivering efficient design, reliable construction or disciplined operations and maintenance, but also behaving ethically and in good faith with clients and one another.

SAICE’s Growing Forward Together strategy comprises eleven different activities grouped into seven areas. The second of these activities is Ethics, which focuses on the promotion of professionalism and integrity in the civil engineering industry. In order to increase awareness of the issue, Civil Engineering will feature short articles on relevant topics around the subject.

Is your ethical compass broken?

Gregory Skeen PrEng
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with clients and one another. It means resisting the urge to take shortcuts, cheat, collude or deliver substandard service even if we think we will not be caught.

With this in mind, and as part of the objectives of SAICE’s Growing Forward strategy, the intention of the “Ethics” activity is to engender renewed pride in the profession, with the following mission and vision:

MISSION
The promotion of professionalism and integrity within the civil engineering industry.

VISION
- Civil Engineering will be seen as a noble profession, whose members uphold the highest standard of professional and ethical behaviour.
- Civil Engineering will be the benchmark to which other professions refer.
- Civil Engineering Practitioners will be regarded as incorruptible custodians of our industry.

These are ambitious goals, but they are worth striving for. In fact, there may be an opportunity now more than ever to reform the industry, starting with building a solid foundation. The initial reaction to the significant downsizing by contractors and consultants is typically one of hand wringing and shaking heads, wondering who will be the next to collapse. However, it can be argued that in an industry which is already notoriously cyclical, the current situation is simply “creative destruction”, a phrase coined by economist Joseph Schumpeter to describe the process by which companies and industries reinvent themselves to cope with economic realities. In other words, the industry must be broken down allowing it to rebuild itself and remain relevant and profitable.

This means it’s not all bad news. Those companies that grasp this opportunity to lay the right foundation for the long term will survive, rising with the tide.

Now is the time to ensure that operations are done professionally and ethically.

Our core values are revealed by what we spend our time and money on. For example, if we seriously consider safety whilst designing, this indicates a concern for those who will be tasked with construction and operation. In the same way, our decision-making and actions reflect the state of our ethical compass. Do we do the right thing as a matter of course, or only when it is convenient? Do we really spend time and money on improving ethical behaviour in our industry?

By operating ethically, the company creates a positive climate, growing confidence and the possibility of constant progress. These kinds of companies have a great advantage over the non-ethical ones. – Bulog and Grncic

Internationally, the construction, engineering and public works sector is regarded as the most corrupt2, and some might say that encouraging ethical behaviour is simply fighting a losing battle. However, rather than having a naïve “do-gooder” approach, doing the right thing consistently and in all situations has been shown to lead to more profitable businesses in the long run. It makes sense to act honestly and with integrity. Ethical behaviour leads to better business relationships, higher employee morale and even competitive advantage over unethical firms3. A recent Croatian study4 revealed that the ethical behaviour of decision-makers is of strategic importance for successful businesses. In addition:

- Ethical companies have been shown to be more profitable.
- Making ethical choices results in lower stress for employees.
- Good company brand and personal reputation rely on consistent ethical behaviour.
- Ethical behaviour enhances leadership effectiveness.

The alternative to voluntary ethical behaviour is demanding and costly regulation and compliance.5

Give me a lever long enough and a fulcrum on which to place it, and I shall move the world.

– Archimedes

Part of the Growing Forward: Ethics strategy is to leverage the influence of SAICE’s 14 000 members to influence industry and bring this ethical atmosphere to bear. SAICE’s members, through their knowledge, qualifications and experience are involved at all levels of decision-making in the public and private sectors. Like Archimedes’ lever, a small number will be able to make a big difference through their strategic positioning and decision-making authority. This means that an ethical approach can be infused at all levels at the point of decision-making.

A number of new initiatives will be put in place to create an awareness of what constitutes ethical and professional behaviour in our industry. These include new CPD courses, interaction with tertiary institutions, and initiatives within SAICE to support members.

Watch this space!

One of the truest tests of integrity is its blunt refusal to be compromised.

– Chinua Achebe, Nigerian Novelist

For more information, or if any SAICE member wishes to be involved in the Growing Forward: Ethics strategy, please email ethics@saice.org.za. We welcome encouraging, different or dissenting views.

NOTES
ON THE COVER
After the first timber bridges had been washed away by floods in 1904/5, the Gamtoos River was finally bridged successfully in 1911 with a steel bridge sporting a centre span of 70 m. The photo shows the Gamtoos Rail Bridge today, with its lattice girder, Parker truss and steel plate girder elements.

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**REMINDER:** Websites and email addresses on adverts are **LIVE**, and so is our contents page. **HAPPY CLICKING!**
INTRODUCTION
What is BERRT, you may well ask? And what does it have to do with civil engineering, bridges and SAICE?

Named for the first History and Heritage tour undertaken by members of SAICE in 2012, BERRT is an acronym for the Barkly East Railway Reverses Tour which explored and documented a remote, and yet fascinating and important part of the rich heritage of railway engineering projects and structures that South Africa has been endowed with.

Since then, BERRT has become an annual pilgrimage in which the vast panorama of South Africa’s civil engineering heritage has been revisited and explored by (mainly) old-timers of the profession to whom more free time is available, and for whom the inclination to document the challenging works of our engineering forebears has become a passion.

BERRT 2019 therefore followed this richly rewarding and informative tradition to pursue parts of a rapidly disappearing part of our heritage (not confined solely to railways), and provide further substance to the incredible ingenuity and resourcefulness of those engineers who have gone before us. To witness the stature and magnitude of many of these amazing projects and structures still standing today, if not all fully utilised, is to truly realise that our generation stands on the shoulders of the earlier giants of our learned profession.

So it was that (what I’ll sensitively call) a motley bunch of engineering enthusiasts, including municipal and civil engineers, seasoned railwaymen, a hydrology specialist, a signals engineer, a geotechnical specialist, a former SAICE president, an historian, current and retired university professors, and locomotive and model railway enthusiasts, gathered in Port Elizabeth in October 2019 to follow the routes of the narrow gauge Apple Express and standard (Cape) gauge Outeniqua Choo-Tjoe railways, and much else in-between and beyond.

While the initial focus for the tour may have been the former railways of the later colonial and early years of the Union of South Africa, now of more than 100-year vintage, it also embraced structures of the latter half of the 20th century, now veterans approaching 50 years of age, which brought South Africa into the realm of greatly significant, modern, reinforced concrete bridge engineering for which our National Road Route N2, encompassing the Garden Route from Port Elizabeth to Mossel Bay and further westward, is renowned continentally, if not globally.

And to follow the route of part of those travels, what better way than starting off the Apple Express route with the marvellous cartography of that renowned railway mapmaker, Bruno Martin, which helped to set the scene on various stops along the way.

This article describes projects considered by the writer to be Really Old or Vintage (at least in South African terms, if not global), at around 100 years or more, and those that are simply Just Old or Veteran, i.e. typically of 40 to 65 year vintage.
VINTAGE BRIDGES (PART 1)
PORT ELIZABETH – AVONTUUR
(NARROW GAUGE RAILWAY 610 mm)

Starting off at the Campanile in Port Elizabeth, not far off the beach landing of the 1820 settlers, we traced the route westward, witnessing the locale, if not the original buildings (since demolished), of the Port Elizabeth Station, narrow gauge shunting yard and workshops at Humewood Road – the home of the Avontuur Railway and Apple Express – reportedly, at 285 km, the longest narrow gauge railway in the world.

Here, among the many abandoned and derelict fruit trucks for one-time apple and citrus exports, we came upon the jewel – the restoration workshop – where a small team of young black and white South Africans were working together restoring locomotives, carriages and wagons to serve the local Mandela Bay tourist rail route, in the process giving us enthusiasts a picture of hope that an otherwise vastly neglected railway heritage is being preserved by the younger generation, albeit on a small scale, in this one-time focal point of early Cape Government Railways (Midland Section).

We followed the historic one-time route of the Walmer Branch Line out of the city. Although none of this remains on the ground today, the line served the local transport requirements of the separate Walmer town/municipality (situated on the other side of the Bakens River from early Port Elizabeth) for roughly 20 years, until suspended in 1927 due to competition from road transport and the bus service.

As with much early railway history of South Africa commencing during the years under colonial rule, the demands of the agricultural community for better access to their markets were the primary motivators for new construction, and the Eastern Cape was no exception.

While the Long Kloof and Gamtoos valleys developed as early breadbaskets for the region, and the ox-wagon transporters held all the logistics cards, the routes to markets remained tenuous and slow, having to negotiate tough obstacles in crossing the wide Gamtoos River floodplain, subject to periodic significant flooding, and the deep and tortuous route through the Van Stadens River gorge. Constant petitions by farmers for the railway, however, finally led to a “hurried survey” being completed in 1896 for a route through to the Long Kloof.

In 1898 the parliament of the Cape Colony approved the construction of the railway, which reportedly for economic (but ultimately technical) reasons was to be limited to a narrower gauge (2 feet or 610 mm) than the standard Cape gauge of the era (3 feet 6 inches or 1 067 mm) to enable it to negotiate the more robust topography of this region [Cape gauge was already notably narrower than the standard (British) gauge of the times (at 4 feet 8.5 inches or 1435 mm) designed to be compatible with the much milder topography of England].

The allocated budget proved entirely inadequate when tenders were first called, and even with additional financial allocation the line had to be constructed departmentally by the Cape Government Railways themselves. The Anglo-Boer War of 1899–1902 intervened, placing significant constraints on the project in terms of availability of labour and materials, but by December 1903 the line had almost reached the Van Stadens River gorge, then a tourist attraction of note, at a distance of roughly 40 km from Port Elizabeth.

The year 1904 brought the construction of the first two major bridges on the line – Van Stadens, being a steel lattice deck supported on slender steel trestles founded on the Table Mountain Group rocks in the gorge, and Gamtoos, first being bridged in a low-level, short-span, timber construction of 17 spans founded in the deep alluvial sediments of the significant floodplain.

The Van Stadens Rail Bridge, which comprises six spans across a gorge width of 197 m, contains reportedly 574 tons of steelwork – surely a remarkable economy of design for a structure of this magnitude. It is described as a lattice Warren truss bridge supported on wide-braced steel towers, the highest approaching 70 m. Construction was facilitated by means of an aerial cableway spanning the gorge.

The bridge remained in regular commercial use until the early 2000s and is still reputed to be the highest narrow gauge railway bridge on the planet – at 76 m above the riverbed. Abandonment of agricultural transport arrangements in favour of road haulage, and closure of the Eastern Province Cement Company limestone quarries (also served by this railway) in the Hankey and Loerie areas, progressively led to the final economic demise of this most historic and scenic of railways.

From the highpoint at the nearby Summit Siding, at 228 m AMSL (above mean sea level), the railway drops rapidly to Loerie at 30 m AMSL over the remarkably short distance of 13 km, through robust topography described by the Engineer-in-Chief of the Cape Government Railways (CGR) at the time as comprising “engineering difficulties above the average for a large proportion of its length” – surely a typical engineering understatement of the time!

At Loerie our tour visited the site of a unique locomotive turntable, the first seen by the writer in southern Africa, complete with fabricator’s plate (Cowans Sheldon & Co of Carlisle, England) dating from 1883 – quite obviously salvaged from a prior life elsewhere. Cowans Sheldon was founded in 1846 by four engineers, of whom two had been apprenticed to Robert Stephenson on the earliest railway engineering in England. They specialised in the manufacture of...
all manner of cranes for railways, marine and harbour works, many of which survive today in the UK and around the globe. The company itself survives today with other well-known names of the era, as a subsidiary of Clarke Chapman, manufacturers of mechanical handling equipment.

The floods of 1904 and 1905 washed away both the initial Gamtoos Bridge (timber) and its premature reconstruction in similar form. As our resident hydrologist (on the BERRT 2019 trip) stated, and was to reiterate a number of times during our tour, South African/Colonial bridge engineering was then already beginning to learn, by tough and expensive consequences, the outcome of a scientifically inadequate hydrological appreciation of Africa’s rainfall and river flow patterns.

Not that the issue wasn’t then already appreciated at the highest levels of engineering investigation and design, as articulated in a 1905 paper by Wilhelm Westhoven (more of him later) presented to the fledgling Cape Society of Civil Engineers (established in 1903 as the predecessor of SAICE), in which he stated, “The most important point in connection with these preliminary [bridge] investigations is the determination of the highest flood level … following a period of heavy rainfall … Engineer has frequently to perform a most difficult task … necessary to rely on observations … by inhabitants of the district, more particularly the oldest inhabitants … as a rule … fairly reliable … but … cases … proved the oldest inhabitants’ memory wrong … with somewhat disastrous consequences.”

Gamtoos was finally bridged successfully in a composite steel construction, in 1911, with a prodigious centre span (for the day) of 70 m (230 feet) (interpreted by the writer as a Parker truss, or Pratt truss modified with a polygonal top chord). This span was fabricated (and fully preassembled for testing in the manner of the day) by Braithwaite & Kirk, of West Bromwich, England, notable bridge builders of the era.

The Transnet Heritage Library (THL) in Gauteng holds a photograph dated 1910 showing this bridge span, fully assembled for inspection and testing. The bridge was then disassembled and shipped out to the Cape Colony – as a giant Meccano set! – thereafter reassembled fully and riveted together on a working platform including timber piles driven into the deep river bed alluvium, and raised in short lifts by an ingenious jacking arrangement, each lift sequentially followed by the incremental raising of its supporting piers.

**VINTAGE BRIDGES (PART 2) GEORGE – KNYSNA RAILWAY (CAPE GAUGE 1 067 mm)**

The former highly popular tourist Outeniqua Choo-Tjoe line was built in the post-World War 1 years, primarily for transport of timber and related products from the Knysna forests. However, recent years of extreme climatic events have seen this line fall into disrepair as a result of several landslide/slope failures of the highly sheared, and often unfavourably inclined, schist-dominated formations of the Cape Fold Belt mountains in the vicinity of the Kaaimansrivier Railway Bridge, which was recently the subject of an extensively researched and highly informative article by our BERRT colleague, Johannes Haarhoff (published in Civil Engineering, November 2019, pp 8–19).

Similar instability events have also dramatically impacted the N2 National Road, giving rise to spectacular slope stabilisation and road construction works in recent years, including an impressive bridging viaduct around Dolphin Point overlooking this world-renowned railway bridge near Wilderness.
The Kaaimansrivier Railway Bridge received the SAICE History and Heritage Panel’s Landmark award for 2019 during the course of the BERRT 2019 tour, which was celebrated through a rather thunderous and heavy rainfall-curtailed event by a small interest group which included the mayor of George, local Southern Cape Branch representatives of SAICE, local media and the BERRT tour group. The occasion was formally addressed by SAICE’s President for 2019, Brian Downie. (The downpour was nevertheless greatly welcomed by this drought-stricken part of the country.)

Settlement and damage to the railway causeway/viaduct across the Swartvlei Lagoon at nearby Sedgefield, underlain by deep lacustrine sediments, and general deterioration of the rail track present further concerns with regard to the estimated high cost of rehabilitation works necessary to restore this most attractive of railway lines to viable operation. In spite of intensive lobbying for its restoration by heritage and tourism groups, the necessary sanction of the very essential rehabilitation works and re-opening of this prime tourist facility sadly continue to fall on deaf ears.

Environmental concerns and objections to the continued running of steam locomotives, and the ever-present concerns for initiating severe forest fire damage in this area have also sadly (for the enthusiast and tourist), but very clearly put paid to the future of steam on most southern African rail routes.

VINTAGE BRIDGES (PART 3)
MOSSEL BAY – ALBERTINIA

Although strictly beyond the westernmost limits of the planned BERRT 2019 tour, the old bridges traversing the Gouritz River...
deserve particular attention, in the context of this article, for the significant gorge they span, and the spectacular engineering solutions for the era(s) in which they were built.

The site, located roughly 35 km west of Mossel Bay, is shared by two vintage steel road and railway bridges, the oldest of which (of double-balanced cantilever design with drop-in span, similar in concept to the Forth Rail Bridge in Scotland, and dating from 1892) is attributed to the design of the renowned Victorian (UK) engineer, Sir Benjamin Baker, with the following citation on an embossed commemoration panel, today well hidden amongst the heavy vegetation above the eastern abutment of the bridge:

**GOURITZ RIVER BRIDGE**
**ERECTED IN THE REIGN OF QUEEN VICTORIA**
SIR HENRY BROUGHAM LOCH, G.C.M.G; K.C.B. GOVERNOR OF THE COLONY
DESIGNED BY SIR BENJAMIN BAKER, K.C.M.G; M.I.C.E.
ERECTED BY WILHELM WESTHOVEN, A.M.I.C.E. AND JAMES CHADWICK, CLERK OF WORKS
UNDER DIRECTION OF WILLIAM MAGEE GRIER, M.I.C.E, CHIEF INSPECTOR OF PUBLIC WORKS, CAPE COLONY
OPENED TO THE PUBLIC MARCH 1892

While the designer, Sir Benjamin Baker, needs little introduction, having been co-designer with Sir John Fowler of the Forth Railway Bridge, further research on Wilhelm Westhofen records him as being in the employ of the Cape Colony Public Works Department, and subsequently 5th President of the Cape Society of Civil Engineers (the forerunner of the current SAICE) in 1907. He was also the author of a paper presented to the Society in 1904, on materials for bridge construction in the Cape Colony, included in which he discussed the rationale for the cantilever bridge design adopted for the first (1892) road bridge on this site, which was subsequently modified to carry rail traffic as well.

The contemporary photograph (Figure 8) shows the 1892 (road and later combined rail), 1932 (dedicated rail) and 1978 (current N2 road) bridges together – a remarkable triplet which majestically displays the skill and ingenuity of three generations of notable bridge engineers and contractors.

The 1932 rail bridge, although built for the wider Cape gauge traffic, represents a similar, but clearly heavier (lattice truss on braced steel towers) design, to the Van Stadens narrow gauge rail bridge.

**VETERAN BRIDGES**
**N2 GARDEN ROUTE BRIDGES (1950s – 1980s)**

The **Storms River Bridge** on the N2, located between Humansdorp and Plettenberg Bay, in the Tsitsikamma Forest area, was the first South African arch bridge exceeding a 100 m span, which replaced the original road pass paved through the deep Storms River ravine by Thomas Bain around 1885.

It was built to a revolutionary design and construction technique, and was completed in 1956. The South African contractor, Concor Construction Corporation, engaged the renowned Italian engineer, Professor Morandi, to design the structure which incorporated a number of his characteristic traits, including inclined spandrel deck-support columns which radiate, rather than rising vertically, from the main arch. The design was reportedly done remotely in Italy in its entirety, based solely on photographs (and probably surveys) of the site, and verbal communication. Professor Morandi first visited the site only on final completion of the bridge.

An extensive photographic display in the adjacent roadside restaurant, comprehensively records the complex construction process followed by the contracting team. This effectively required the two halves of the arch formwork to be erected vertically on massive hinges, on opposite sides of the gorge, to facilitate the concrete pour, each arch rib being cast in two elements and allowed to gain strength before being lowered into position. It is reported that the contractor had to wait several hours for the design temperature to be reached to ensure that final closure of the arch “gap” was achieved. Clearly too, the survey technology of the day – preceding today’s electronic wizardry – proved to be of an exceptionally high degree of accuracy.

A scale model of the bridge, donated to the University of the Witwatersrand by Concor, adorns the entrance lobby to its Civil Engineering Department.

The **Van Stadens Road Bridge** on the N2 between Port Elizabeth and Humansdorp – the first of the modern era of concrete arch bridges on the N2, built using the suspended cantilever method – was completed in 1971 by the JCI / Impresa / Di Penta consortium to a design by South African engineers Liebenberg & Stander.

This bridge, located a short distance downstream of the rail bridge (discussed previously), replaced the long twisting pass and low-level bridge and causeway built initially by the Cape Colony Government and rebuilt a number of times as a result of flooding and wash-aways in the 1850s, 1860s and since. When completed in

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**Figure 8** The unique triplet of bridges across the Gouritz River gorge, constructed (from left) in 1978 (current N2), 1892 (road and later combined rail) and 1932 (dedicated rail).
October 1971, it was the longest concrete arch bridge in South Africa and the sixth longest in the world at that time. It has a main span of 198 m and soars to a height of 125 m above the gorge. The two halves of the arch were constructed simultaneously from their respective abutments founded on the competent Table Mountain (quartzitic) Sandstone formation.

The Gouritz River Bridge was not part of the BERRT 2019 inventory of sites. However, the writer, in travelling from Cape Town to join the tour, had the pleasure of a brief visit in passing to photograph this fine rigid concrete frame structure (alongside its illustrious predecessors [discussed previously]). It was completed in 1978 by the Murray & Roberts / Concor Construction consortium, to a design by Liebenberg & Stander in association with Freeman Fox & Partners of the UK.

The bridge is 270 m long, consists of four spans and stands 61 m above the river gorge. The deck comprises a continuous pre-stressed concrete box girder, supported on twin diagonal struts to form the rigid framed structure and was constructed cantilever-style, suspended by cables from temporary support towers. Geological mapping indicates that the abutments are founded in sandstones of the Baviaanskloof Formation, part of the Table Mountain Group.

The Bloukrans Bridge, and its nearby neighbours – Bobbejaans and Groot River – are concrete arch bridges designed by South African and UK Engineers in consortia (see Table 1). All three were constructed by a consortium of South African contractors – Murray & Roberts and Concor Construction – and are founded on highly metamorphosed Table Mountain Sandstone exposed on the flanks of the steep-sided ravines.

These bridges replace the steep and tortuous road passes initially built during the late 1800s era by Thomas Bain.

This 'triumvirate' of bridges proved to be one of the most demanding and technically complex contracts Murray & Roberts had ever worked on (as stated in M&R’s project overview) – from a design as well as construction point of view – with a tremendous amount of work expended in the design of the temporary stage structure(s), which proved more complex than the permanent (finished) structure.

All three bridges were constructed in similar manner, by the free suspended cantilever system. That is, every fourth segment – each averaging 5.25 m in length – was tied back by BBR suspension cables. This was reportedly the first time that the (Swiss-developed) BBR system of pre-stressing was used for this application.
At the time of construction, the Bloukrans Bridge was the largest concrete arch bridge in Africa and the fourth largest in the world. The arch alone has a mass of nearly 12 000 tons! Bloukrans Bridge was opened in June 1983, after being completed a staggering five months ahead of the tender schedule, and received both the Fulton Award for Excellence (South Africa) in the use of concrete from the Cement & Concrete Institute (formerly the Portland Cement Institute) and the SAICE Eastern Cape Branch Award in 1983.

In a critical review of the aesthetics of the Bloukrans design (and it is presumed this could justifiably apply equally to that of its two close neighbours) it was reported at an international Bridge Engineering Conference in 2008, 25 years later, that “Bloukrans is a great success and compares favourably with Leonhardt’s (doyen of bridge engineers) 10 rules for aesthetics” and “it would be difficult to improve on the aesthetics of the design”.

Truly a mega-project on the global stage and a credit to all involved in its design and construction.

In concluding this commentary on these latest six modern arch bridges, dating since the earliest one in 1956, it is pertinent and sobering to note that their value to our modern world, in terms of convenience for present-day travel, transport and logistics, is barely appreciated by the non-engineering public (other than bungee jumpers maybe) who, whether in private vehicles or public transport, continue to traverse at great speed across these great edifices of civil engineering in the space of seconds – a tiny fraction of the time we’d need today to traverse the (replaced) road passes of old.

But for those with a passion for documenting the wonders of our great profession, such iconic structures remain a continuous joy to the heritage and photographic enthusiasts of our era.

**OTHER CIVIL AND RAILWAY ENGINEERING HERITAGE PROJECTS VISITED BY BERRT 2019**

The BERRT 2019 tour uncovered a good deal more of heritage interest and monuments to past projects and schemes, including the following of which brief mention is made:

- The Montagu Pass (with its adjacent railway), which crosses the significant Outeniqua Mountain barrier out of...
George on its way to the Little Karoo and hinterland, was opened in 1848 and was described by John Montagu, the Colonial Secretary of the day, as “one of the most stupendous and gigantic works undertaken by the Central Roads Board” (the precursor to the Public Works Department). Its design and construction included ingenious measures to curb the tendency of ox-drawn wagon axles to destroy the dry stone walls which protected them from the sheer mountain sides, as well as culverts and underdrains which function as well today as when built roughly 175 years ago.

The English novelist of the Victorian era, Anthony Trollope, described the Montagu Pass as “equal to the mountain roads through the Pyrenees”.

Construction on the 15 km long Outeniqua Pass out of George (originally located by National Roads Engineer PA de Villiers and comprising prodigious cuts and fills) was commenced as a low-key project during the World War II years, making use of limited numbers of Italian prisoners-of-war. Thereafter construction was ramped up by the South African contractor Clifford Harris and completed in 1951. Further road widening and improvements to ease the alignments and improve traffic flow were constructed by LTA Earthworks and completed in 1997.

The Outeniqua Railway Museum in George proved to be a gold mine of information covering all aspects of Transnet (formerly South African Railways & Harbours – SAR&H) history, including airways, railways, and harbours (the latter including the revolutionary dolos harbour/wave-protection design of the 1950s by the South African harbour engineer, Eric Merrifield, which has been replicated around the globe as a most highly efficient wave-energy dissipater.

The Great Brak River Hydro-Electric Power Plant, constructed by the Searles Company in 1924 provided power for their growing business interests in that village and was fully operational until the 1990s. The facility comprises headrace/furrow of several kilometres, a roughly 150 head penstock and Pelton Wheel turbine of 350 kVA capacity.

The Voorbaai Railway Workshops at Hartenbos, comprising a substantial amount of heavy workshop machinery, and operated today by volunteer teams, have in progress several full-scale steam locomotive restoration projects on behalf of a variety of private investors.

Table 1 N2 (Garden Route) arch bridge ‘triumvirate’ – 1980s construction

<table>
<thead>
<tr>
<th>Category</th>
<th>Bloukrans River</th>
<th>Groot River</th>
<th>Bobbejaans River</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design engineers</td>
<td>Liebenberg &amp; Stander (SA)</td>
<td>Maunsell &amp; Partners (UK)</td>
<td>Freeman Fox (UK) WLPU (SA)</td>
</tr>
<tr>
<td>Contractor</td>
<td>Murray &amp; Roberts / Concor Consortium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completion date</td>
<td>June 1983</td>
<td>1983</td>
<td>1983</td>
</tr>
<tr>
<td>Total bridge length (m)</td>
<td>451</td>
<td>300</td>
<td>286</td>
</tr>
<tr>
<td>Arch span (m)</td>
<td>272</td>
<td>189</td>
<td>165</td>
</tr>
<tr>
<td>Arch rise (m)</td>
<td>62</td>
<td>33</td>
<td>34</td>
</tr>
<tr>
<td>Height above river (m)</td>
<td>216</td>
<td>172</td>
<td>170</td>
</tr>
<tr>
<td>Cost in 1983</td>
<td>R25 million for the three bridges together</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Attributes/awards at time of construction

Global
- Fourth largest concrete arch
- World’s highest arch
- World’s highest bungee site

Africa
- Largest concrete arch
- 26 Weeks ahead of schedule
- Fulton Award C&Ci (SA)
- SAICE Eastern Cape Branch

N2 Highway accolade
Reportedly the only highway in the world outside of China and Italy with THREE bridges exceeding 150 m height

Figure 13 Bloukrans River Bridge – the largest of three concrete arch bridges (with Groot and Bobbejaans) constructed in the early 1980s (note the vertical deck columns in contrast to the Storms River Bridge)
The BERRT 2019 tour finally came to a close with a distant view of the Cape St Blaise Lighthouse in Mossel Bay, which was commissioned in 1864.

CONCLUSION
The question might finally be asked: Who shows such interest in BERRT? To which I would respond that, as one of that body of engineers who fashion the great forces and attributes of nature for the benefit of mankind, it is always a great joy to witness and reflect on the extent to which civil engineers have tamed our planet for human benefit and made possible the convenience of our standards of living in the 21st century, while not ignoring the results of our endeavours on the environment and the measures we need to continually apply towards mitigating the negative consequences of our actions.

THANKS AND APPRECIATION
- To Johannes Haarhoff, our tour leader, who organised the logistics and researched in great detail all the venues we visited.
- To Allen Duff, our resident historian based in George, who added many insights and background information and provided huge substance to the trip.
- Each of the BERRT 2019 team members, whose interest and passion and attendance have made these ongoing heritage tours meaningful and of great value.

DEDICATION
To Francis Legge, BERRT colleague of many years, fellow professional engineer and friend, who passed away shortly before the 2019 tour, and whose presence was sorely missed.

PREVIOUS BERRT ARTICLES PUBLISHED IN CIVIL ENGINEERING

2013
Cry, the beloved railway – revisiting the Barkly East branch line (May pp 40–45)

2014
The Bridge on the River Kraai (May pp 41–48)

2015
Construction of the Prieska – Kalkfontein Railway Line 1914–15

2016
Ingogo to Langsnek – echoes and archaeology of railways and wars (May pp 66–74)

2017
Conquering the Escarpment – Railway Engineering in the Elands River Valley (May pp 20–30) including a profile on Railway Engineer TH Watermeyer (pp 15–18)

2018
Breaking through the mountains – the railway line from Wellington to Touws River (May pp 39–49)
INTRODUCTION
Gravity quay and sea walls, specifically block walls, have been used as some of the earliest engineering solutions. An example is at the historic Lothal Port (in India) where vertical walls have been constructed with fired mudbrick to provide a four-metre-deep dock. These walls date back to approximately 2400 to 2000 BC. As trade routes developed, knowledge transfer increased, which led to the development in construction materials and techniques. Stone and timber material structure combinations, and later concrete, were used. The Romans introduced the concept of timber caissons filled with marine concrete (De Graauw 2019). In the 19th century steam ships started replacing sailing vessels and the draughts of the vessels started increasing, resulting in the need for deeper berth structures. With the introduction of steel reinforcement more slender structures could be constructed. Steel piled solutions also became a viable structure option. To this day blockwork walls can still be the best solution, depending on the project requirements.

A quay wall can be defined as a structure at which ships can berth, and a sea wall as a structure that separates land and water areas, designed to limit damage due to wave action and storm surge. Vertical gravity walls are vertical-faced walls that rely on the structure’s own weight for stability.

In South Africa we have a significant number of gravity structures in our ports, fishing harbours and as sea walls on our coastline. A few examples are the blockwork quay wall at the container quay at the Port of Ngqura, a counterfort quay wall at the multi-purpose terminal of the Port of Saldanha, a caisson quay wall at the coal terminal of the Port of Richards Bay (Figure 1), a blockwork sea wall at the Sea Point promenade and an L-wall sea wall at the Strand promenade (Figure 2).
DESIGN
The design of gravity sea and quay walls requires a multidisciplinary team of designers to work together to ensure a complete design. The basic fields of expertise required typically include coastal engineers, structural engineers and geotechnical engineers. Depending on the project-specific requirements this list can be extended to include, for example, seismic experts, port operation experts and vessel motion experts. It is important to realise that the designer requires the right experience in the marine field or should be supported by an experienced team in order to design these structures. Assuming that the approach taken for the design of land-based retaining walls is also suited to marine structures can be a costly mistake. For marine structures the early involvement of marine contractors is often beneficial. This can significantly reduce the need to re-design elements to ensure that they are ‘constructible’ and easy to install over or under water.

STRUCTURE TYPES
Initially various structure types are considered as possible solutions based on project-specific requirements. The vertical-faced gravity structures that are often included in the optimal structure type assessment include:
- Block walls
- Caisson walls
- Counterfort and L-walls

Gravity block walls are mass concrete (or lightly reinforced) blocks placed on top of each other to form a gravity wall. An example of a sea wall constructed with bonded blockwork is shown in Figure 3.

Caissons are thin-walled reinforced concrete cellular structures with an open top, which are generally floated into position. Once in position they are sunk by opening valves in the walls to let seawater into the cells. The cells are filled with sand or other material once the unit is in position and before the superstructure is constructed. An example of a small caisson block used as a sea wall is shown in Figure 4.

An L-wall is a cantilever wall constructed of reinforced concrete. Stability is provided by the weight of the reinforced concrete, as well as a component of the backfill that rests on top of the base slab.
The portion of backfill that contributes to the wall stability depends on the wall-height-to-slab-width ratio, as well as the backfill properties. Should the depth requirement increase beyond an optimum point, a web is added to the retained fill side. When this web is required the L-wall is classified as a counterfort wall. An example of L-walls used as sea walls is shown in Figure 4, combined with caisson wall construction.

The geometry of the structure is determined by assessing various factors, such as site-specific information (environmental conditions, geotechnical conditions, topographic and bathymetric surveys), operational considerations, architectural requirements, as well as design and construction-related aspects.

**DESIGN CODES AND STANDARDS**

Various design codes and guidelines related to the design of marine structures are available. In South Africa (and a number of other countries) the British Standard (BS 6349 series) for Maritime Works, which are aligned with the Eurocodes, are often used. These standards do not always fully cover all the aspects required for the design of these structure types, therefore reference is often made to other codes and design guidelines. This is especially true for the design of sea walls that are exposed to wave action. The BS 6349 and Eurocode documents can be quite challenging to use, as there are a number of references to other codes within the suite, sometimes leaving one with the feeling that one has entered a maze.

Estimating the magnitude of the various actions and then defining the range of combinations of actions that apply to these structures can be a design activity that requires significant effort. The type of actions that must be designed for is project-specific, but can include the following (also shown graphically in Figure 5):

- Wave action
- Tidal lag and hydrostatic pressures
- Earth pressure
- Actions on the apron (including surcharge and cranes)
- Berthing
- Mooring
- Seismic
- Snow and ice
- Thermal actions

**Figure 4 Example of a combination of caisson and L-wall construction for a sea wall (Ackhurst 2020)**

- **Currents**
  Depending on the structure type, the strength and stability of a maritime structure (when designing to Eurocode) must be verified for some or all of the following ultimate limit states:
  - **EQU**: Loss of static equilibrium of the structure, such as overturning stability, where the strength of the structural members or the ground do not govern.
  - **GEO**: Failure or excessive deformation of the ground where the rock or soil strengths govern.
  - **STR**: Failure or excessive deformation of the structure (structural strength) where the strengths of construction materials govern.
  - **HYD**: Hydraulic heave, internal erosion and piping in the ground caused by hydraulic gradients.
  - **UPL**: Loss of equilibrium of the structure or the ground due to buoyancy and wave-driven uplift.

For each of these ultimate limit states persistent, transient, accidental and seismic design situations may apply, and partial factors are applied to actions (or action effects), material properties (and/or resistances) and geometrical parameters. For geotechnical and structural ultimate limit...
states, design the verification may require the use of up to three design approaches, depending on the country-specific Eurocode requirement. One wonders what the 2000 BC designer would think of the way we do things these days!

Serviceability limit states criteria must be defined in relation to the serviceability requirements. It may be necessary to assess deformation limits for structures supporting crane rails or oil and gas pipelines.

Once the various combinations of actions that may apply are identified, designs should be completed to evaluate the following possible failure mechanisms:
- Deep slip
- Bearing
- Sliding
- Toppling or overturning
- Block-on-block sliding for blockwork walls
- Block-on-block overturning for blockwork walls
- Stability design (EQU, UPL and HYD)
- Structural design

Other details that may also need to be designed include toe protection to the structure, and tidal drain and wall joint details. Furthermore, there may be a requirement to fit the wall with service tunnels, outfalls, wave chambers, quay furniture, equipment and other fittings.

Often physical modelling is conducted for sea wall structures to validate the design.

For further information, including step-by-step worked examples and information to include in the technical specifications, reference can be made to the new ICE design guide, *Design of Vertical Gravity Sea and Quay Walls* (Ackhurst 2020). The guide is available from the ICE online bookstore (www.icebookshop.com) and will soon be available from the SAICE bookshop.

**BIBLIOGRAPHY**


The study examines how security data on South African women compares with international studies. The first section of the two-part study sets the context by examining international trends in travel-pattern differences between women and men, while the second part examines data on mobility, based on the South African National Household Travel Survey (SANHTS) of 2013, looking for trends in trip frequency, duration, distance and mode choice.

Co-author Prof Marianne Vanderschuren of the University of Cape Town, says that, although rail offers the cheapest daily commute, trains are the most dangerous mode of public transport for South African women. Prof Vanderschuren, who is based at UCT’s Centre for Transport Studies in the Faculty of Engineering and the Built Environment, says transport planning is male-dominated, hence better guidance is needed for transport planners and city authorities to draft and design more gender-sensitive networks and services. According to her, women’s priorities must be met if urban transport is to cater for the needs of the entire population. “Currently, transport is not gender-neutral and is in sharp contrast to the country’s progressive Constitution.”

She says furthermore that the commuter safety issue must also be viewed against the South African National Development Plan’s 2030 vision, which includes improved access to economic opportunities, social spaces and services by bridging geographic distances affordably, reliably ... and safely. As such Prof Vanderschuren and her co-authors’ findings have significant implications for the country, calling for more nuanced public transport policies. According to her, “Treating communities as homogenous is one of the major flaws in current policies and practices which do not recognise that women and men have different needs and patterns of mobility and accessibility.”

WOMEN’S TRAVEL TRENDS

The authors’ research has shown that harassment on the bus and train, as well as at public transport hubs and stops, strongly influences how women choose to travel in their daily commutes. The safety issue is aggravated by the urban environment that includes poor lighting at stations, in

Transport engineer Prof Marianne Vanderschuren (in the foreground) and her co-authors’ award-winning paper calls for more gender-sensitive transport networks and services (Photo: Lerato Maduna)
subways and along the pathways en route to transport hubs.

Literature from different parts of the world shows that women make more personal trips than men of the same age group. Typically, women make multiple stops or ‘trip chains’, combining shopping, collecting and dropping off children, visiting family and running errands, in the process paying multiple fares and travelling during off-peak hours when public transport services are less reliable and waiting areas less busy.

In South Africa more women than men (26.5% vs 23.5%) use public transport (men use cars more as drivers and passengers), and more women (31% vs 27%) travel to work, while men make more business trips. In line with international literature, South African women make 2% more ‘care trips’ (taking children to school, clinic visits, etc) and 8% more shopping trips.

The second part of the study also unpacks harassment experiences in Cape Town. This is based on fieldwork with four focus groups (including women from Langa, Atlantis and other areas), as well as interviews with 285 rail passengers.

Overall, between 20% and 56.5% of household heads consider parts of the public transport journey risky. Trains are considered the least safe and are used mainly because fares are cheaper.

Vanderschuren says that an alarming percentage of household heads expressed concerns about Metrorail train services, run by the Passenger Rail Agency of South Africa, which is responsible for 2.2 million people trips daily (before the collapse of the central line in Cape Town and the effect of Covid-19) in the country’s major urban areas. Household heads were particularly concerned about the walk to and from the station (56.6%), and many worried about the time spent on the train (47.3%) and at Metrorail stations (32.4%).

The study found that when respondents travel alone, especially female passengers, they often meet up with the same people while out travelling to keep an eye out for each other, and if they are not planning to travel the next day, they let their fellow travellers know.

The focus group reduced risks in the same way. However, the time of day did not appear to affect the risk of harassment significantly in the South African context. This contradicts global findings, where travelling at night is considered more dangerous.

The train passenger focus group were overwhelmingly in favour of security on and around train stations. They also called for workshops focused on the youth, who are seen as the main perpetrators of harassment on trains.

**MOBILITY DEPRIVATION**

“It’s time for a different approach,” says Prof Vanderschuren.

According to her, research in transport planning and practice has consistently failed to apply a social science perspective when determining patterns of transport and travel. Too little research on this topic has been done in the global south, and the resulting systematic lack of understanding
of the gender-based differences in system requirements leads to what she calls *mobility deprivation*. However, she is confident that research will continue to play its part in finding solutions.

For example, in the future it may be useful to define different categories of journey length – 5 km, between 5 km and 10 km, and journeys of more than 10 km, or even journeys from one urban centre to another or across provincial boundaries.

“There is also potential to look at comparing transport users in urban centres beyond the Cape Town metropolitan area over similar distances, and contrast these results with transport users’ behaviour in rural areas.”

**POLICY RECOMMENDATIONS**

While the South African government has policies and strategies to invest in public transport modes to make them accessible, safe, affordable and reliable, recent investments have not resulted in the anticipated personal safety improvements. To address the issue, Prof Vanderschuren and her co-authors’ paper lists seven policy recommendations:

- Public transport integration is needed to improve public safety, especially for women, and to accommodate the care trips they make to serve others.
- Public transport and non-motorised transport masterplans should feature women’s need for safety as a unifying element for investment. Key linkages are needed between communities and public transport precincts, and should include proper lighting, paved walkways and designs that encourage safety and security, especially around train stations.
- Involvement from civil society is needed, awareness campaigns should be created, and options should be available within the law to address security concerns.
- Government should partner with minibus taxi (MBT) organisations to advocate for better security. Focus should be placed on the MBT service as an integral part of the South African transport system to establish it as a safe and secure service.
- Visible policing and security (24 hours) should be the norm for public transport precincts.
- The research has shown that men and women perceive safety differently in South Africa. Therefore the SANHTS addressing questions to household heads only might be limiting. The paper recommends using women within households as the benchmark for security concerns.
- The legislative framework should ensure women’s safety, but the laws are not implemented adequately (in bylaws, for example), hence fear of harassment remains a barrier to women’s mobility and access to public transport. Although the Constitution does not make explicit reference to the right to transport, access to safe public transport is intrinsically linked to the right to freedom of movement.

Prof Marianne Vanderschuren can be contacted at the following address if readers would like to share their concerns and experiences with her: marianne.vanderschuren@uct.ac.za

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Technicrete is a subsidiary of ISG, a leading supplier of innovative infrastructure products to the construction and mining markets in Southern Africa.
The current atrociously poor ‘integrated’ public transport system in South Africa’s metropolitan areas has been moulded by short-sightedness in past and present decision-making, as well as political influences. This has led to a number of lost opportunities. More recently alleged mismanagement and corruption have also played a role. Despite all these problems there is an opportunity to restore the system, provided certain actions are decisively taken.
The first government comprehensive analysis of the growing urban traffic problem

With the realisation in the early 1970s that urban arterials and rail infrastructure alone were inadequate to solve the problem of the growing congestion in urban areas, the government of the day appointed a Committee of Inquiry into Urban Transport Facilities in the Republic, the Driessen Committee. The Committee, comprising in the main transport engineering professionals, submitted its report to the Minister in June 1974, making comprehensive recommendations towards addressing the looming problem of urban transport in South Africa.

The major recommendation of the Committee was the need to give public transport planning in major metropolitan areas a primacy in the ordering of national economic priorities. Unfortunately, the recommendations, which were accepted by government, and which led to the promulgation in June 1977 of the Urban Transport Act, were not fully put in place for various reasons, primarily the failure of the Treasury to provide adequate financial support. Also, the proposals for the coordination and integration of all urban transport modes, particularly rail, as well as the integration of land use and transport planning floundered because of political and professional institutional jealousies. Treasury also failed to grasp the nettle in making funds available to adequately address the growing urban transport problem. A major lost opportunity.

The next attempt to address the urban transport problem – the Welgemeed Commission

Towards the end of the 1970s taxi operators came onto the public transport scene. The movement grew rapidly, and to be true, some politicians saw this development as desirable in that it work opportunities for the poorer segment of the population were created. This movement escalated rapidly, and has carried on doing so for four decades, so much so that it currently carries by far the major part of public transport trips. However, the intransigence of the taxi industry to accept regulation as part of an integrated and controlled public passenger transport system without the subsidisation which buses receive has been a major problem to transport planners.

The situation was fast getting out of hand even as far back as 1981. In a search for stability the government appointed a Commission of Enquiry into, inter alia, the effect of taxis on bus passenger transportation. This led to various proposals being made as to how to handle this industry, most of which have not been successful, primarily because indecisiveness by government has resulted in inadequate control of the taxi industry, either because of its inability or because of its lack of resolve, or perhaps for political or ideological reasons. Another lost opportunity.

The role of rail in public transport

Commuter rail transport in South Africa has had a chequered history over the past 60 or so years. Unfortunately, institutionally rail has to a large extent operated outside of a properly coordinated public passenger planning endeavour. It is, however, an important element in an integrated public transport system. To be efficient, though, heavy-rail services require a high passenger patronage, much higher than that for bus transport. Compared to world figures, residential densities are very low in South Africa, thus creating a problem for the efficient use of heavy-rail transport in the country’s urban areas, which consequently needs extensive subsidisation. There are various lost opportunities in optimising the use of rail in public transport in our metropolitan areas, of which only three are given below.

The first is the non-implementation of two separate proposals to introduce a rail-based public transport system outside of the Transnet stable. Compared to other cities in the world of a similar size, Johannesburg is unique in that large numbers of low-income workers used public transport to travel from their homes to the central area and large numbers of high-income workers used private vehicles to travel less than 15 km from their homes to the central area. Accordingly, in 1970, in cooperation with the UK London Transport Executive, a scheme of 22.6 km in total length was prepared for a large rail-based mass transport system. Because rail mass transit systems require...
For many decades public transport systems in South Africa’s metropolitan areas have developed to support dispersed and segregated land use conditions brought about by the apartheid ideology. They are generally disjointed, uncoordinated and de facto racially segregated. The networks generally support dispersed low frequency, whereas peak concentrated operations primarily use modes unsuited to the demand conditions and operations of mixed traffic conditions.

extremely high capital expenditure and take a long time to implement, the authorities concerned would not commit themselves to expenditure of the order that was necessary. A lost opportunity.

In an attempt to resuscitate the rail mode as an important mode of transport in urban areas, the Department of Transport in the mid-1980s commissioned a second study to investigate the feasibility of a rapid-rail mass transit system for Johannesburg. This study was largely carried out by a London-based firm of consulting engineers who had vast experience in the design of large parts of the London underground rail system. The study was concluded in 1986 with a recommendation that “it is unavoidable that Johannesburg would have to prepare itself for a rail-based mass transit system by the year 2000”. A system was proposed at a cost of approximately R1 600 million (in 1986 rand values).

Unfortunately, because of political indecisiveness, possible financial problems and institutional jealousies, the proposal was not accepted by government — another lost opportunity towards the creation of an integrated public passenger transport system for the then Johannesburg area, the largest metropolitan conurbation in the country.

In 1990 the South African Rail Commuter Corporation (SARCC), an autonomous statutory body with its Board of Control comprising members from both the public and private sectors, came into being as a commercial entity under the overall control of the Minister of Transport. Its main function was to ensure that, at the request of any designated transport authority, rail commuter services are provided in the public interest.

From the outset the Exchequer did not provide adequate financing to enable the SARCC to provide and maintain an efficient public passenger service in the country’s urban areas. The commuter rail system reached the point of breakdown, with much of its rolling stock exceeding 40 years in age and with, in some places, dangerously inadequate signalling systems and permanent way because of inadequate financial input by the Treasury. Transnet consequently disinvested in commuter rail. Rail commuter transport was becoming, in some instances, dangerous and most definitely unattractive to the commuter — a lost opportunity as a result of intransigence of the two authorities concerned.

In 1996 in another attempt to remedy the rail public transport problem, the Department of Transport made proposals for the concessioning to the private sector of rail commuter services in a similar fashion to the successful endeavour in Buenos Aires, Argentina. Unfortunately the intransigence of Metrorail and SATS, as well as lack of political support, resulted in the rejection of the proposal — a lost opportunity to rescue a floundering commuter rail service in South Africa.

The above examples are only some of the lost opportunities to create effective public transport facilities in our metropolitan areas. More importantly, however, is the question of how this disastrous situation may be rescued.

THOUGHTS ON REJUVENATION OF PUBLIC TRANSPORT SYSTEMS

Change to the generally existing poor and disjointed systems in favour of efficient and integrated public transport systems in our metropolitan areas will not occur without concerted intervention on a number of broad fronts. There is a need for a system-wide change-orientated approach towards developing an effective high-coverage public transport system, which is coordinated and managed by adequately capacitated and jurisdictionally enabled metropolitan transport authorities. The following are some relevant areas:

Resistance to change

Change to integrated and efficient public transport systems for our urban areas will not occur without determined intervention. There are strong entrenched interests both from the land use and the operation of public transport viewpoints, which will resist change.

Distorted network conditions

For many decades public transport systems in South Africa’s metropolitan areas have developed to support dispersed and segregated land use conditions brought about by the apartheid ideology. They are generally disjointed, uncoordinated and de facto racially segregated. The networks generally support dispersed low frequency, whereas peak concentrated operations primarily use modes unsuited to the demand conditions and operations of mixed traffic conditions.

Institutional dysfunction in the management and control of public passenger transport

South Africa has three levels of government, all of which have strong original powers. This also applies to public passenger transport. During recent decades the provinces have however lost much of their transport-related expertise. The current allocation of public transport functions needs to change and the local level of metropolitan government should be given greater control of the function.

Destructive competition

For at least the past three decades South Africa’s public transport system has been beset with destructive competition. This competition between operators, both within and between modes, needs to be eliminated.

A FUNDAMENTAL RESTRUCTURING FRAMEWORK

There were a number of occasions during the past 60 years in respect of public passenger transport where recommendations by professional transport engineers were not implemented for various reasons, often political; these represent lost opportunities. These lost opportunities, some of which were mentioned above, if taken up
at the time might well have resulted in a sound passenger public transport system being currently the order of the day in our metropolitan areas.

Developing an approach to efficient and effective public passenger transport systems will not be an easy task in a market dominated by heavy government subsidisation and a de facto unregulated and often violent, but unsubsidised minibus taxi industry. Some of the components of a fundamental restructuring endeavour could include:

- Encouraging or enhancing trip patterns which lead to use of the appropriate mode of transport for the particular demand volumes, and higher operating revenues through improved vehicle fleet utilisation. This could be facilitated through encouraging public transport supportive land use development towards greater densities and corridor development.
- Discriminatory pricing in line with the externalities caused for low-occupancy motor vehicles in CBD areas.
- Increased powers, capacity development and funding for passenger transport authorities constituted outside of the scope of political involvement, and with the removal of provincial involvement in public passenger transport in metropolitan areas, in line with the 1988 Draft Passenger Transport Bill.
- Implementation of effective and efficient rail systems, such as the Masstran concept for Johannesburg developed in the 1980s, together with franchising of rail operations as proposed by the Department of Transport in 1996.
- Stricter control of minibus taxis as part of an integrated public transport system, but with subsidisation of operating costs.
- Greater involvement by users in the planning of public transport systems.
- An effective and efficient tendered contract approach for the provision of services by all modes of public transport, with strict monitoring.
- Maximising the potential for inter-route transfers between modes.
- Determining ridership profiles as a contributor to network design and development.
- Implementing the above in a phased approach.

CONCLUSION

This analysis concludes that there is a need for a widespread change-orientated approach if effective and efficient public passenger transport in South Africa’s metropolitan areas are to meet the needs of the public. At the least some of the lost opportunities of past decades need to be re-visited, and the fundamental issues discussed in this document also need to be addressed. Of particular importance is to address the element of destructive competition that exists both within the taxi industry and between it and the other modes of transport. The problem of restructuring public transport and creating an urban form supporting public transport, as well as removing the dominance of private cars, needs to be addressed on a number of fronts. The creation of a ‘new-look’ public transport system will not be easily tackled by small-scale changes over a period of time, but requires institutional realignment, a capacity-orientated approach to regulatory control, and enforcement and significant investment, both in monetary and personnel terms, embracing a paradigm change and a quantum leap in thinking. Do we in South Africa have the capacity and the will to do so?

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Copley, P & Mitchell, M F. Transport and logistics in Africa: Missed opportunities, future potential. Very condensed chapter from the book, which is in the course of preparation.
INTRODUCTION

Even though transport infrastructure is a foundation for development, the transport sector in Africa is plagued by numerous infrastructure challenges owing to a huge infrastructure gap that has developed over many years. Since the 1980s, the gap between demand and supply in all infrastructure subsectors has been widening rapidly in Africa. While transport demand has increased tremendously due to a high population growth and high levels of urbanisation, supply has remained constant, if not decreased. According to the African Finance Development Bank, a total of between US$35 and US$47 billion is required annually to close the infrastructure gap on the continent by 2025.

The case is no different in the Southern African Development Community (SADC) where several hard and soft infrastructure constraints, including poorly maintained road sections along regional road networks, limited bridge capacity, disjointed regulatory frameworks and market access restrictions, impede the seamless movement of traffic within and across neighbouring countries. SADC’s response to infrastructure challenges is noted by the adoption of the SADC Regional Infrastructure Development Master Plan (RIDMP) in 2012. The RIDMP outlines the region’s priority infrastructure projects in six sectors, including transport, totalling US$500 billion. Of the total, around US$100 billion are required for the implementation of priority transport projects between 2010 and 2027.

The infrastructure financing deficit in the SADC region is well known, and the importance of addressing it to drive regional growth and development is well understood. However, various methods of tackling the financing deficit have been debated over the years, and this has delayed the timely delivery of infrastructure programmes outlined in the RIDMP. Although eight years have passed since the adoption of the RIDMP, several of the prioritised projects are still in the planning or conceptual phases of the project lifecycle due to various factors, including declining public-sector resources allocated to infrastructure development.

FINANCING PARTICIPANTS

Although the SADC’s governments (like many other African governments) struggle to raise enough public funds for infrastructure projects, national governments are still the most active participants in infrastructure financing. During 2016, new commitments worth US$ 62.5 billion were made to Africa’s infrastructure sector, both at national and regional level. Budget allocations from national governments accounted for the bulk of infrastructure financing commitments at US$ 26.3 billion (42.1% share of total commitment) in 2016, while the members of the Infrastructure Consortium for Africa (ICA) accounted for 28.8% of financing in the same year. The private sector committed a mere US$2.6 billion, or 4.2% share of total commitment.

The SADC intends to establish an infrastructure financing mechanism to support the region’s ambitious transport and industrialisation plans. In this respect, the region resolved to establish the SADC Regional Development Fund (RDF). All SADC member states must contribute US$120 million in seed funding towards the RDF and make regular replenishments towards maintaining this fund.

The changing nature and unpredictable future landscape of international development aid, coupled with uncertainty as to whether the RDF will be sustainable over the long-term, still necessitates that the SADC countries continue seeking alternative funding sources to operationalise strategic transport projects. It is thus important that member states create a conducive environment that entices private sector players to fund infrastructure projects that are commercially viable.

PARTNERING WITH THE PRIVATE SECTOR

Given the constraints faced by the public sector with respect to financing infrastructure development, innovative funding solutions are required to address infrastructure deficiencies in the SADC. The private sector is globally recognised as an important source of investment in transport infrastructure, and the SADC region should therefore harness private sector participation. This can be done through full, or partial privatisation, with the latter often assuming the form of public–private partnerships (PPPs). PPPs involve financing from conventional and innovative mechanisms, in some combination of equity and debt, with the latter usually being used as the predominant part of financing. Given the monopolistic character and physical nature of transport infrastructure, infrastructure debt investment frequently offers greater flexibility to lenders than traditional corporate loans or bonds. Protection for the lender is enhanced by comprehensive risk monitoring.
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**Introduction**

While many formulae have been developed in international literature, the capacity equations used in this article for stop streets (TWSC, i.e. two-way stop control), roundabouts and right-turning in gaps were extracted primarily from the *Highway Capacity Manual* (HCM) (TRB 2000; 2010). The equations used for all-way stops were derived from first principles as described below.

**Two-Way Stop Capacity**

The capacity of a two-way stop is determined by the following HCM equation:

\[
C_x = \frac{V_c \times e^{-qc} \times tc}{1 - e^{-qc} \times tf}
\]

Where:

- \(C_x\) = capacity of movement \(x\) (veh/hr)
- \(V_c\) = conflicting flows to which minor movement must give way (veh/hr plus ped/hr)
- \(qc\) = \(V_c / 3600\) = conflicting flows (veh/sec)
- \(tc\) = critical gap (time required for the first waiting vehicle to accept a gap in traffic) (secs)
- \(tf\) = follow-up time or headway (i.e. the time between following vehicles taking the same gap) (secs)
- \(e\) = the base of natural logarithms.

**Derivation of \(V_c\) (conflicting flow)**

In Table 1 movements are numbered as per Figure 1 (movements 13 to 16 are pedestrians crossing in front of the approach).

The calculation of opposing flow is done using example movements ‘1’, ‘2’, ‘3’ and ‘12’ where ‘1’, ‘2’ and ‘3’ stop at a stop sign and ‘12’ is a “free” right turn from the main road.

The method used is identical to the HCM method, except that the pedestrian volume directly in front of the stop line ‘13’ is divided by two, as in South Africa most drivers will take a gap and not wait for pedestrians unless they are directly in front of the vehicle. Also, most pedestrians will yield to a vehicle if it is seen to be taking a gap.

**Derivation of \(tc\) (critical gap)**

Table 2 gives the critical gap acceptance factors from various references and are adjusted based on modelling for South African traffic conditions and for use in the AutoJ simulation (Sampson 2016). Quite a wide variation can be noted, and the fact that a larger gap is needed for wider crossings is evident.

---

**Table 1 Conflicting volumes**

<table>
<thead>
<tr>
<th>Movement x</th>
<th>(V_c) (conflicting flow) is the sum of:</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘1’ left turn from stop</td>
<td>‘4’*1 + ‘5’/j + ‘13’*0.5 + ‘16’</td>
</tr>
<tr>
<td>‘2’ straight from stop</td>
<td>‘4’*1 + ‘5’ + ‘6’*2.0 + ‘10’*0.5 + ‘11’ + ‘12’*2.0 + ‘13’*0.5 + ‘15’*0.5</td>
</tr>
<tr>
<td>‘3’ right from stop</td>
<td>‘4’*1 + ‘5’ + ‘6’*2.0 + ‘11’ + ‘12’*2.0 + ‘13’*0.5 + ‘14’</td>
</tr>
<tr>
<td>‘12’ right from main</td>
<td>‘4’ + ‘5’ + ‘13’</td>
</tr>
</tbody>
</table>

\(i = 0\) if movement ‘4’ is in an exclusive turn lane \(i = 0.5\) if in shared lane \(j = \) the number of straight lanes
The values in Table 2 are for two-way cross roads with no median island. If a median island is present, the crossing can be done in two stages, which would reduce the critical gap needed. That adjustment is described later.

The simulated two-lane values are for a 10 m wide crossing with no median.

In the HCM formula, the critical gap \( (c) \) determines the rate at which capacity decays with increasing conflicting flows. The effect of using a higher critical gap is therefore a faster and greater reduction in capacity as conflicting volumes increase.

Many references (e.g. Joubert 2010) and extensive testing done for AutoJ (Sampson 2016) indicate that using the critical gap values in HCM resulted in an overestimation of capacity of the movements taking gaps, particularly as conflicting flows neared saturation.

It was found that one way to overcome this without getting negative or zero capacity was to multiply the critical gap values by a correction factor of between 1.0 and 2.0. The correction factor has a minor influence on capacity at low conflicting flows but substantially reduces capacity with mid to high conflicting flows. Although in earlier versions of the AutoJ program this correction factor was used, to be more in line with international practice it was decided to rather use a value of critical gap on the high side (as per HCM 2000) in most instances and to adjust this by factors developed below to take roadway crossing width and the presence or absence of shelter (median island width) into account. In addition, in AutoJ the calculated capacity is reduced by 80 vehicles per hour, which is the estimated extent of the HCM overestimation at high conflicting volumes.

It can also be mentioned that, when motorists on the main road give courtesy gaps to side road traffic, it does increase side road capacity.

The adjustments to critical gap values have been derived as follows:

- **A crossing width** adjustment has been made to account for the longer critical gap needed on wider roads. In Table 2 some authors have found that longer critical gaps are needed for crossing four-lane roads. This has been translated into an adjustment for wide road crossings based on the crossing width in metres.

The standard crossing width is set at 10 m (from stop line to clearance on far side), and an additional 0.02 seconds are added for each additional metre to be crossed by straight-across traffic and 0.04 seconds for right-turn traffic. An additional crossing time of 0.02 seconds per metre is also added for right turns from the main road. As an example, the critical gap for a straight crossing would be 0.2 seconds more for a 20 m crossing than for a 10 m crossing.

The values of 0.02 and 0.04 were obtained firstly by reference to Table 2 and then by simulating various widths of crossings and noting their effect on capacity. Further research is needed to refine these values.

- **Median islands** enable a two-stage crossing, provided the median is wide enough, but even a narrow median provides some shelter to a crossing vehicle. For the purposes of AutoJ, the critical gap acceptance time was reduced by 0.2 seconds for every metre of median island width (based on simulation). Field studies are needed to refine this value – another opportunity for future research.

- **Adjustments are made for heavy vehicles.** For this adjustment, every heavy vehicle is considered equal to two light vehicles, but AutoJ users can modify this figure.

- A further adjustment needs to be made for **grade.** For each 1% upgrade, 1% was subtracted from the capacity (or added for downgrades). The latter is the same adjustment made in the HCM (TRB 2000), although, according to more recent research (Bruwer et al 2019), this should be 3% for every 1% grade change for both uphill and downhill grades.

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**Table 2** Typical values of critical gaps found in references

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>left into r/about</td>
<td>4.1 4.6</td>
<td>3.2</td>
<td></td>
<td></td>
<td>3.2</td>
<td>4.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>left at slip</td>
<td>4.1 4.6</td>
<td>5.0</td>
<td>2.5 5.4</td>
<td>5.5</td>
<td>5.0</td>
<td>5.5</td>
<td>6.5</td>
<td>6.5</td>
<td>4.8</td>
</tr>
<tr>
<td>left from stop</td>
<td>6.2 5.5</td>
<td>5.5</td>
<td>4.1 5.0</td>
<td>7.2</td>
<td>6.9</td>
<td>5.5</td>
<td>6.5</td>
<td>6.5</td>
<td>6.2</td>
</tr>
<tr>
<td>str from stop</td>
<td>6.5 6.0</td>
<td>5.9</td>
<td>6.1 5.8</td>
<td>7.5</td>
<td>6.5</td>
<td>6.5</td>
<td>6.3</td>
<td>6.8 8.0</td>
<td>6.5</td>
</tr>
<tr>
<td>right from stop</td>
<td>7.1 6.5</td>
<td>5.1</td>
<td>4.3 6.3</td>
<td>7.7 8.0</td>
<td>7.5</td>
<td>7.0</td>
<td>5.4</td>
<td>5.7 8.5</td>
<td>7.1</td>
</tr>
<tr>
<td>right from main</td>
<td>4.1 5.0</td>
<td>4.7</td>
<td>5.3 5.5</td>
<td>4.1 5.5</td>
<td>4.7</td>
<td>5.5</td>
<td>6.0</td>
<td>5.5</td>
<td>5.5</td>
</tr>
</tbody>
</table>
two main factors to consider: saturation flow as a single lane. There are for multiple approach lanes, each added

**Table 3** The recommended follow-up (headway) times

<table>
<thead>
<tr>
<th></th>
<th>HCM (TRB 2000)</th>
<th>Used for AutoJ (Sampson 2016)</th>
<th>Equivalent saturation flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>free-flow, left</td>
<td>1.89</td>
<td>1.900</td>
<td></td>
</tr>
<tr>
<td>free-flow, straight</td>
<td>1.80</td>
<td>2.000</td>
<td></td>
</tr>
<tr>
<td>free-flow, right</td>
<td>1.98</td>
<td>1.820</td>
<td></td>
</tr>
<tr>
<td>gaps signal, right</td>
<td>2.2</td>
<td>2.000</td>
<td></td>
</tr>
<tr>
<td>slip, left</td>
<td>2.50</td>
<td>1.440</td>
<td></td>
</tr>
<tr>
<td>mini-circle, left</td>
<td>2.25</td>
<td>1.600</td>
<td></td>
</tr>
<tr>
<td>roundabout, left</td>
<td>2.6 – 3.1</td>
<td>2.50</td>
<td>1.440</td>
</tr>
<tr>
<td>2.1 – 2.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>stop, left</td>
<td>3.3</td>
<td>3.30</td>
<td>1.090</td>
</tr>
<tr>
<td>stop, straight</td>
<td>4.0</td>
<td>4.00</td>
<td>900</td>
</tr>
<tr>
<td>stop, right</td>
<td>3.5</td>
<td>3.50</td>
<td>1.050</td>
</tr>
<tr>
<td>all-way stop, left</td>
<td>2.58</td>
<td>1.394</td>
<td></td>
</tr>
<tr>
<td>all-way stop, straight</td>
<td>3.16</td>
<td>1.140</td>
<td></td>
</tr>
<tr>
<td>all-way stop, right</td>
<td>3.32</td>
<td>1.085</td>
<td></td>
</tr>
</tbody>
</table>

a significant influence on capacity. For example, a two-second headway results in a saturation flow of 1 800 veh/hr, while a three-second headway reduces this to 1 200 veh/hr.

The HCM (TRB 2000) follow-up times were compared with saturation flows (S) reported in other literature (S = 3 600/ff), and after simulation the values listed in Table 3 were found to be best.

The all-way stop saturation flow values in Table 3 were derived from first principles based on the fact that vehicles at an all-way stop do not take gaps, but operate on a first-come first-served basis, which, in the absence of conflicting traffic, is how quickly a driver can stop, look and proceed. Because gaps do not have to be judged, the capacity at an all-way stop is higher than at a conventional stop.

**Multiple approach lanes**

For multiple approach lanes, each additional lane does not have the same saturation flow as a single lane. There are two main factors to consider:

- Vehicles do not distribute themselves exactly equally in each available lane, even if they are the same movement. Straight-through vehicles share the lanes approximately equally, but where there is more than one turning lane, vehicles will stagger themselves rather than turning together. At stop streets, the middle lanes are avoided as visibility in both directions is limited. Site observations suggest that each additional lane at a stop line is equivalent to 0.6 of a full lane. This capacity reduction for additional lanes is quite severe and does require further research; however, more than two lanes at stop streets are quite rare and should be avoided anyway.

- Shared lanes are avoided in preference to exclusive lanes, e.g. straight-through vehicles will avoid being stuck behind a right-turner in the same lane if possible. The recommended adjustment for a shared left and straight lane is a 4% reduction in capacity; for shared right and straight, a 10% reduction; and for a shared left, right and straight, an 8% reduction. Although similar factors are mentioned in references, they also have not been well researched.

**Stop street capacity calculation summary**

In summary, the Highway Capacity Manual (HCM) formula for Two-Way Stop Control was found to be the best available, but it is necessary to apply factors to adjust the critical gap and headway to account for crossing width, number of lanes, two-stage crossings, heavy vehicles, grade and the underestimation of the effect of conflicting flows. Adjustments are also suggested to the HCM method to determine opposing flow volumes to allow for pedestrians who tend to cross behind or yield to the first vehicle on the stop line (0.5 of the pedestrian crossing volume is used whereas HCM uses full volume).

**ALL-WAY STOP CAPACITY**

As no suitable method to automatically calculate all-way stop capacity was found in the references consulted (other than cumbersome iteration methods), the all-way stop capacity for AutoJ has been developed from first principles.

Motorists at an all-way stop do not take gaps, but make their decision to proceed on a first-come first-served basis. In all cases it is assumed that motorists behave legally, bring the vehicle to a complete stop, wait for their turn before proceeding and do not “follow on” the vehicle in front when it is not their turn. While this does not always happen in practice, for a fair comparison with other controls it was decided not to account for illegal behaviour.

The two possible extremes of opposing flow facing a motorist at the stop line are (1) no conflicting vehicles (allowing maximum stop line flow) and (2) saturation conflict (minimum stop line flow):

1. The **maximum possible capacity** per lane (saturation flow) occurs when a queue of vehicles arrives at the stop line and there are no other vehicles or pedestrians on any approach. The saturation flow rate is therefore determined only by the headway between following vehicles. From Table 3 the saturation flow rate of an unopposed left, straight and right turn from a stop can be calculated to be 1 394, 1 140 and 1 085 veh/hr respectively before adjusting for heavy vehicles and grade.

2. The **minimum capacity** occurs when a vehicle arrives at the stop line and there are vehicles and pedestrians on every other approach that have arrived before the subject vehicle. This vehicle will have to wait for the vehicles and pedestrians proceeding straight from the approaches to the left and right (assumed to go together), the vehicles turning right from the approaches to the left and right (also assumed to turn together), and the right-turner opposite. Other opposing pedestrians are assumed to cross while the vehicle waits for its turn. The total wait will therefore be the combined time for the first vehicle on each of the opposing movements to clear.

The time, t, for a movement to clear is calculated from the formula \( s = \frac{t}{2} + 0.5 \frac{t}{f} \) where \( s \) is the clearance distance (from stop line to far side), \( u \) is the initial velocity (zero from a stop), \( f \) is the acceleration rate.
(considered to be 2.0 m/s² for a normal car ready and anxious to take its turn and allowing for the fact that the vehicle does not always have to clear completely before the next vehicle begins to move), hence time to cross \( t = s^\alpha \). A reaction time is not added as the vehicle has been waiting.

As an example, if the intersection is 9 m wide, each vehicle would need 3.0 seconds to clear and the minimum capacity of each approach would be 3 600 / (4 * 3.0) = 300 vehicles per hour, whereas a 16 m crossing would have a capacity of 225 veh/hr. Because left-turners can also turn with side road-right-turners, they get two opportunities to turn, therefore their minimum capacity is double the straight and right capacity (provided they have an exclusive left turn lane and are not blocked by other movements).

The minimum capacity of vehicles at the stop line at an all-way stop in a saturation-flow situation is substantially higher than at a two-way stop, as vehicles do not have to find gaps, but simply take their turn regardless of the other approach demand volumes.

3. Having established the maximum and minimum capacities, the actual capacity under varying traffic volumes needs to be calculated, obviously somewhere between minimum and maximum. This was originally done in AutoJ by calculating the “unused” capacity on each approach and adding that to the minimum available capacity. For example, if the volume on an approach in the above example was 100 vehicles per hour and the capacity was 300, this would “release” a capacity of 300 – 100 = 200 vehicles per hour to be used by the other movements. This released capacity is shared by the other movements up to the maximum capacity.

In later versions of AutoJ the V/C of the intersection as a whole is calculated. If the V/C is 1.0 or above, the minimum capacity applies. If the V/C is 0.0, the maximum applies. If the V/C is anywhere in-between, the difference between maximum and minimum capacity multiplied by (1 – V/C) is added to the minimum capacity for each movement.

In multi-lane situations, the same principles apply, but the volume per lane, not the total volume, is used to determine if there is spare capacity. These are the calculations built into AutoJ.

As an aside, some users have noted that while the program determines that substantial delays should occur at an all-way stop intersection, in practice it is observed to flow with little delay. The reason for this is that most vehicles observed do not stop at the stop line and that many “follow on” movements occur without stopping as well. As stated above, the author decided not to adjust the calculations for such illegal practices. What is recommended in these situations is that the all-way stop control be changed to a mini-circle, which would then make what is observed to be happening in practice at the intersection (yielding and following on) legal and safe.

### Roundabout Capacity

Six roundabout capacity equations were tested, namely Tanner (1962), McDonald and Armitage (1974; 1978), Highway Capacity Manual (TRB 2000), Highway Capacity Manual (TRB 2010), and Kittelson and Associates (Rodegerdts 2015).

It was noted that, although in the HCM (TRB 2000) the equation for roundabouts appears to be quite different from the equation for two-way stops, it is in fact the same equation with different symbols. Also, for a roundabout HCM 2000 specifies that the number of lanes may not exceed one and the conflicting flow may not exceed 1 200 vph.

Based on later research, although the HCM 2000 formula below was adopted for AutoJ, the factors and limits were adjusted as per HCM 2010 and Kittelson (Rodegerdts 2015).

The formulae from the respective researchers are:

- **1962 Tanner:**
  \[
  C = \frac{Q \cdot (1 - tz \cdot q)}{(1 - e^{-q/\text{tf}}) \cdot e^{-(m-m) \cdot \text{q}}} 
  \]

- **1974 McDonald & Armitage:**
  \[
  C = \frac{N \cdot Q}{(1 - \text{e}^{-\text{tc}})} \cdot \text{e} \text{-}\text{tc} - 1
  \]

- **1978 McDonald & Armitage:**
  \[
  C = S \cdot (1 - tz \cdot q) \cdot e^{-q/\text{tf}}
  \]

- **2000 HCM (TRB 2000):**
  \[
  C = \frac{Q \cdot e^{-q/\text{tc}}}{1 - e^{-q/\text{tc}}}
  \]

- **2010 HCM (TRB 2010):**
  \[
  C = S \cdot e^{-q/\text{tc}}
  \]

- **2015 Kittelson (Rodegerdts 2015):**
  \[
  C = S \cdot e^{-q/\text{tc}}
  \]

Where:

- \( C \) = capacity
- \( q \) = conflicting volume (veh/sec)
- \( Q \) = conflicting volume (veh/hour)
- \( S \) = saturation flow (veh/hr) (1 656 M+A 1978, 1 130 HCM 2010, 1 420 Kitt 2015)
- \( \text{tc} \) = critical gap (secs)
- \( \text{tf} \) = following gap / headway (secs)
- \( \text{tz} \) = min headway for circulating vehicles (sec)
- \( T \) = lost time
- \( N \) = number of circulatory lanes (one)
- \( B \) = factor (−0.001 HCM 2010, −0.00085 Kitt 2015)

In 2012 and 2013, Kittelson and Associates collected data from 23 roundabout sites throughout the USA (NCHRP Report 572 data: 2013). That data, together with fitted curves, is reproduced in Figure 2 (Rodegerdts 2015).

It can be noted that the HCM 2010 formulation appears to underestimate roundabout capacity (compare the HCM curve with the exponential regression curve).

The six formulae described above, with their default values, were then plotted to the same scale and the AutoJ formulation for a roundabout, mini-circle and left turn slip was added to provide Figure 3. The HCM 2010 formulation is common to Figures 2 and 3.

The Tanner formula at some point gives negative capacity at high conflicting flows (in this example exceeding 1 800 vph) and therefore cannot be considered for use in a simulation program. The two M + A formula had the same problem, but also did not fit the field data well. The HCM 2010 formula clearly underestimated the average roundabout capacity, as did HCM 2000 with the default factors. The Kittelson formulation was clearly the best fit of the field data (Figure 2).

It was therefore decided to use the HCM (TRB 2000) formula for roundabouts, with the factors in Tables 2 and 3, which gives almost exactly the same result as Kitt2015 (Rodegerdts 2015), as can be seen in Figure 3. The equation used for AutoJ was therefore:

\[
C = \frac{V_c \cdot e^{-q/\text{tc}}}{1 - e^{-q/\text{tc}}}
\]

with the critical gap \( \text{tc} \) set at 4.4 seconds (Table 2) and the follow-up gap \( \text{tf} \) set at 2.5 seconds (Table 3). This formula gives the AutoJ RR graph in Figure 3.
MINI-CIRCLE CAPACITY

At low conflicting flows, mini-circles operate almost like roundabouts. However, as flows increase the circle is too small to operate on modern roundabout principles (i.e. gap acceptance) and starts to operate on a first-come first-served basis (i.e. like an all-way stop).

To simulate this it was decided to use the same roundabout formula, but to set the critical gap and follow-up gap to 5.6 and 2.25 seconds respectively. The effect is shown in Figure 3.

It is also interesting to note that, because of the widespread illegal ignoring of the stop at an all-way stop, it too operates in a similar manner to a mini-circle at low volumes, but not as well, as there will always be those law-abiding citizens who do stop despite their fellow drivers’ behaviour.

PEDESTRIAN CAPACITY

The saturation flow rate of pedestrians is 4 800 pedestrians per hour per metre crossing width (TRB 2010). This would apply to pedestrians with right of way, such as crossing in front of vehicles at a stop or yield sign, or at a green traffic signal.

For pedestrians crossing uncontrolled roadways this cannot be achieved. In these circumstances it is assumed pedestrians will take the same gaps as vehicles. The pedestrian capacity is therefore taken to be the saturation flow rate for pedestrians multiplied by vehicle capacity to saturation flow ratio at a stop street.

RESULTS

The results of applying the adopted formulae (as modified) on capacity per lane are summarised in Figure 4. In the figure:

- Ly is left at a yield sign
- Lg, Sg, Rg and Rfl are left, straight, right and right flash at a signal with 100% green (Lg must yield to pedestrians and Rg to pedestrians and opposing traffic, while Sg and Rfl are unopposed, influenced only by surrounding vehicles)
- Lrr is left turn into roundabout
- Lf, Sf and Rf are left, straight and right free flows (no control, but turners must take gaps in vehicular and pedestrian traffic)
- Lx, Sx and Rx are left, straight and right after stop
- Lxx and SRxx are left, straight and right at an all-way stop.
CONCLUSION ON CAPACITY OF PRIORITY CONTROL

From an examination of international literature, it has been found that the Highway Capacity Manual formulae are appropriate to use for stop and roundabout priority intersection capacity calculations. However, it was also found that it is necessary to expand and refine the gap acceptance and follow-up values to cater for wider intersections, intersections with median islands and intersections with opposing volumes higher than the limits determined in HCM.

Furthermore, it was found that no suitable analysis method for all-way stops was available in HCM or other literature (other than an iterative method which is not practical), and a new formula, calculated from first principles, was derived for these situations.

NEXT ARTICLE

The next article in this series will discuss the capacity of signalised intersections.

REFERENCES


Figure 4 Effect of conflicting vehicle and pedestrian flows on capacity
Reinforced Earth® Bridge Abutments

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Mechanically stabilised earth reinforcements

BACKGROUND
French engineer and architect Henri Vidal invented Reinforced Earth® in the 1960s, an invention that has spawned a global industry of earth-reinforced structures. Vidal founded Reinforced Earth® design and supply companies throughout the world. Reinforced Earth South Africa (Pty) Ltd (RESA) was founded in 1975 and is a subsidiary company of Soletanche Freyssinet.

The generic name used in South Africa for this material is Mechanically Stabilised Earth (MSE).

An MSE structure is a composite structure comprising frictional backfill, reinforcements and a cladding. RESA MSE structures are optimised according to the nature of the structure and its location. Group research and development, complemented by 45 years of experience in African conditions, have led to the backfills, reinforcements and claddings currently supplied by RESA.

The reinforcements are divided into two categories:

- Inelastic reinforcements
  - HA strips: high-adherence, medium-tensile steel, hot-dip galvanised
  - HAR strips: high-adherence, padded, medium-tensile steel, hot-dip galvanised

- Elastic reinforcements
  - GeoStrap® and HA Geostrap®: discrete channels of closely packed high-tenacity polyester fibres encased in a polyethylene sheath
  - EcoStrap™ and HA EcoStrap™: compact bundles of polyvinyl alcohol (PVA-L) yarns protected by a polyethylene sheathing

INELASTIC STRIPS COMPARED TO ELASTIC STRIPS
The stiffness of steel is 210 GPa compared to PET 9 GPa and PVA 21 GPa. Steel can capture 10 times more lateral strain of the backfill than PVA, and 20 times more than polyester. This order of magnitude difference in stiffness leads to significant changes in the state of stress and behaviour of structures reinforced with RESA steel inelastic strips compared to those reinforced with RESA elastic straps.

Figures 1 and 2 illustrate the state of stress in an inelastic structure and an elastic structure respectively. Figures 3

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**Figure 1** Inextensible reinforcement

**Figure 2** Extensible reinforcement
and 4 illustrate the results derived by a numerical analysis with all parameters other than the strip stiffness being equal.

Under working conditions, the inextensible strip structure is acting as a coherent gravity block while the extensible strip structure is only partially stressed. Some movement is required to mobilise the full length of the extensible strips.

PROPERTIES OF RESA’S INEXTENSIBLE STRIPS

The steel used is a medium-tensile steel with an elongation, after yielding, greater than 20%. This property provides a highly indeterminate structure. Brittle reinforcements should not be used in MSE structures for this reason. The stiffness of the strips is 210 GPa.

High adherence (HA) strips

These strips are ribbed, which mobilises the full angle of internal friction of the backfill (Figure 5). The shear plane is in the backfill on top of the ribs and not between the strip and the backfill as would be the case for smooth strips.

In addition, a granular backfill dilates during shear. Tests have shown that this dilation raises the apparent coefficient of friction between the strips and the backfill. This increase can be significant depending on the coefficient of uniformity of, and the vertical stress on, the backfill. The dilation of the backfill is a consequence of ribbed strips and does not apply to smooth strips.

High adherence reinforcing (HAR) strips

The HAR strips are thicker than the HA strips, which allows more of the strip thickness to be allocated to strength and less to the sacrificial thickness required to meet the required service life of the structures.

The section at the end of the strip is thickened and narrowed in such a way that the net section of the strip, after deduction of the bolt hole at the connection, is greater than the strip cross-section. This ensures that the strength at the connection is greater than the strength of the strip and full elongation of the strip will occur before failure. There is no loss of strength when two strips are joined with cover plates and bolts (Figure 6).

Construction with inelastic strips

HA and HAR strips are bolted to the cladding and laid out on compacted backfill. Track machines should not run directly on the strips. A rocky backfill will not damage the strips (Figure 7).

PROPERTIES OF RESA’S ELASTIC STRAPS

GeoStrap®

- High-tenacity polyester (PET) fibres contained in a polyethylene sheath.
- Durability: suitable for backfills with high concentrations of salts and marine applications.
- Versatility: easy to handle and cut on site to convenient lengths.
Reliability: polyethylene sheath ensures efficient protection against damage during installation.

Stiffness: 9 GPa.

EcoStrap™

Polyvinyl alcohol (PVA) fibres contained in a polyethylene sheath.

Durability: not sensitive to the presence of salts in the backfills and are particularly adapted to applications in which the backfill is potentially highly alkaline (as is the case with lime and cement-treated fills) or fills made of recycled aggregates containing crushed concrete; moreover, they do not show any sign of sensitivity to high temperatures.

Versatility and reliability: easy to handle and cut on site to convenient lengths.

Low elongation under service: PVA-L yarns are twice as stiff as high-tenacity polyester yarns (GeoStrap); this leads in practice to lower deformations during construction.

Stiffness: 21 GPa.

Construction with elastic straps

Unlike inelastic strips, it is necessary to tension elastic strips. The back of the strip is secured with a peg, or for continuous rolls of strip it is laced through a connection at the cladding and an anchor, or at the back of the strips. A trench enables further tensioning (Figure 9).

SELECTION OF REINFORCING STRIPS

A study of Figures 1, 2 and 3 clearly shows that inelastic strips behave quite differently to elastic strips. When specifying MSE structures, design engineers should be aware of the differences.

Technical considerations

When able to choose between reinforcement types RESA prefers inelastic strips since they have ideal properties of stiffness, strength and elongation after yield.

An MSE structure with inelastic reinforcing strips behaves in working conditions as a coherent gravity block.

Inelastic strips do not need to be tensioned during installation, enabling easier and faster construction.

Live loads on the structure produce negligible strain increments in the reinforcing strips.
- Coarse backfill, including rocky material, will not damage inelastic strips.
- The strips are ductile after yield and will shed load to neighbouring strips should they be overloaded.

Should the proposed backfill not meet the electro-chemical requirements for inelastic strips, then elastic strips comply with the most demanding up-to-date standards.

**Cost considerations**
The cost of elastic reinforcing strips may be lower than that of inelastic strips for structures other than heavily loaded walls and true abutments. When taking the total cost into account – including design, supply of reinforcing strips, claddings, jointing material and the construction – the cost of the reinforcing strips may be of the order of 25% of the total cost. A saving of 10% on the reinforcing strips would then save 2.5% of the total cost.

**CONCLUDING REMARK**
All MSE structures can be customised to produce an optimal combination of geometry, backfill, reinforcing strips and cladding.

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**We are Hiring!**

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A full position description can be found on our website [http://www.gbaengineers.com.au/](http://www.gbaengineers.com.au/) or emailing hr@gbassoc.com.au
There is a growing realisation that large-scale infrastructure development in Africa will only be achieved through a co-funding arrangement with the private sector, but even then there are plenty of technical hurdles that projects must clear. Africa clearly needs infrastructure improvements to open doors to trade and create opportunities for economic investment. As the implementing arm for the African Union’s 2063 development strategy, the New Partnership for Africa’s Development (NEPAD) focuses on incubating high-impact projects that demonstrate proof-of-concept. These are intended to translate the AU’s strategic development frameworks into national priorities.

The drive for high-impact initiatives has led a few sub-Saharan countries, including South Africa, Nigeria, Kenya and Uganda, to partner with the private sector on some infrastructure projects. Despite the ample opportunities for public–private partnerships (PPPs), and their obvious benefits, governments have been slow to drive this agenda. This may be the result of prior bad experiences with ill-prepared PPPs or even with less than competent PPP project sponsors. However, there are well-proven strategies and lessons that can pave the way for efficient, cost-effective and manageable infrastructure building.

Experience shows that it is necessary to start small before embarking on larger PPPs. Ensuring a higher risk allocation to government in the first generation of PPP projects can help to unlock the flow of private capital – as investors and lenders develop enough comfort with the PPP environment of a country.

There is also a range of technical and regulatory risks to all infrastructure projects that needs to be well managed, especially with ever-stricter environmental and social regulations.

Due diligence reviews of infrastructure deals are vital to ensure that there are no fatal flaws and material risks and liabilities. With many financial institutions subscribing to the Equator Principles (a risk management framework), risk management has become a key consideration in the funding decision-making process. Funders want to know if there are any issues that can place the project at risk, or pose reputational damage.

They will prioritise proper planning, permitting and cost-efficiency in a project – and will examine how the project plans to deal with social licence issues like compensation and resettlement.

Climate change and its impact on a project are also on funders’ agendas, as climate change becomes a key cross-cutting issue for proponents of infrastructure projects to address.

To address possible misalignment of a project with funders’ requirements, project champions need to involve funders early in the project development process; it is difficult to achieve bankable feasibility if potential funders are not satisfied with the way that project risks are addressed. Such lack of alignment can disrupt the schedule or even derail the whole project. This can be avoided by taking a systematic approach to infrastructural projects, which means setting out a clear process through the stages of initiation, feasibility studies, planning, execution, monitoring and control, and closure.

Planning and budgeting for maintenance is often underestimated. In the initiation stage, the project’s value and feasibility are measured. This includes assessing the project’s goals, timeline and costs to determine if the project should be executed. Feasibility studies balance the requirements of the project with available resources, ensuring that there is a business case, that risks are adequately catered for and that it makes sense to pursue the project.

In addition, funders stress the importance of independent due diligence reviews and reporting. It is vital that third-party experts – who do not have any vested interest in the project – give their professional view on all aspects to confirm the veracity of the technical studies, business case and plans.

Africa certainly has the need and capacity to accelerate its infrastructure development, but this needs a greater commitment to best practice in initiating and pursuing infrastructural projects. Considerable potential remains for leveraging PPPs in doing just that.
Reflecting the rich history of Franki (the oldest geotechnical contracting company in sub-Saharan Africa), the fifth edition of its widely acknowledged “Blue Book” on geotechnical engineering incorporates elements of its holding company, the Keller Group, and many of Keller’s state-of-the-art ground improvement and grouting technologies.

The new book, *A Guide to Practical Geotechnical Engineering in Africa*, was officially launched by Keller’s senior technical advisor, Prof Michal Topolnicki, at the 17th African Regional Conference on Soil Mechanics and Geotechnical Engineering held in Cape Town from 7 to 9 October last year.

This latest edition maintains the long tradition of updating the now well-established textbook approximately every ten years. This new edition also mirrors the evolution and changes within Franki, from a small piling company in the era after the Second World War to a leading geotechnical engineering company in the African region.

The first and second editions, published in 1976 and 1986 under the title *A Guide to Piling and Foundation Systems*, portrayed Franki as a piling company and the southern African branch of the international Belgian-owned Franki group. The first edition was authored by then managing director Ian Braatvedt, with a foreword by the legendary Prof JE Jennings.

The third and fourth editions, published in 1996 and 2008, were both titled *A Practical Guide to Geotechnical Engineering in Southern Africa*. They demonstrated Franki Africa’s change of logo and ownership, as well as its evolution into a geotechnical contracting company offering a wide range of geotechnical products and marine engineering capabilities. The development of Franki Africa’s in-house geotechnical design capability was demonstrated by the significant sections on design and the co-authoring of Gavin Byrne as a senior member of the Franki team for both these editions.

The fifth edition, co-authored once again by Gavin Byrne, together with Dr Nicol Chang (Technical Director of Franki) and Dr Venu Raju (the Keller Group’s Director for Engineering and Operations) depicts Franki Africa’s expansion through the African continent and the Indian Ocean Islands.

The ownership of Franki Africa by the Keller Group, the largest geotechnical contractor worldwide, is reflected in the significant change and evolution of the book’s content, the inclusion of colour into the graphics and illustrations, as well as in the doubling of its number of pages from 270 (first edition) to 540.

In addition to the design and construction of deep foundation, lateral support and marine works, the new edition incorporates Keller’s extensive range of ground improvement, grouting and associated design methodologies. Trenchless technology and the introduction to limit state design are also added features of the comprehensive publication.

The foreword by Dr Peter Day (recognised internationally as a leading geo-practitioner in the African region, and adjunct professor at Stellenbosch University) is highly appreciative of the Blue Book’s contribution to the geotechnical industry, and the authors thank him for that. The authors would also like to thank Franki and all in the Keller Group for their contributions and support during the preparation of the fifth version of the “Blue Book”.

**FIFTH EDITION OF THE FRANKI “BLUE BOOK”**

**OUTPUT AT OMV STILFONTEIN BOOSTED BY UPGRADES**

A range of upgrades at OMV’s aggregate and sand plant at Stilfontein in the North West Province has led to a 40% capacity growth over just 18 months.

OMV’s plant processes quartzite rock dumps generated from shaft-sinking in the area to produce road construction material. While production capacity could previously be pushed to about 1 000 t a day, the plant’s daily output now regularly reaches some 1 400 t.

One of the first improvements was the installation of a 100 m overland conveyor extension from the dump to the feed box, which improved productivity and overcame the loading constraints experienced previously with the use of front-end loaders. A new feed box was also installed – with its own 6 m conveyor belt – to feed the overland conveyor. This
addition reduced excessive wear and tear, improving uptime on that part of the plant.

Production has also been improved with the incorporation of a vibrating pan feeder on the secondary crushing plant, regulating the flow of material onto the conveyor belt. Supplied by Weir Minerals Africa and installed by the OMV team, the feeder was the first step in the automation of the secondary crushing process.

A programmable logic controller (PLC) and human machine interface (HMI) have been added to the circuit to automatically regulate the feed box. This allows the choke-feeding of the crusher, which is difficult to accomplish manually.

To raise sand production, a deep cone thickener was installed to extend fines separation. Among the benefits of the new fines separator is that it reduces the amount of saleable material discharged to tailings. It recovered about 10% of saleable product previously discarded into the tailings pond, and contributed to the plant’s sand production capacity rising from 25 to 33 t per hour. This step also lessened the plant’s environmental impact by reducing the quantity of tailings.

LEGAL REQUIREMENTS FOR BORROW PITS

Borrow pits in South Africa need to be carefully controlled to avoid unfair competition with existing quarries and to ensure that all environmental and safety requirements are met.

Even despite the toughest economic circumstances, or urgent requirements for readily available sand and aggregates, the rule of law still applies, hence road construction companies and other construction enterprises need to ensure that they are compliant with all mining-related legislation, as well as water, environmental and other legislation. Local bylaws also need to be observed.

According to Nico Pienaar, Director of the surface mining association...
ASPASA, quarries and borrow pits are essential for keeping the country’s construction industry supplied, especially in light of backlogs resulting from the Covid-19 lockdown. However, extreme care needs to be exercised when operating these, as they are often situated close to built-up areas or near to roads and railway lines to ensure quick and easy supply.

“Therefore, community concerns need to be top-of-the-mind in order to ensure a harmonious and mutually beneficial relationship throughout the lifecycle of the operation. If operated correctly there should be little cause for concern. ASPASA members especially are dutybound to work within the confines of the country’s stringent environmental legislation and uphold the strict standards imposed by the association itself.”

Pienaar says that the public is understandably still sceptical of new quarries within their neighbourhoods as past practices left a lot to be desired – landscapes were scarred, waterways polluted and nearby residents had to bear the brunt of damaging blasts, dust pollution and degraded roadways as a result of overladen trucks.

Fortunately things have changed. Strict legislation exists to protect the public and the environment from these damaging practices, to the extent that mines and quarries nowadays are far less likely to get away with damaging practices. Communities are also increasingly aware of their rights.

New-age quarry owners and managers are more sensitive to community expectations, and even in highly competitive operating areas they still have tight controls in place to ensure that legislation and standards are adhered to. By making certain that communities and the environment are not negatively impacted they retain their good reputation, which in turn ensures that they can operate unimpeded.

Pienaar reminds the public of the following controls that are in existence to effect correct planning, development, operation, rehabilitation and final decommissioning of quarries and borrow pits:

**Application and approval**

Several different Acts govern the approval of quarry operations, depending on location, land tenure and likely impact. These in turn determine the approval procedure to be followed and the degree of detail which must be provided in a licence application.

**Planning and development**

Site planning needs to be done in association with a development application supported by all relevant information required to get approval. Only once this has been obtained can the plan be implemented according to site development steps laid out. When these have been met the operation can go ahead.

**Site operation and controls**

Once the quarry operation is in progress, careful environmental management must be sustained to ensure that dust emissions and noise impacts do not become a significant issue. At the same time rehabilitation must be planned to dovetail with quarry operations.

**Rehabilitation**

This should be done progressively where the operation allows staged development and subsequent closure and rehabilitation of different areas. Or it can take place at the end of the total operation if it is a short-term project or if staged development is not possible.

**Decommissioning**

When quarry operations and any associated processing are completed the area should be tidied up. All facilities not otherwise required should be removed, and rehabilitation should be completed on the remaining disturbed areas.

**Short-term alternatives**

For short-term quarries and borrow pits the range and intensity of measures drawn will generally be modest. In these cases, the staging of developments may not be necessary if the quarry or pit has a life less than one or two years, and total rehabilitation might be carried out as part of site decommissioning.

**REVOLUTIONISING COST AND QUALITY FOR A FLAWLESS SPRAY-PAINTING FINISH**

It is colourless, odourless and tasteless and is invisible to the human eye. And yet compressed nitrogen is set to bring about a major advance in the professional spray-painting industry.

“The key factor with compressed nitrogen is that it is inert, absolutely clean and devoid of moisture and contaminants,” explains the Managing Director of NitraLife, Tom Sowry.

NitraLife, which was founded in 1996 as a local supplier and manufacturer of nitrogen generation equipment, was the first company internationally to use a membrane separation process as a local supplier and manufacturer of nitrogen generation equipment, was the first company internationally to use a membrane separation process as a local supplier and manufacturer of nitrogen generation equipment, was the first company internationally to use a membrane separation process as a local supplier and manufacturer of nitrogen generation equipment, was the first company internationally to use a membrane separation process as a local supplier and manufacturer of nitrogen generation equipment, was the first company internationally to use a membrane separation process. The company expanded its offerings with the development of the NitraCut generator, which is mainly used by the laser-cutting and fabrication industries. In 2018, the company expanded its offerings with the development of the NitraSpray generator.
for superior spray-painting finish in the manufacturing, panel-beating and other industrial sectors.

“Compressed air has been the transport medium for spray-painting since the inception of the technique. However, air has some disadvantages in that it often contains particulate matter, traces of oil and, most importantly, moisture. These three factors affect the quality of the paint finish and result in commonly occurring blemishes such as ‘fish eyes’ and pinholes,” says Sowry.

He adds that, while most panel-beating shops have sophisticated filtration systems in their air-lines, the level of purity these filters achieve comes nowhere close to the cleanliness and purity of compressed nitrogen.

“The NitraSpray generator effectively filters output down to 0.01 micron, and this level of purity is absolutely consistent,” continues Sowry. “Importantly, when spray-painters use compressed nitrogen, they are able to spray at a lower pressure, which results in significantly reduced paint consumption.

Reports from NitraSpray customers feature paint savings which are in the order of 10%. NitraLife recently installed a NitraSpray at a leading vehicle canopy manufacturer, where careful digital measurements were taken, and the data collected proved paint savings of 15%.

“With NitraSpray being able to spray at a lower pressure, overspray is dramatically reduced. Overspray and paint blemishes are a major cause of rework, extra cost and lost time, so with the use of NitraSpray nitrogen a spray-painter can significantly improve productivity,” Sowry adds.

“The major advantage that the NitraSpray generators have is that they employ a basic principle of physics to extract pure nitrogen from the air. Our generators have no moving parts, which make them extremely reliable and simple, and wonderfully low-maintenance.”

A further advantage for South African spray-painters is that, as NitraLife is a wholly South African-based company, it can manufacture generators suited precisely to customer requirements, while also meeting local procurement stipulations.

NO SHORTCUTS TO QUALITY – AN ALERT FROM SAPPMA

South Africa, like the rest of the world, is facing the stark new reality of “life after lockdown”, as the Covid-19 pandemic forced most companies to shut down their operations for weeks on end. As pipe manufacturers have now been allowed to resume their operations, many of them have to do so with a reduced workforce and a negatively impacted cash flow. The Southern African Plastic Pipe Manufacturers Association (SAPPMA) has urged pipe makers and pipeline installers to avoid giving in to the temptation of compromising on quality or side-stepping certain processes and procedures for the sake of saving a few rand.

“Piping systems are key elements in a country’s infrastructure. Communities rely on the fact that the pipes we provide for their water, sewage removal, telecommunication and gas supply, will last for fifty to a hundred years before they need replacing. Similarly, a wide spectrum of industries, such as mining, agriculture, telecommunication, building and construction also need pipelines they can trust, as the cost of failure in terms of disruption and repairs is prohibitive,” says Jan Venter, Chief Executive Officer of SAPPMA.

SAPPMA is an association of leading companies in the plastics piping business, with the purpose of facilitating high standards of ethics, product quality and technical information. Its primary focus is to create absolute customer confidence in the plastics pipe industry by ensuring that pipes produced by its members, and bearing the SAPPMA mark, meet local and international quality and manufacturing standards.

However, Venter warns that past experience has shown how manufacturers quickly look for ways to save money or take shortcuts when the economy takes a downward turn. “Without continuous intervention, product quality and standards inevitably deteriorate. We
then end up seeing things like pipes that are underweight or shorter in length entering the market, companies using substandard procedures, skipping certain quality tests or including recycled materials,” he says.

For this reason, SAPPMA members undergo regular announced and unannounced factory visits during which every step of the production process is inspected and pipe samples are randomly picked and sent away for testing by an independent body. Only once the compliance officer is satisfied that every standard has been met, are members allowed to display the SAPPMA logo on their pipes as guarantee of quality, reliability and dependability.

“It is important to understand that seeing the South African Bureau of Standards (SABS), South African Technical Auditing Service (SATAS) or SANS logo displayed on a pipe does not mean that the pipe automatically meets SAPPMA standards or that it was produced by a SAPPMA member. The first two are certification bodies who work closely with us to test and certify the pipe samples we send to them. The South African National Standards (SANS) on the other hand, is part of the SABS and is the custodian of the national standards according to which all locally produced pipes are manufactured,” Venter says. He explains further that SAPPMA is not in competition with these entities, but plays a crucial coordinating role between all the stakeholders in this industry.

“Because our sole focus is on a relatively small, but crucially important sector of industry, we are in the ideal position to detect problems much earlier than any other organisation. To this end we closely monitor our members to ensure product quality and full adherence to all relevant national standards. This is what clearly differentiates our members from non-SAPPMA members, and why municipalities are increasingly insisting on membership to SAPPMA or our sister organisation, the Installation and Fabrication Plastics Pipe Association (IFPA), when they prepare tender and specification documents for new infrastructure installations or upgrades,” he says.

There is no shortcut to success. Skipping certain important steps, avoiding tests or using sub-standard materials ultimately and undoubtedly undermine the integrity of the final product and run the risk of causing irrevocable damage to the industry.

“Trust is a very fragile thing. It takes years to build, seconds to break and forever to repair. It only takes a few pipe manufacturers who cheat rather than toe the line to produce sub-standard pipes that crack, bend or fail, thereby destroying the reputation and the future of an entire sector. We urge our industry to strengthen SAPPMA’s hand as we diligently work on building consumer confidence in an industry known for being responsible, ethical and conscious of quality,” Venter concludes.

### BCCEI Gets Green Light from CCMA

The ongoing success of the Bargaining Council for the Civil Engineering Industry (BCCEI) has led to its accreditation by the Commission for Conciliation, Mediation and Arbitration (CCMA) being extended for another three and a half years.

“This is a great achievement, especially for a relatively young bargaining council, and we are very proud,” says Merle Denson, Dispute Manager at the BCCEI.

Denson notes that this is the second consecutive accreditation by the CCMA – demonstrating the BCCEI’s capacity to deliver on its mandate.

The CCMA’s accreditation allows the BCCEI to continue performing its dispute resolution functions, either by conciliation or – if the dispute remains unresolved – through arbitration. The green light from the CCMA follows the recent extension by the Minister of Labour of the BCCEI’s dispute resolution collective agreement, allowing its decisions to be binding on non-parties.

“The stringent accreditation process demands that we meet a range of targets and standards, as well as efficiency indicators, to ensure a standardised and optimal performance of our duties,” Denson says.

“Our services have consistently met CCMA standards in terms of targets like conciliation and arbitration turnaround times, zero late arbitration awards, settlement rates and quality control measures.”

She says this shows that the dispute resolution centre of the BCCEI is on the right track as far as both the CCMA and the Labour Relations Act requirements are concerned. The CCMA’s latest accreditation will run from 1 April 2020 to 31 August 2023.

Detailed reporting of the BCCEI’s operations is required on a regular basis for various bodies, highlighting everything from the number of referrals, outcomes of processes, cases scheduled and analysis of the types of cases being referred. Reports also track specific efficiencies on a monthly basis.

“Reporting documents must be submitted to the CCMA each quarter, for instance,” says Denson. “We are constantly monitoring ourselves in terms of efficiency and performance through the statistics that the BCCEI system generates.”

Among the CCMA’s other requirements is that the commissioners used for conciliation and arbitration – who must be CCMA-accredited in their own right – are all independent and qualified. Their performance is also monitored by the BCCEI in line with a specific Code of Conduct.

Signatory parties to the BCCEI are the National Union of Mineworkers (NUM) and the Building Construction and Allied Workers Unions (BCAWU) from the trade unions, and the Consolidated Employers’ Organisation (CEO) and South African Forum of Civil Engineering Contractors (SAFCEC) from the employers.
UKZN CIVIL ENGINEERING IS FLYING HIGH

The University of KwaZulu-Natal (UKZN) School of Engineering’s disciplines have once again received accreditation with the Engineering Council of South Africa (ECSA), following an assessment of its Bachelor of Science in Engineering (BSc Eng) undergraduate programmes in 2019.

After completing their assessment of Civil Engineering in October 2019, ECSA conferred continued accreditation with no deficiencies and no concerns until 2024. “The Civil Engineering team indeed showed their outstanding standards during the accreditation process. It’s a wonderful team,” says Academic Leader of Civil Engineering, Professor Mohamed Mostafa.

Dean and Head of School Professor Glen Bright called the successful conclusion of the accreditation process “a fantastic team effort” on the part of the School. He gratefully thanked Deputy Vice-Chancellor and Head of the College of Agriculture, Engineering and Science (CAES), Professor Albert Modi, CAES Dean of Teaching and Learning, Professor Naven Chetty, and all staff in the School for their support, which ensured a successful accreditation visit.

“ECSA was impressed all round with the quality, the staffing, the administration, the paperwork and the facilities,” reports School Manager Mr Ronal Thakurpersad. “They also indicated that we were comparable to the best in the world.”

Accreditation by the industry’s professional body (ECSA) recognises that programmes being offered at a particular tertiary institution, such as UKZN, meet a range of criteria which demonstrate that graduates from that institution have met the education requirements for their particular field of engineering, and would allow them to register with ECSA and eventually practise as professional engineers. Accreditation is an important measure of quality assurance, and ECSA-accredited qualifications are recognised in countries that are signatories to the Washington Accord. Accreditation visits are undertaken by ECSA on invitation from and with full cooperation of staff at the institution.

UKZN Civil Engineering enjoys a mix of well-experienced staff and dynamic young academics. The 17 full-time staff members are led by Prof Mohamed Mostafa (Cluster Academic Leader, and a transportation and paving engineering expert) and include six professors covering waste management, transportation, water and structures. Three more senior lecturers offer structures and concrete subjects, with eight academic lecturers supporting environmental engineering, water, transportation, structures, wastewater and geotechnical engineering. Moreover, the number of involved professional engineers has started to increase significantly, which allows the academic experience to be mixed with industry experience.

Different research groups are available for post-graduate studies and post-doctoral research. They include a SARCHI (South African Research Chairs Initiative) Chair in Waste and Climate Change, as well as an eThekwini Infrastructure Chair. Other research groups include, but are not limited to, the Centre for Research in Environmental, Coastal and Hydrological Engineering; the Sustainable Transportation Research Group; the Structural Engineering and Computational Mechanics Research Group; and the Advanced Concrete Materials Research Group. With three rated researchers, research within UKZN’s Civil Engineering Department is in good hands and moving forward continually.

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Think you know the industry you work in?

Then try our Know Your Sector Competition in the June 2020 edition of the magazine

The competition will be in the form of a Fun Quiz to promote knowledge of our industry service providers. Readers will be able to find the answers by linking through to the pages indicated via the quiz logo displayed above. Once readers have found the answers by clicking on the website links, submissions (only one per reader) will be collected online until 31 July, whereafter the winner will be announced from a random draw.

And if you are the lucky winner, you will pocket a neat R10 000 in cash!

PS: Advertisers who wish to capitalise on the reader attention here by including their marketing messages into the Fun Quiz should please contact:

Barbara Spence (barbara@avenue.co.za / 011 463 7940) before our deadline date of 10 June to find out more.
INTERESTING CONSEQUENCES

Variation Orders have always been an interesting topic, as the very nature of the Variation Order, or the timing thereof, may bring about some interesting consequences for the Parties to the Contract.

Clause 6.3.1 of the General Conditions of Contract for Construction Works (3rd Edition 2015, or “GCC 2015”) provides the list of Variations the Employer’s Agent may order the Contractor to implement. This is a closed list of what the Contractor may be ordered to do. In other words, a Variation may only be ordered if it falls within the definitions of the items listed in Clauses 6.3.1.1 to 6.3.1.6 of GCC 2015.

Such Variation may be ordered at any time before the issue of the Certificate of Completion.

Clause 6.3.2 of GCC 2015 provides a very clear requirement, which is rarely followed by Employers’ Agents, in that when the order is issued, it must clearly state that it is a “Variation Order”, whereby it is identifiable as such. If it is not identifiable as such, then the intention of the Employer’s Agent is that the order or instruction does not constitute a Variation Order. The obligation is then on the Contractor in terms of Clause 6.3.2 that he must not construe the order or instruction to be a Variation Order.

Once the Contractor receives a written order stating “Variation Order”, the onus is on the Contractor to verify that the written order falls within one of the listed definitions of Clauses 6.3.1.1 to 6.3.1.6, and if not clear, to seek clarification from the Employer’s Agent to ensure there is a “meeting of the minds”.

Now, Clause 6.3.2.1 of GCC 2015 provides that an oral order also constitutes a competent instruction but the onus is on the Contractor to confirm the understanding within seven days from receipt of an oral order that such oral order is to be construed as a “Variation Order”. If the Contractor fails to comply within the seven-day provision, then the order shall not constitute a Variation Order. It would therefore be more than just “good practice” for a Contractor not to follow or rely on oral orders or oral instructions, and to rather request from the outset that all orders falling within the provisions of Clauses 6.3.1.1 to 6.3.1.6 of GCC 2015 be in writing.

The wording of Clause 6.3.2.1 of GCC 2015 also provides some interesting opportunities to a Contractor. Where the Employer’s Agent issues revised drawings or instructions to the Contractor during the progress of the Works and then, on the basis of Clause 6.3.1.3 or 6.3.1.4, the Contractor may write to the Employer’s Agent and contend that the resultant effect of the drawing or instruction must be treated as a “Variation Order” and that it must be valued in terms of Clause 6.4 of GCC 2015. This proposition is also supported in Clause 5.9.5 of GCC 2015 where Clause 6.3 is referred to in this Clause.

At this juncture it must be clarified that the document which contains the bills of quantities or the valuation of the work contained in the Variation Order is not the “Variation Order”. A Variation Order requires no monetary value to be attached to it. The document which is usually issued containing the valuation of the work to be done in respect of the Variation Order is the “Valuation of the Variation” in accordance with Clause 6.4 of GCC 2015, and this “Valuation of the Variation” should state it as such in the heading.

Where an Employer is taking the authority away from the Employer’s Agent to issue a Variation Order, the consequence is that the delay in the issuing of a Variation Order may cause a delay to the progress of the Works, which may then result in a claim for an extension of time. The additional payment related to the extension of time claim may then, in some instances, exceed the cost of the Variation Order. Serious consideration must therefore be given by an Employer before reducing the limit of the powers of the Employer’s Agent in terms of Clause 6.3 of GCC 2015.

The obligation to value the Variation Order is on the Employer’s Agent in terms of Clause 6.4.2 of GCC 2015 and must
be issued to the Contractor within 28 days of the date of the Variation Order. Clause 6.4.2 of GCC 2015 does not provide for a process of offer and acceptance. The Employer’s Agent must determine the value as certifiable amounts payable to the Contractor. The Contractor is then entitled to raise a dissatisfaction claim in terms of Clause 10.2 of GCC 2015. Where the Employer’s Agent failed to issue the Valuation of Variation, the Contractor may invoke the claims procedures of Clause 10.1 of GCC 2015 in order to pursue the amounts due.

CASE IN POINT
This now brings me to a case in point which played off in the year 2010 in the beginning of my career as a full-time construction law consultant.

I was approached by a Contractor for some advice on a very unfortunate event. The Contractor was in the process of completing a civil engineering infrastructure project to the value of R25 million. The project was completed in phases and at the time of the unfortunate event, the value of the work completed to date was in the order of R20 million. The contract was let under the GCC 2004 conditions of contract.

The Contractor was issued with a letter of termination by the Engineer, and the letter of termination was not preceded with a notice of default. It was just a summary termination without any warning or notice to rectify any default. I then wrote to the Engineer to confirm that the termination amounted to repudiation as, firstly, the Engineer had no authority to terminate the Contract, and secondly, the termination was contractually flawed. The Contractor would also be entitled to a contractual claim as a result of the repudiation.

The response of the Engineer was unexpected. The Engineer confirmed that he was instructed by the Employer to terminate the Contract forthwith, as the project was under financial pressure and the Employer had obtained a better price from another Contractor to complete the outstanding work of R5 million on the Contract.

In terms of Clause 36.1.2 of GCC 2004 (now Clause 6.3.1.2 of GCC 2015) the Engineer could have issued a Variation Order to “omit any such work” if the Contract was under financial pressure, but he did not pursue this avenue. Also, if he had issued such a Variation Order and the Employer then appointed another Contractor to execute such work, then this would also amount to a breach of Contract, as any omission of scope must be a genuine omission and cannot be ordered for the purpose of negotiating “a better bargain” with another contractor.

At the time of GCC 2004 there was no further provision in Clause 36.1.2 of GCC 2004 which stated “… provided it is not to be carried out by someone else …” The Contractor had to argue his case on the basis of the outcome of the case of Hydro Holdings (Pty) Ltd v Minister of Public Works and Another (1977) where the legal principle was established on “genuine omissions”.

Fortunately, in GCC 2015 you will now find that Clause 6.3.1.2 provides an express contractual obligation in that the omission of any work may only be ordered by the Employer’s Agent “… provided it is not to be carried out by someone else …”.

In terms of the case in point, the Employer eventually withdrew the termination letter issued by the Engineer and the Contractor completed the project as originally intended.
Dispute Boards – Ethics in Today’s World of DRBs¹ (article 12)

INTRODUCTION

An introductory article on Dispute Board ethics appeared in the July 2017 edition of Civil Engineering.²

It reminded the reader of a series of six articles on Dispute Boards (DBs) which had appeared in previous editions of Civil Engineering and advised that the next series of articles on DBs are aimed at specifics, dealing with pertinent aspects of DBs in more depth. It also advised that interspersed with these will be a series of articles on DB ethics penned by Jim Phillips PhD, Chair of the Dispute Review Board Foundation (DRBF) Ethics Committee. These articles were first published under the general heading of “Ethics in Today's World of DRBs” in the DRBF Forum³ and are republished by kind permission of the DRBF and the author Jim Phillips.

The article that follows is the twelfth of these articles on DB ethics that we will be reproducing (the first eleven articles appeared in the August 4 and September 5 2017, and March 6, May 7, August 8 and September 9 2018, and January/February 10, March 11, June 12 and July 13 2019, and January/February 14 2020 editions of Civil Engineering, respectively).

The July 2017 article stated the DRBF Canons of Ethics. Included furthermore in the article were practice guidelines and further discussion on how Board members are expected to conduct themselves, which were reproduced from Chapter 2.10 of the DRBF Practices and Procedures Manual. Accordingly, it serves as a handy reference guide when reading the articles on DB ethics.¹⁵

At the end of the January/February 2020 article the following question was posed, which forms the basis of this twelfth article by Dr Phillips:

“What should the DB do?”¹⁶ (by Jim Phillips PhD, Chair of the DRBF Ethics Committee)

The question posed at the end of the last ethics column was how should a Dispute Board respond to a contractor's request for a formal hearing the day after a regular project meeting at which both parties claimed there were no disputes despite correspondence to the contrary that the Board had reviewed.

Allen Thompson in Florida wrote in and commented that the Board should proceed according to the procedures established when the Board was formally seated, and at some point turn it into a teaching moment.

I agree with Allen’s view. The Board should go ahead and schedule a hearing. This is the purpose of the DRB, obviously. Just because the parties choose not to discuss issues that rise to the level of a dispute at a regular meeting should not cause the Board not to hold the hearing. The fact that the request came the next day after the regularly scheduled meeting and the parties failed to discuss the issues, despite the project correspondence, gives rise to Allen’s second comment that the DRB might use this sequence as a teaching moment.

This schedule of meetings accomplishes several purposes: it allows the parties to view the work in process and, if there are discussions about issues during the course of the meetings, the Board can adjourn and take a site tour to view the work in progress and be shown what the issue is about, usually with explanations from both parties.
The majority of projects that have a contract specification that authorises the formation of a DRB also contains language that requires regular, often quarterly meetings to be held on the project site. This schedule of meetings accomplishes several purposes: it allows the parties to view the work in process and, if there are discussions about issues during the course of the meetings, the Board can adjourn and take a site tour to view the work in progress and be shown what the issue is about, usually with explanations from both parties.

This is an invaluable opportunity, one that does not occur during a claims or administrative process, and certainly not during litigation. One of the purposes of the regular meetings is to have discussions on issues where the Board can offer feedback and suggestions, and on some occasions provide an informal recommendation. The idea here is for the Dispute Board to be preventative and head off issues that are percolating before they become disputes.

In the question posed in the previous Forum, the Dispute Board had read correspondence wherein the parties were discussing disagreements about the prosecution of the work. There is a view that one of the Board’s responsibilities is to elicit discussions that lead to possible solutions of issues in the work before they evolve into disputes. The practice of providing the Board correspondence of major events, notices to file a claim, change orders, requests for information, or even weekly reports, is designed to have the Board up-to-speed when it walks in the door for the regular meetings. In my opinion, if the Board is not up-to-date with the correspondence when it comes in for a regular meeting, then it is missing opportunities to assist the parties. Others would argue if that is the case, that the Dispute Board is not fulfilling its contractual responsibilities.

Canon V of the DRBF Code of Ethics provides that the DB shall consider impartially all of the disputes referred to it. In this case, the Board Chair should proceed and schedule a formal hearing on the disputes as requested.

Canon V of the DRBF Code of Ethics provides that the DB shall consider impartially all of the disputes referred to it. In this case, the Board Chair should proceed and schedule a formal hearing on the disputes as requested.

is represented by an attorney who is not well-spoken and for whom English is a second language. The contractor’s attorney is having a very difficult time being understood by the DRB and by the owner and their attorney. During a recess one of the members asks the chair if it would be possible to “level the playing field” and somehow try to assist the contractor’s attorney to make it fairer to everyone. What would you do as the chair and how should the Board respond?

NOTES
1. Dispute Review Board – gives a non-binding recommendation.
3. The DRBF Forum is a quarterly publication of the DRBF.
SAICE-PDP impacts lives

SAICE Professional Development and Projects (SAICE-PDP), a non-profit company set up by SAICE to develop and drive capacity building initiatives, continues to contribute to capacity development both in South Africa and further afield. In response to the findings of the Numbers and Needs research carried out in 2004/2005, the company has worked tirelessly to address challenges faced by those wishing to develop in the engineering profession, and more recently has spread its wings to also support engineering institutions in the SADC region with capacity building.

Over the years SAICE-PDP has managed various bursary and internship programmes, but its most important support relates to developing the full potential of engineering graduates during their candidacy phase towards professional registration with the Engineering Council of South Africa (ECSA). The company proudly boasts having mentored over 1 800 candidates for one to three years on a wide selection of programmes, in both the public and private sectors, since the start of these programmes in 2006.

MENTORING PROGRAMMES

During 2019, SAICE-PDP, with the assistance of the South African Institute of Electrical Engineers (SAIEE), provided a team of 21 civil, electrical and mechanical mentors to guide and support some 300 candidates who are employed in local government, parastatals, contractors and consulting practices.

Many organisations intuitively develop their candidates towards professional registration, but without rigour the process can take many years. SAICE-PDP assists companies to review and enhance their approaches to candidate development by workshopping with senior management, or by assisting with the development of training plans and programmes and training mentors, or by providing a complete service including the provision of external mentors.

TRAINING COURSES FROM THE CANDIDATE ACADEMY

In 2010 SAICE-PDP, in partnership with Consulting Engineers South Africa (CESA), established the Candidate Academy to support graduates on their journey to professional registration.

The Academy’s philosophy is to offer Initial Professional Development (IPD) courses that address the foundation areas of engineering practice. The training focuses on the practical application of theory in the workplace. Candidates are exposed to ‘action learning’, which prepares them to be discerning, responsible and imaginative practitioners.

Well over 11 000 delegates have attended Candidate Academy courses since its inception in 2010. The Academy prides itself on delivering top-quality services and products that are relevant and practical. We urge readers to submit suggestions on additional courses they would find useful or ideas on how to improve existing courses (contact details are given below).

The demand for in-house courses has continued to increase over the years. Where required, material has been customised to suit client requirements relevant
to their sector or discipline. Additional courses planned for the coming year include courses on project planning, and ethics in construction and engineering. The Academy has been quick to respond to the need for online courses, and successfully delivered the first two of its two-day courses towards the end of May. Action Learning was retained with extensive use of breakout rooms and chats. Details of courses for the rest of the year appear on page 57 of this edition of the magazine.

RESEARCH
Having launched the company on the basis of the initial Numbers and Needs research, the company has continued with major research projects over the years, the most notable of which have been the background research on the skills required for the Strategic Infrastructure Projects (SIPs) and more recently a massive research project (Engineering Numbers and Needs in the SADC Region), which has now also been completed. Sadly, the research highlighted that tertiary education and graduate support challenges exist throughout the region and not only in South Africa, as had been identified in the first Numbers and Needs.

Road to Registration guidance is now being given to several SADC countries, and material has even been translated into French for the DRC and Madagascar!

INTERESTING PROJECTS
Interesting projects carried out over the years have included the development of candidates in local and provincial structures and support offered to engineering institutions in the SADC region.

Gauteng CoGTA support
A notable programme in this regard was a Gauteng provincial initiative aimed at providing support to senior management in Gauteng local governments to become professionally registered, as it was found that the number of senior engineering personnel in municipalities who were professionally registered had reduced as a result of large numbers of technical staff retiring. There was therefore a shortage of registered personnel who could assume the ultimate responsibility for projects, fill senior engineering management posts, and mentor young graduates. The target was to submit 40 applications for registration to ECSA within a 12-month period. At the end of the programme, 45 applications were submitted, with 36 candidates having successfully registered as professionals to date.

Websites and support for engineering institutions in SADC
A very rewarding project, funded by the Royal Academy of Engineering, has been a commission to help small and emerging engineering institutions in sub-Saharan Africa to develop websites and services for their members. SAICE-PDP has developed an easy-to-use WordPress series of functions, and set up sites for some 20 organisations, after which they were trained to manage the sites on their own. Of interest are the many events that have been organised using these sites, including soccer matches, for which participants received certificates!

SAICE-PDP has also been able to connect many of these institutions with South African and British engineering institutions to offer additional technical data to share on their sites, and has been instrumental in facilitating attendance of office-bearers from several of the institutions at various technical conferences held in the SADC region and the UK. Opening an international workshop organised with the Royal Academy in Antananarivo, an exuberant Mamy Rabenahary, president of the Ordre des Ingénieurs de Madagascar (OIM) thanked the Royal Academy and SAICE-PDP for organising “the first ever international engineering function in Madagascar”.

SUCCESS STORIES
Mogomotsi Ramotshwane, from the City of Johannesburg (JRA) Metropolitan Municipality, joined the first LGSETA 2015/2016 programme cohort in November 2015 with the aim to register as a Mechanical Engineering Technician. He was mentored by John Browne. In October 2018 he submitted his professional registration application to ECSA and was successfully registered in June 2019. He sent us the following message:

I was part of your Road to Registration programme (LGSETA) since 2015. I would gladly like to

Training Voluntary Associations in Madagascar on how to set up and manage their websites
inform you and your team that I have successfully managed to register as a Professional Engineering Technician in June 2019. I would like to thank you guys for helping candidates to become professionals, and to also tell you that you are doing great work. I enjoyed being on the programme and I benefited a lot more than my company or even myself could afford to provide. May God bless you! (Mogomotsi Ramotshwane Pr Techni Eng)

Fred Fryer was the first candidate on the Gauteng CoGTA Programme, and was tasked to submit his professional registration application to ECSA within six months. His message to us was equally inspiring:

While working at Alberton Municipality Electricity Department, I had little time to pay proper attention to the ECSA registration process. Then came the opportunity afforded by Gauteng CoGTA, with professional, hands-on assistance given in completing the registration process, resulting in me being able to register quickly and painlessly. My sincere thanks go to my principals at the City of Ekurhuleni, the Gauteng CoGTA, SAICE-PDP, the SAIEE (particularly John Gosling), ECSA and all the other value chain members who had made my registration possible. (Fred Fryer Pr Tech Eng)

SAICE-PDP has similarly brought motivation, mentoring and training to hundreds of graduates on their road to registration. We salute the registered candidates for their dedication, enthusiasm and insight!

**WHAT CAN SAICE-PDP DO FOR YOU?**

With our considerable experience in mentoring and development of plans and guidelines for the workplace training process, SAICE-PDP provides systems and support to ensure a clear road to registration.

**We develop training programmes**

Working with management, supervisors and human resources staff within your organisation, we can help develop training programmes for technical staff to lead them towards professional registration and beyond.

**We provide external mentors**

External mentors help to ensure that your candidates are developed adequately by:

- Assessing candidates initially to determine gaps in experience and then working with management to identify appropriate tasks or projects.
- Reviewing progress quarterly and assessing readiness for registration.
Suggesting supplementary training or secondments where required.

Advising candidates when completing their ECSA reports and finalising their applications.

Acting as referees for the final ECSA submission.

**We provide coaching support**

Where there is insufficient internal capacity to ensure skills transfer, an external professional can be engaged to:

- Review work and assist candidates to recognise and/or solve problems.
- Attend meetings and/or site visits with candidates.
- Help candidates enhance their technical knowledge and application in the workplace.

**We offer advisory services**

One of our experienced reviewers can carry out once-off assessments of candidates to advise on their progress towards registration and identify gaps which need to be addressed. Please feel free to contact zan@saicepdp.org or lizelle@saicepdp.org for more information on how we can assist you.

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**Zan Mlambo GradICSA**
SAICE-PDP
MISA training
LGSETA Programme Administrator
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OBIITUARY

Solly Gerald Stock – the last of a generation

17 January 1925 – 6 March 2020

Gerald, as he was popularly known, grew up in Carnarvon where he attended primary school. His father, who started off as a smous, became both a successful sheep farmer and a businessman in the town, owning a number of small businesses in the main street. His father was fondly remembered by the community of Carnarvon for his generosity during the Great Depression.

Gerald’s home language was English, but as one would expect in a small Karoo town, his “street” language was Afrikaans. He was completely bilingual and enjoyed speaking Afrikaans until the day he died at the age of 95. He completed his school education at Grey High School in Port Elizabeth as a boarder.

When asked by his granddaughter if it was not boring growing up in a small town, he replied “… not if you had an enquiring mind”. When home on school vacations, he would attach himself to practitioners of various trades – the local electrician, carpenter, auto-electrician and plumber. Not surprisingly Gerald acquired a phenomenal practical knowledge of how things worked.

He completed his degree in Civil Engineering at Wits in 1947 as one of the illustrious group of engineers of that era amongst who were Alf Abramowitz, Tony Goldstein and Philip Slotzky. In 1948, soon after starting his career, he married Sadie. In the early 1950s Gerald started his own consulting practice, a basement room at home serving as his office. Sadie was his secretary and office manager. In the days before word-processing his children remember Sadie having to retype documents until Gerald, always a perfectionist, was happy that they were flawless.

His enquiring mind was a defining character trait, reading almost exclusively about how things worked – from rotary engines, to the movement of objects in the solar system.

He had a large collection of slide rules and calculators used by engineers which he donated to the School of Civil Engineering at Wits, where it is being housed as a special collection. The collection was the subject of an article in the March 2008 edition of Civil Engineering and makes for fascinating reading, especially for those of us old enough to have used slide rules.

Around 1962 Gerald sold his consulting practice to Ove Arup & Partners, joining them as a project manager. (Sadie became the Office Manager at Ove Arup until her retirement, when she returned to working with Gerald until her passing in 2003.) After a relatively short period Gerald left Arup to start Metricomp Programmes (in 1965), to develop and market engineering software on a rental basis – this was the first company in South Africa to do so.

The author met Gerald and became a renter of Metricomp software in 1978. The programs were all written and ran on Hewlett Packard “desk top programmable calculators” in HP Basic language. Gerald started programming on Olivetti 16k models before switching to HP. By 1980 the HP “calculators” were “massive” 128k machines. No one knows how many structures, still proudly standing today, were analysed and designed using his software – testament to the man.

Professionally, Gerald was still active well into his late eighties, marketing finite element software and consulting in that area. He used to present lectures to practising structural engineers, usually challenging them to draw in free hand (definitely without using a laptop) how a structure would deflect under various load conditions, a subject which is basic to structural engineering. He would get great delight in catching them out!

More than 50 years ago, Gerald was President of the SA Association of Consulting Engineers (CESA today), and he was a Fellow of both CESA and SAICE, as well as a committee member of the Board of the Joint Structural Division between SAICE and the Institution of Structural Engineers (UK).

Gerald’s son Leonard says that his father was always a progressive thinker. “I never heard him speak in a derogatory manner of anyone of another race, language or religion. He was always community-minded, spending his younger years as an active member of Round Table and the Greenside School Governing Body, and in his later years he was chairman of the Emmarentia Rate Payers Association.” Gerald could often be seen in the early mornings walking around the Emmarentia Dam with Sadie, both with black garbage bags, picking up litter left lying around by the many users of the dam’s facilities, and for this he was awarded civic recognition by the Mayor of Johannesburg.

Gerald is survived by his son Leonard and daughter Hilary Janks, and by his partner of 16 years, Sally Thompson.

Spencer Erling Pr Eng
spank2017@outlook.com
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<td>Leadership and Project Management in Engineering</td>
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<td>David Ramsay</td>
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<td>The Legal Process dealing with Construction Disputes</td>
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<td>28–30 October 2020</td>
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<td>SAICEcon19/02447/22 3 Credits: 3 ECSA</td>
<td>Prof Zvi Borowitzh</td>
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<td>Legal Liability Occupational Health and Safety Act (OHSA)</td>
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<td>SAICEbus19/02456/22 Credits: 2 ECSA</td>
<td>Elaine Matchett</td>
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<td>Water Security and Governance</td>
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<td>SAICEwat19/02412/22 Credits: 2 ECSA</td>
<td>Martin van Veelen</td>
<td><a href="mailto:cheryl-lee@saice.org.za">cheryl-lee@saice.org.za</a></td>
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<td>Equipment Options to reduce Hammer Water</td>
<td>22 July 2020</td>
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<td>Peter Telle</td>
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<td>NEC3 Project Manager Accreditation Programme</td>
<td>6–9 October 2020</td>
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<td>SAICEcon19/02464/22 Credits: 4 ECSA</td>
<td>Mile Sofijanic Andrew Baird</td>
<td><a href="mailto:mile.s@ecs.co.za">mile.s@ecs.co.za</a></td>
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<td>Introduction to the NEC3 family and the NEC3 Engineering and Construction Contract (ECC3)</td>
<td>22–23 July 2020</td>
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<td>Introduction to the NEC 3 Professional Services Contracts (PSC3 and PSSC3)</td>
<td>24 July 2020</td>
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<td>Introduction to the NEC4 and the ECC4</td>
<td>29–30 July 2020</td>
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<td>20–21 August 2020</td>
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<td>CESA-1434-05/2021 Credits: 2 ECSA</td>
<td>Bruce Raath</td>
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<td>Project Presentation Skills</td>
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<td>SAICEbus19/02457/22 Credits: 2 ECSA</td>
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<td>Stellenbosch</td>
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<td>Chris Brooker Onno Fortuin</td>
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<td>Stormwater Drainage</td>
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<td>Alaster Goyns</td>
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<td>Concrete Road Design and Construction</td>
<td>19 August 2020</td>
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<td>SAICEtr19/02472/22 Credits: 1 ECSA</td>
<td>B Perrie Dr P Strauss</td>
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<td>Traffic Signals Design and Intersection Optimisation</td>
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<td>Dr John Sampson</td>
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<td>Prof Alex Visser</td>
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<td>Perspective on Traffic Impact Assessment</td>
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<td>Steven Sutcliffe</td>
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<td>Craig Proctor-Parker</td>
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<td>Road to Registration for Candidate Engineers, Technologist and Technicians</td>
<td>8 July 2020</td>
<td>Online</td>
<td>CESA-1579-04/2022 Credits: 1 ECSA</td>
<td>Allyson Lawless</td>
<td><a href="mailto:lizelle@saicepdp.org">lizelle@saicepdp.org</a></td>
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<td></td>
<td>9 September 2020</td>
<td>Online</td>
<td></td>
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<td><a href="mailto:dawn@saice.org.za">dawn@saice.org.za</a></td>
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<td>Road to Registration for Mature Engineers, Technologist and Technicians</td>
<td>22 July 2020</td>
<td>Online</td>
<td></td>
<td>Stewart Gibson</td>
<td><a href="mailto:lizelle@saicepdp.org">lizelle@saicepdp.org</a></td>
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<td>17 September 2020</td>
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<td>1 October 2020</td>
<td>Midrand</td>
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<td>24 November 2020</td>
<td>Cape Town</td>
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<td>Road to Registration for Mentors, Supervisors and HR Practitioners</td>
<td>20 July 2020</td>
<td>Online</td>
<td>CESA-1580-04/2022 Credits: 1 ECSA</td>
<td>Allyson Lawless</td>
<td><a href="mailto:lizelle@saicepdp.org">lizelle@saicepdp.org</a></td>
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<td><a href="mailto:dawn@saice.org.za">dawn@saice.org.za</a></td>
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</tbody>
</table>

In-house courses are available. To arrange, please contact:
Cheryl-Lee Williams (cheryl-lee@saice.org.za) or Dawn Hermanus (dawn@saice.org.za) on 011 805 5947.
For SAICE-hosted Candidate Academy in-house courses, please contact:
Dawn Hermanus (dawn@saice.org.za) on 011 805 5947 or Lizelle du Preez (lizelle@saicepdp.org) on 011 476 4100.

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