# CONCRETEBETON

CEMENT & CONCRETE SA

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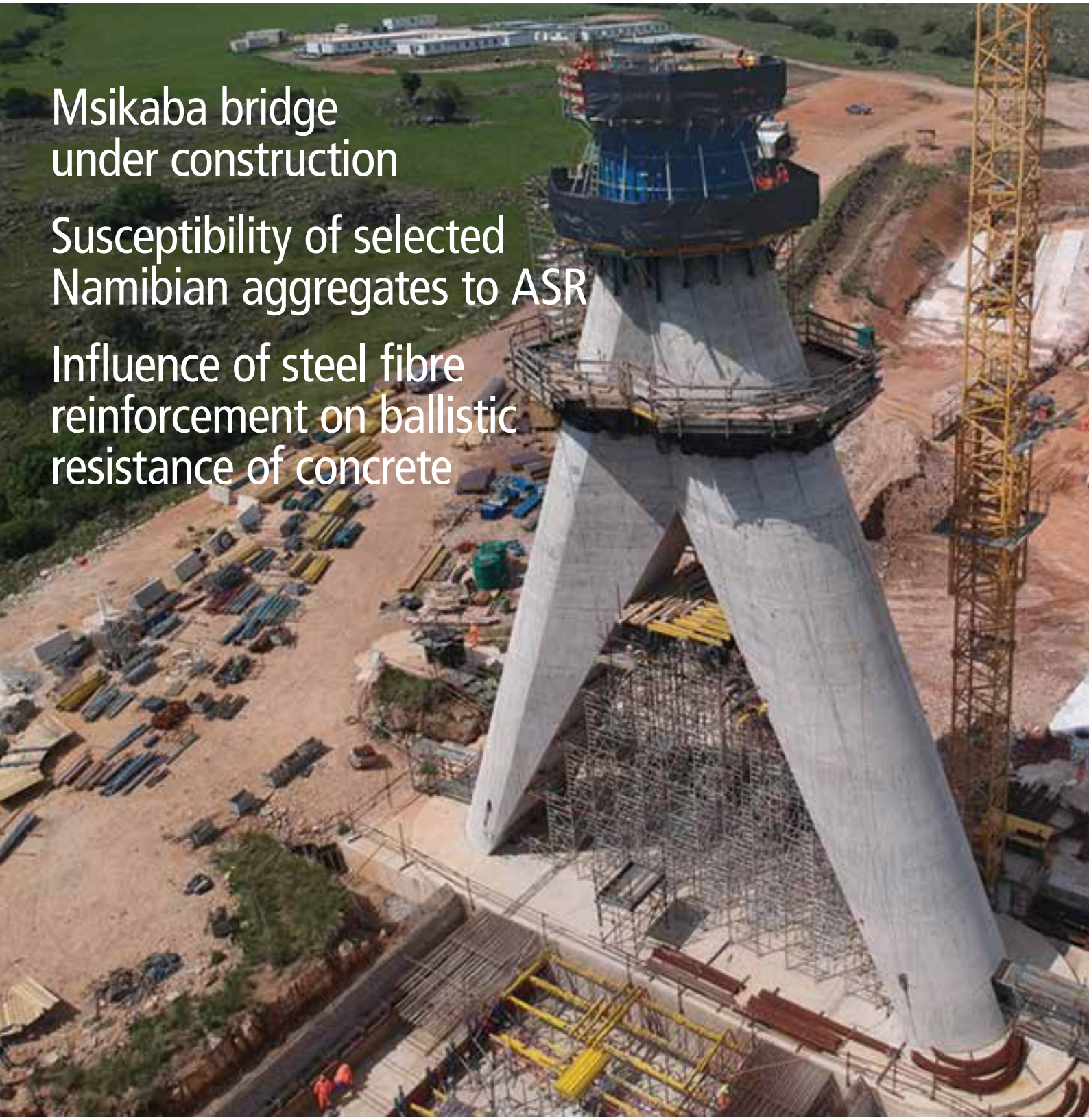

## Msikaba bridge under construction

## Susceptibility of selected Namibian aggregates to ASR

## Influence of steel fibre reinforcement on ballistic resistance of concrete

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# CONTENTS








*COVER: Construction of the Msikaba Bridge near Lusikisiki in the Eastern Cape: the most complex structure of its type ever to be built in South Africa and probably in Africa.*

Concrete Beton, as the only non-commercial magazine for cement and concrete in South Africa, remains the prime source of authoritative technical and industry-related information.

Not only does this issue carry two technical papers from the 2021 YCRETS symposium, but is shares information about the upcoming 2023 YCRETS symposium (p.6) , with an open invitation to attend this event in support of our leaders of the future. The call for nominations for the Young Researcher Award will be available soon.

In a breaking news announcement read more about ConPaveStruc 2023, the 1st National Conference on Concrete Roads and allied Structures to be held on 29 & 30th August.

Creating opportunities for cement and concrete to be presented in trustworthy platforms as the construction material of choice, has become critical in an era where so much is said, published and shared by entities who do not have the authority, nor the necessary knowledge to speak on the subject.

Cement & Concrete SA has the pole position to address cement and concrete matters through various channels (see the COE's message on the next page).

I remain proud and committed to be the editor of this prestigious magazine.

Enjoy the read, be inspired, and be energised.

*Hanlie*

**Hanlie Turner**, Editor

During the recent #CCCA 2023 @ work roadshow, I shared with audiences how Cement & Concrete SA's operating structure of Industry, Technical and Business Development, ensure that our reach is far and wide to address our mission of creating long-term value and industry growth by driving collaboration, skills development, innovation and the highest standards in sustainable cement and concrete materials and products.

We deal with a variety of industry matters to ensure that we are well represented on government steering committees to influence policies and legislation. There has also been engagement with Government on several environmental issues namely climate change, air quality, water management, rehabilitation of mining activities, and waste management including waste tyres. Air quality emission standards, dust management & fugitive emissions and carbon capture and utilisation are being addressed with the SABS. Representation on BUSA sub-committees means that we have input on environment, water, waste, climate change and Just Transition at a business level.

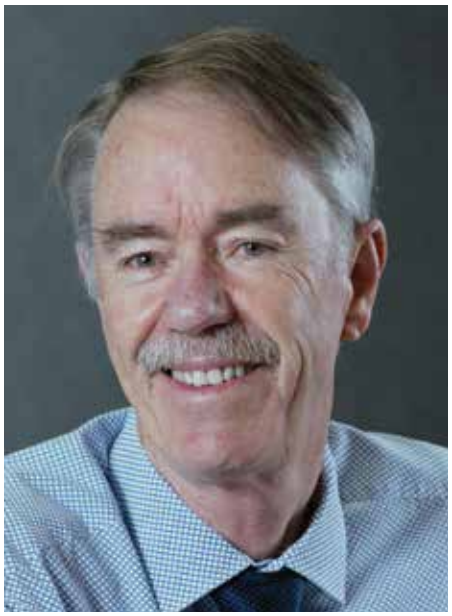
Interaction with government has ensured that great progress has been made to protect our local industry in terms of anti-dumping tariff applications, and safeguard application for general import tariff. We are also interacting with the NRCS on an ongoing basis to address lack of action on complaints of poor quality cement being sold sometimes without a valid Letter of Authority from the NRCS.

The technical pillar of CCSA continues to deliver authoritative concrete education through The School of Concrete Technology to ensure that specifiers, contractors, material suppliers and all those involved in construction will understand that quality concrete that meets all strength and durability requirements are critical for success. A variety of courses, focussed on sustainability and best practices makes it possible for concrete education to reach all sectors.A free advisory service is offered to all members, while consulting services are available at members' discounted rates on request. These services are rendered by suitably qualified CCSA staff members. Underpinning the technical portfolio is the most comprehensive library on cement and concrete in the southern hemisphere, based at our offices in Midrand. This facility adds value to all involved in concrete work, be it in the design office, on site, the research environment or for the entrepreneur. CCSA staff and members chair, or participate in, numerous SABS committees to ensure that standards for cement or concrete are up-to-date and relevant, and do not disadvantage either material.

Our Business Development arm deals with memberships and industry interaction. Many different interventions are hosted creating opportunities to share technical formation, showcase excellence in concrete, present research and fun events for students and practioners alike. Careers in Concrete is an initiative to expose students to the great variety of occupations within our industry.

CCSA's members come from diverse enterprises ensuring that we live up to our values of providing a united body the lead the industry through relevance for all stakeholders.

I am confident that what has been achieved during the past two years of our existence, has laid a solid foundation for CCSA to continue to create and add value in the South African built environment.



Bryan Perrie, CEO

Cement & Concrete SA's vision is to be the unified voice of the cement and concrete industry in South Africa, defending and promoting the industry, driving growth and delivering shared value.

**OUR VISION**
To be the unified voice of the cement and concrete industry in South Africa, defending and promoting the industry, driving growth and delivering shared value.

**OUR MISSION**
To create long term shared value and industry growth in South Africa. We do this by driving collaboration, skills development, innovation and the highest standards in sustainable cement and concrete materials and products.



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Cement & Concrete SA NPC

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# YCRETS 2023

YOUNG CONCRETE RESEARCHERS, ENGINEERS & TECHNOLOGISTS SYMPOSIUM

## 12 – 14 JULY 2023 *BOOKINGS NOW OPEN!*

The Young Concrete Researchers, Engineers, and Technologists Symposium (YCRETS) is convened under the auspices of Cement & Concrete SA. This peer-reviewed event gives individuals, 35 years and younger (in 2023), a platform to present their research on concrete and cementitious based materials. YCRETS 2023 will be a live event hosted at Stellenbosch University.

After the very successful YCRETS 2021, which ensured extended exposure for all the participants, we are inviting the greater industry to join our young Researchers, Engineers and Technologists for an insightful and informative symposium on the overarching theme of CIRCULARITY. The importance of a circular economy in construction, and particular in cement and concrete, cannot be over-emphasised to ensure that concrete retains its position as the most widely used construction material.

### PROGRAMME SYNOPSIS:

**12 JULY 2023**
- Registration
- Site Visit at Stellenbosch University's Engineering Lab
- Wine Tasting Excursion

**13 JULY 2023**
- Day 1 of Presentations

**14 JULY 2023**
- Day 2 of Presentations
- Closure

### VENUE:

Jan Mouton, Neelsie Student Centre, Victoria Street, Stellenbosch University, Stellenbosch

Directions will be posted on Cement & Concrete SA's website.

### RSVP:

Natasja Pols at
***natasja.pols@cemcon-sa.org.za***

Closing date for bookings:
**Friday, 30 June 2023**

### COSTS:

- Early Bird Student Fee:.....R1,000.00 (Closing date: 31 March 2023)
- Student Fee:.....R1,500.00

- Early Bird Delegate Fee:.....R3,000.00 (Closing date: 31 March 2023)
- Delegate Fee: .....R3,500.00

Accommodation is for your own account and is not included in the attendance fee.

**CPD points will be applied for.**
Sponsorship opportunities available, contact Natasja for more information on this or visit the YCRETS Webpage: ***https://cemcon-sa.org.za/ycrets2023/***

Organised by: CEMENT & CONCRETE SA

Hosted by: Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT

### Symposium theme: CIRCULARITY
### Symposium sub-themes:

**INNOVATION**
Additive manufacturing, AI, automation, BIM, data management, optimisation or regulation related to concrete materials or concrete incorporating structures.

**MATERIALS**
Cement-based materials, alternative binders, waste materials, recycled aggregate, environmentally adaptable materials, green composites, intelligent materials, self-healing, self-sensing materials and materials suitable for additive manufacturing.

**DESIGN**
Sustainable renovation or repurposing of concrete structures, especially incorporating life cycle analysis and design for deconstruction, thermal comfort and near-zero energy buildings, carbon neutral concrete structures.

**ANALYSIS**
Structural analysis of various structural elements or structures, especially ones designed for deconstruction, that consist of or incorporate concrete.

**DURABILITY**
Durability aspects of concrete in a variety of structures (including buildings, highway infrastructure, dams and energy harvesting structures) and harsh environments, maintenance and management of civil infrastructure and sustainable repair, rehabilitation, retrofitting and reuse.

### KEYNOTE SPEAKERS:

**PROF. ELSABÉ KEARSLEY,**
**University of Pretoria**

**PROF. LESLEY PETRIK,**
**University of Western Cape**

### CONTACTS:

**ORGANISING COMMITTEE**
https://cemcon-sa.org.za/ycrets2023/
***(Click on Organising Committee Tab)***

**SYMPOSIUM WEBSITE**
https://cemcon-sa.org.za/ycrets2023/

# ACI Expanding Outreach to Africa

Greetings from the United States of America. It's an honour to provide this brief update on recent developments within the American Concrete Institute (ACI) for the March issue of Concrete Beton. For readers who might not be familiar with ACI, it is a professional society that was founded in 1904. ACI envisions a future where everyone has the knowledge needed to use concrete effectively to meet the demands of a changing world and, accordingly, has a mission to "develop, disseminate, and advance the adoption of its consensus-based knowledge on concrete and its uses." ACI is based in Farmington Hills, Michigan and has an international office in Dubai, UAE as well as regional offices in California, Illinois, and Maryland. Globally, ACI has a membership that tops 30,000 and a student membership of about 15,000. In addition, globally, ACI has 93 chapters, over 250 student chapters, and 64 international partners, including Cement & Concrete SA.

ACI has lived up to its tagline of "Always advancing" by creating three Centers of Excellence (COEs) since 2021 - NEx: An ACI Center of Excellence for Nonmetallic Building Materials in 2021; and, in 2022, NEU: An ACI Center of Excellence for Carbon-Neutral Concrete and PRO: An ACI Center of Excellence for Advancing Construction Industry Productivity. The COEs are setting a bold new direction for ACI, and their initiatives will help transform the concrete industry.

As ACI President, I attend select events not just in the U.S., but globally. I recently completed a schedule-intensive trip to Africa that started in Kigali, where Bernie Pekor, ACI Director of International Business Development, and I attended the 2023 Conference of the Federation of African Engineering Organisations (FAEO) before visits to Djibouti; Addis Ababa, and Johannesburg for various meetings and events with ACI's International Partners. In an address to the FAEO delegates, I conveyed ACI's commitment to collaborate with FAEO and the various member engineering institutions to improve the quality of concrete construction and, thereby, the durability and resiliency of concrete structures in Africa through certifications and access to ACI's vast concrete knowledge. As a result of the visit, ACI will be signing International Partner Agreements with six FAEO member organizations and I'm particularly proud of these signings.

Our African visit ended in Johannesburg where Bernie and I had a very productive lunch meeting with Bryan Perrie and Hanlie Turner. Our discussions covered a myriad of topics including sustainability, concrete industry productivity, and dissemination of concrete knowledge. Bernie and I are now the proud recipients of the 10th Edition of Fulton's Concrete Technology and I'd like to congratulate Cement & Concrete SA on the publication of this comprehensive manual on concrete. I truly believe that Cement & Concrete SA has a role to play in helping to advance the quality of concrete construction in Africa. **CB**

***Dr. Charles K. Nmai, PE, FACI***
***ACI President (2022-2023)***

*Fltr: Bryan Perrie(CEO, CCSA), Dr Charles Nmai (President, ACI), Hanlie Turner (Business Development Manager, CCSA) and Bernie Pekor (Director: International Business Development, ACI)*

# Hope from our country's national budget, or more implementation inertia?

Remaining the worst performer in the South African economy, the construction sector is hoping that government finally delivers on the fixed capital investments that were promised in Finance Minister Enoch Godongwana's budget speech in February 2023.

Speaking at construction materials leader AfriSam's Budget Breakdown event in Johannesburg, renowned economist Dr Azar Jammine of Econometrix pointed out that there was still uncertainty about government's ability to implement its stated expenditure plans. He pointed to a string of previous announcements by President Cyril Ramaphosa about large investments to be made by government in the economy, which had not come to fruition.

"If you look at the gross domestic product (GDP) performance of different sectors of the economy over the past decade, I am sad to say that the manifestation of this lack of investment is clearly evident in construction," said Dr Jammine. "It is down around 25% compared to where it was in 2010 – in absolute terms."

He highlighted that construction has had the poorest performance of all economic sectors, driven by the lack of investment by government and state owned enterprises (SOEs). Indeed, the investment in construction projects has "fallen off a cliff" since 2015, he noted.

"What is tragic about this is that the construction sector is the most employment intensive in the economy," he said. "Even though it accounts for only 2,6% of GDP, it provides 7,8% of all employment. That is one of the reasons why we have seen employment levels lagging behind GDP growth."

**Fiscal rectitude**

On the positive side, he said, the budget speech indicated that government was sticking to its fiscal discipline, and the importance of this should not be underestimated. In this regard, South Africa was in fact doing relatively well in comparison to many countries – in both the developed and developing world – where governments had foregone their fiscal rectitude.

Overcapacity in the non-residential building sector – exacerbated by the Covid-19 pandemic and the move to hybrid working arrangements – was depressing demand. The value of building plans passed in this segment had dropped from an average of over R3 billion per month to just over R1 billion a month. This affected mainly commercial office and retail space; the only area not affected by massive oversupply was in industrial and warehouse space.

"The picture is even worse when you look at figures for buildings completed," he said. "Building completions are about 50% down on where they were in 2019."

In terms of a provincial perspective, the Western Cape had seen a steady increase in building plans passed relative to other provinces, he noted. This province's share of the country's new building plans passed has risen to over 40%, while Gauteng has dropped to below 30%. The business confidence index among building contractors continued to deteriorate, although last year had seen a slowing in the rate of deterioration.

**Real hope**

Cement demand suffered negative growth in 2022, and despite current trends, is expected to improve only marginally – achieving low positive growth over the next few years, he said. What is helping somewhat is a fall-off in imports of Portland cement, according to figures from the Department of Trade and Industry, creating a little more capacity for local production.

"Where the real hope lies is in government getting its act together and starting to implement its capital projects," said Dr Jammine. "What was encouraging in the budget was the three-year projection for infrastructural investment projects – including a rise to R903 billion from R812 billion last year."

This was a significant change from the effective decline in planned infrastructure spending over a number of previous years. Almost 40% of this spending will be directed to transport and logistics, more than 17% on renewable energy and nearly 15% on water infrastructure. SOEs are earmarked to carry out about a third of this investment.

**Past promises**

His concern was that the plans might not be well implemented, a problem that had already emerged from previous government pronouncements. In the launch of its Economic Recovery and Reconstruction Programme in 2020, for instance, government said R340 billion would be spent on infrastructure – through 51 projects in housing, sanitation, schools, roads, harbours, water and energy.

The following year, an additional R595 billion was mentioned in the Medium Term Budget Policy Statement, for investing in 55 projects. Last year, a R100 billion infrastructure investment fund was announced, along with R1,14 trillion in commitments to capital projects.

Dr Jammine placed these stated intentions in stark contrast to this year's report by the Steel and Engineering Industries Federation of Southern Africa (SEIFSA), which described "a beleaguered industry a steep decline in investment". SEIFSA reported that government had promised a pipeline of projects that would cut across several sectors as a central feature of economic recovery.

However, not much progress has been made – and SEIFSA noted that much of the sector's growth could be attributed to company's own capital projects, rather than government investment in infrastructure. In fact, SEIFSA went as far as saying that the rollout of infrastructure spending to date had been "very slow to non-existent".


*Dr Azar Jammine, Econometrix Economist at the AfriSam Budget Breakdown event.*

**Game changer**

"So we have these wonderful plans but very little implementation," said Dr Jammine. "These numbers [announced by government] are so big that if we were to see their full implementation, it would be a game changer not only for the construction sector, but for the entire economy."

He said the result would be growth levels in capital investment of around 20 to 30% each year, rather than the 3 to 4% per annum that is being projected. This would spark massive job creation, and the economy would grow by 5 to 6% a year.

"According to SEIFSA, what has not worked well is the stop-start approach to infrastructural investment, which comes with 'big bang' orders that overwhelms local firms who are not prepared for the uptake," he explained. "The problem is that so much of the sector's capacity has been destroyed with the demise of leading construction companies. It would now take quite a while to start cranking up such an infrastructural growth period."

Commenting on Dr Jammine's presentation, Richard Tomes, Sales and Marketing Executive at AfriSam said: "Although the operating environment remains challenging, one of the positive elements AfriSam has noted is the increase in the infrastructure spend budget allocation, and we remain hopeful that the implementation of the infrastructure projects will gain momentum and start delivering true value for the construction industry."

A key aspect of the budget speech related to the energy crisis, and how government planned to deal with Eskom's future, he said. With the levels of loadshedding becoming worse over recent months, he questioned whether even the 0,9% growth projection for this year, and the 1,5% growth for the following year, is too positive if the energy crisis becomes worse.

"This would in turn affect government revenue and all its metrics – which then might not be as promising," he said.

**Embrace of private sector**

A critical step announced in the budget speech was the planned restructuring of Eskom debt. Once again, Dr Jammine raised a concern about whether this would be implemented, and whether it would signal a more enthusiastic embrace of the private sector.

"Will that debt restructuring be allowed to happen?" he asked. "Maybe it won't happen for another year because of opposition from within the ANC, but after that, necessity will force that to happen."

He suggested that 2024 could see a complete realignment of national politics, with political alliances being based on certain parties supporting private sector solutions to the country's problems, and others who continue to favour more government control.

**AfriSam SA Budget Breakdown Event**

About this annual event itself, Tomes remarked that AfriSam's purpose is to make valuable information available to the various stakeholders that interact with its business. "With many of us operating in the same industry, material matters such as the external environment we operate within not only relates to AfriSam but also to our stakeholders' businesses. We hope that the information shared at this event will not only provide stakeholders with insight about some of the decisions that AfriSam takes but will also provide them with valuable insights to enable decision-making in their own businesses or organisations to ensure their future success and sustainability. **CB**

*Contact: www.afrisam.com, Facebook: @AfriSamSA*
*Twitter: @AfriSam, LinkedIn: AfriSam*

# The susceptibility of selected Namibian aggregates to ASR

Philemon A. Arito (1), Petrina T. Johannes (1) and Martin T. Mulundu (1)
(1) Department of Civil and Environmental Engineering, University of Namibia

## ABSTRACT:

This paper investigates the potential alkali silica reactivity of selected Namibian aggregates from certified quarries in the following towns: Opuwo, Omakange, Tsumeb, Otjiwarongo, Walvis Bay and Windhoek. The susceptibility of the selected aggregates to alkali silica reaction (ASR) was investigated using laboratory-made cement-based mortar bar specimens cast according to ASTM C 1260 specifications. Six mortar mixes were used to cast the test specimens. Three replicate specimens were cast for each mortar mix. The concentration of reactive silica in the aggregates was determined using X-Ray Fluorescence (XRF). From the test results, it can be concluded that the susceptibility of the aggregates under investigation to ASR was minimal. All aggregates, except for those sourced from Windhoek, were non-reactive. Aggregates from Windhoek exhibited slow/mild potential to alkali silica reactivity. An increase in SiO2 content in aggregates resulted in a corresponding increase in the susceptibility to ASR and the percentage expansion.

**Keywords:** Alkali silica reaction, XRF, aggregates, mortar bar

## 1. INTRODUCTION

Alkali aggregate reaction (AAR) is a global problem that has been observed in many concrete structures. It was first reported by Stanton in the USA in 1938 and has been researched extensively since then [1–3]. AAR is an adverse chemical reaction between the alkali in concrete pore solution and the reactive compounds in aggregates. It can be classified into three broad categories depending on the nature of the aggregate involved in the process: alkali-silica reaction, alkali-silicate reaction and alkali-carbonate-rock reaction.

Alkali silica reaction (ASR) is the chemical reaction that occurs between the alkaline concrete pore solution and the metastable forms of silica found in aggregates such as volcanic glasses, cristobalite, tridymite and opal. It can also refer to the reaction between the concrete pore solution and aggregates containing or comprising cherts, chalcedony, microcrystalline quartz, cryptocrystalline quartz or strained quartz. It entails the formation of two types of gel products, namely a non-swelling calcium-alkali-silicate hydrate (C-N(K)-S-H) and a swelling gel alkali-silicate-hydrate (N(K)-S-H) [2–4]. ASR is deemed safe if only the non-swelling gel is formed and unsafe if both products are formed. For the swelling gel to form, four conditions ought to be met simultaneously: (i) a sufficient amount of alkali (generally believed to be higher than 0.6% in terms of sodium oxide equivalent) should be present in the concrete; (ii) a reactive form of silica in sufficient quantity (generally in the aggregates) is required; (iii) a source of soluble calcium (such as portlandite) to react with dissolved silica and form the deleterious gel; and (iv) a sufficient source of moisture is required. ASR will not occur if any of the four mentioned conditions fails to exist. ASR results from a series of reaction processes which occur sequentially, namely: the dissolution of metastable silica, the formation of non-colloidal silica sol, the gelation of the latter and the swelling of the gel [2, 3, 5, 6].

ASR is influenced by: aggregate type, content of reactive aggregate, porosity of aggregate, mineralogy of the reactive silica, diffusivity of the relevant ions, source and concentration of ions, the presence of a pozzolan, the quantity of free $Ca(OH)_2$ in the hydration process, aggregate size, the property of the reaction product and exposure conditions [2, 3, 5–9]. A detailed explanation on how each of these parameters influence ASR can be obtained from the cited literature. The expansive gel formed due to ASR induces tensile stresses in the concrete. These stresses result in cracks which would compromise the aesthetics, durability and structural integrity of the affected concrete structures. The negative effects of ASR have been countered in practice through the use of low-alkali cements (sodium oxide equivalent lower than 0.6%), chemical admixtures containing lithium and calcium nitrate, concrete moisture control, use of non-reactive aggregates and the partial replacement of cement with supplementary cementitious materials (SCMs) [1–4, 7, 8, 10–12].

Whereas extensive studies on the susceptibility of aggregates from various localities to ASR have been reported in literature [1–3]; research on the susceptibility of Namibian aggregates to ASR has not been reported. Consequently, many engineers and contractors in Namibia have continued to specify and use concrete without an in-depth knowledge on their susceptibility to ASR. Chatterji [7], Rashidi et al [13] and Mahomed [2] report that a proper understanding of the composition and behaviour of aggregates ought to inform the assessment of the susceptibility of an aggregate to ASR. Considering the lack of local research on the susceptibility of Namibian aggregates to ASR, this study sought to: (i) investigate the elemental composition of selected Namibian aggregates from six towns; and (ii) assess the potential reactivity of the selected aggregates to ASR using the accelerated mortar bar test as described in ASTM C 1260 [14]. The chemical composition of the aggregates was examined using X-Ray Fluorescence (XRF). The results from this study would inform the selection of suitable aggregate sources for use in the construction of concrete buildings and infrastructure in Namibia.

## 2. EXPERIMENTAL METHODOLOGY

The following materials were used to cast the mortar mixes for this study:

i. Cement: CEM I, 42.5 N (meeting ASTM C 150 requirements); percentage alkalis = 0.9521% Na2Oeq (Sourced from a local cement plant).
ii. Fine aggregates: passing through the 4.75 mm sieve and retained on the 150 µm sieve (sourced from different quarries across Namibia).

*Table 1: Mix design proportions per batch (aggregates with relative densities ≥ 2.45)*

| Material | Quantity | |
|---|---|---|
| | Relative density ≥ 2.45 | Relative density < 2.45 |
| Cement (g) | 440.0 | 440.0 |
| Water (ml) | 206.8 | 206.8 |
| Graded aggregate (g) | 990.0 | 440.0 |
| Water:cement (w/c) ratio | 0.47 | 0.47 |

iii. Sodium hydroxide (NaOH): concentration = 1.0 ± 0.01 N (Source: Biodynamics, Windhoek, Namibia).

Coarse aggregates samples were collected randomly from certified quarries that supply aggregates for use in construction in the following towns in Namibia: Opuwo, Omakange, Tsumeb, Otjiwarongo, Walvis Bay and Windhoek. The sampling was done according to Method MB1 of TMH5 [15]. The samples were labelled as S1 (Walvis Bay), S2 (Opuwo), S3 (Tsumeb), S4 (Otjiwarongo), S5 (Omakange) and S6 (Windhoek). The labelled samples were oven-dried, cooled, crushed and sieved according to ASTM C 33 [16], ASTM C 136 [17] and ASTM C 1260 [14] specifications. The portion of the graded fine aggregate that passed through the 4.75 mm sieve and was retained on the 150 µm sieve was separated for use in this study.

A 1 kg aggregate from each quarry was pulverised, packed in a plastic bag and sent to the Ministry of Mines and Energy in Windhoek for X-Ray Fluorescence (XRF) analysis. XRF was used to determine the elemental composition of each aggregate sample. The relative density of the graded aggregates from each source was determined using a pycnometer according to TMH1 Method B15 [18] specifications. The proportioning of the materials for casting the mortar mixes was determined. A mortar mix was cast from each aggregate source. The mass of each mix constituent was determined on the basis of the relative density (r.d) of each aggregate as presented in Table 1 The equations that were used to determine the aggregate proportions are presented in ASTM C 1260 [14] and Strack et al [6].

The constituents of each mortar mix were mass batched and mixed using a mixer, paddle and a mixing bowl. Mixing was done according to ASTM C 305 [19]. Three specimens were cast from each of the six mixes. 18 No. 25 x 25 x 285 mm mortar bar specimens were cast within 2 minutes and 15 seconds after mixing and placed in steel moulds in two approximately equal layers. Each layer was hand compacted with a tamper. The top surface of each specimen was levelled and smoothened with a trowel. The freshly cast specimens were marked then kept in a moist cabinet (temperature = 23 ± 2°C; relative humidity = 100%) for 24 ± 2 hours before demoulding. Figure 1 shows a freshly-cast mortar bar in a moist cabinet.

Specimens were removed from the cabinet and dried using a towel to a saturated surface dry (SSD) condition. A digital Vernier calliper was used to measure the initial length of each specimen immediately after its removal from the cabinet (Figure 2). Measurements were made to the nearest 0.002 mm. Utmost care was taken to prevent the loss of moisture in the specimens.

*Figure 1: A freshly-cast mortar bar in a moist cabinet.*

The accelerated mortar bar test – despite its limitations as presented in Chatterji [7], Kandasamy and Shehata [11], Rashidi et al [13], Mahomed [2] and Strack et al [6] - was used to test for the potential alkali silica reactivity of the aggregates in accordance with ASTM C 1260 [14]. The constraints of limited time for this research and the unavailability of equipment informed the adoption of this test method. The SSD mortar bar specimens were immersed fully in a storage container with potable tap water at a temperature of 23 ± 2°C. The container was then sealed and placed in an oven maintained at 80 ± 2°C for 24 hours. The hot mortar bar specimens were removed from the oven, one at a time, and their surfaces dried using a towel. A zero length reading was taken and recorded. Thereafter, the mortar bar specimens were immersed in a container with 1.0 N sodium hydroxide solution (NaOH) at 80 ± 2°C for 14 days. The change in length in each specimen was monitored throughout the 14 days of immersion in NaOH. Length measurements were taken at 1, 5, 7, 12 and 14 days after immersion in NaOH. The percentage expansion in each specimen was calculated as per the ASTM C 1260 [14] recommendations. The mean percentage expansion of each mortar mix was calculated from three test results.

## 3. RESULTS AND ANALYSIS

### 3.1 Elemental composition

The elemental composition of the aggregates under investigation were determined using XRF analysis. The XRF results are presented in Figure 3. From the XRF results it can be observed that silica content in the aggregates decreased in the following order: S6, S2, S1, S5, S3 and S4. Based on the geological map of Namibia [20], it can be inferred that the variations in silica content can be attributed to the mineralogy of the rocks from which the aggregates were sourced. The silica content is generally high in aggregate sources that contain quartzite and granite (e.g., S1 and S6).

### 3.2 Mortar bar test results

*The test results from the mortar bar test are presented in Figure 4. From Figure 4, it can be*

*Figure 2: length measurements using a digital Vernier calliper*

*observed that aggregates from Windhoek (S6) exhibited the largest percentage expansion while aggregates from Otjiwarongo (S4) exhibited the least percentage expansion after 14 days of immersion in 1.0 N sodium hydroxide (NaOH) solution. The percentage expansion in the other aggregates varied between these two values.*

The relationship between silica content and the percentage expansion after 14 days of immersion in NaOH solution in each aggregate is presented in Figure 5.

The percentage expansion in the aggregates after 14 days of immersion in 1 N NaOH is closely related to their silica content as shown in Figure 5. A juxtaposition of Figure 3 and Figure 5 reveals that very strong positive correlation - with a correlation coefficient of 0.9 - exists between silica content and the percentage expansion in the aggregates after 14 days of immersion in NaOH. Thus, it can be concluded that an increase in silica content will result in an increase in percentage expansion. The expansion in the aggregates was also observed to be closely related to the Ca/Si ratio. The reported observations are consistent with literature [2,3,5–7]. The percentage expansion was larger in aggregates with low Ca/Si ratio than in those with high Ca/Si ratio. Aggregates with a low Ca/Si produces a net negative charge in the C-S-H gel. This negative charge would absorb the cations in the pore solution which would consequently increase the percentage expansion and the susceptibility to ASR. Aggregates from Windhoek (S6) had the most silica content (90.1%) while those from Otjiwarongo (S4) had the least silica content (1.6%). All the aggregates under investigation, except for those from Windhoek, can be classified as 'innocuous' as per the ASTM C 1260 [14] specifications. The aggregates from Windhoek, however, are potentially reactive. Thus, their use in concrete ought to be carefully informed, especially in critical infrastructure such as dams where the susceptibility to ASR would result in disastrous consequences.

A strong positive correlation – with a correlation coefficient of 0.5 - exists between the silica content and the percentage expansion in the aggregates from 5 to 14 days. Thus, it can be inferred that an increase in silica content will result in an increase in the percentage expansion due to ASR. A negative correlation with a correlation coefficient of 0.6 exists between Ca/Si ratio and the expansion at 14 days. Similarly, a weak negative correlation coefficient exists between the Ca/Si ratio and the percentage expansion in the aggregates from 5 to 14 days. It can thus be inferred that

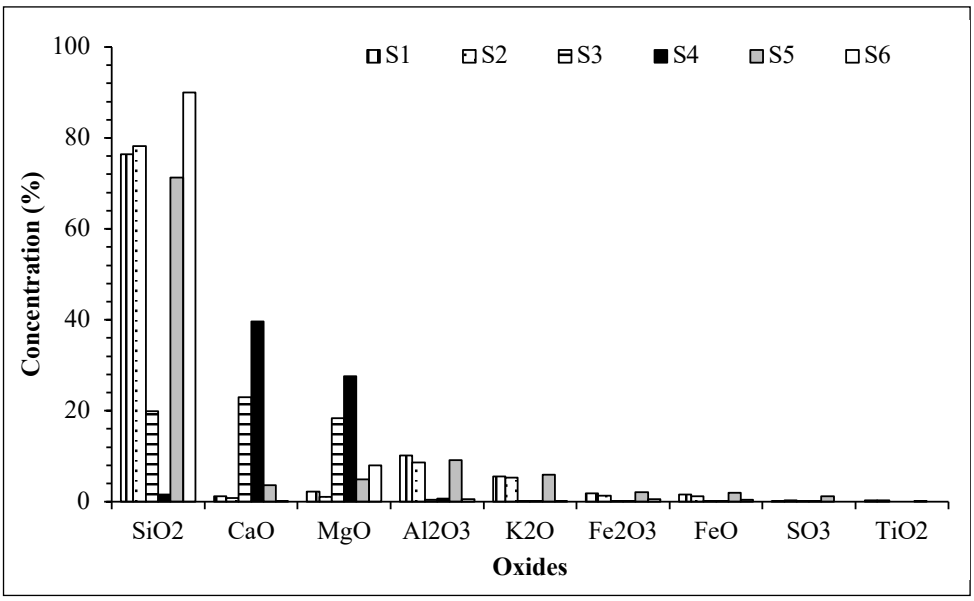


*Figure 3: Elemental composition of aggregates.*

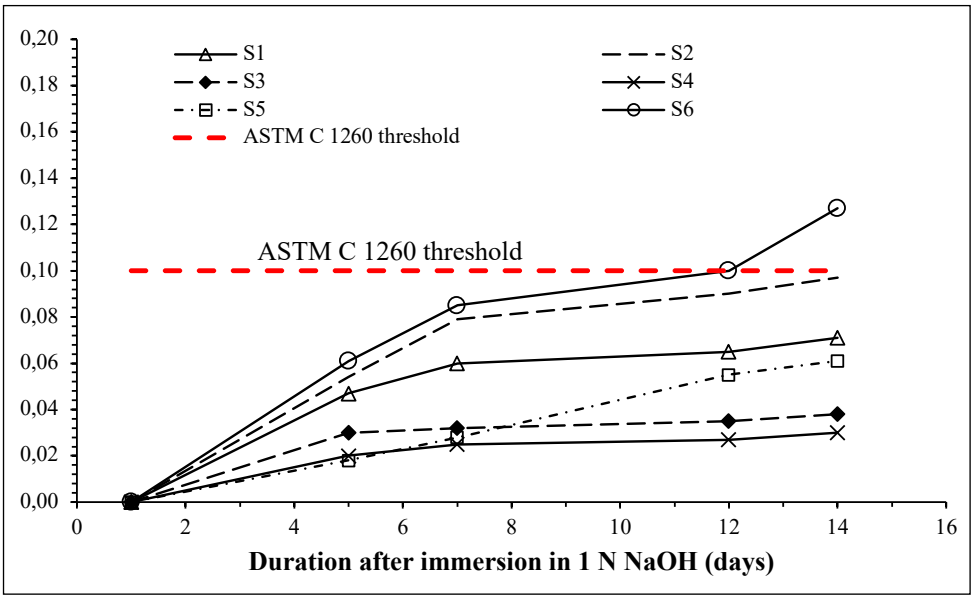


*Figure 4: Mortar bar results.*

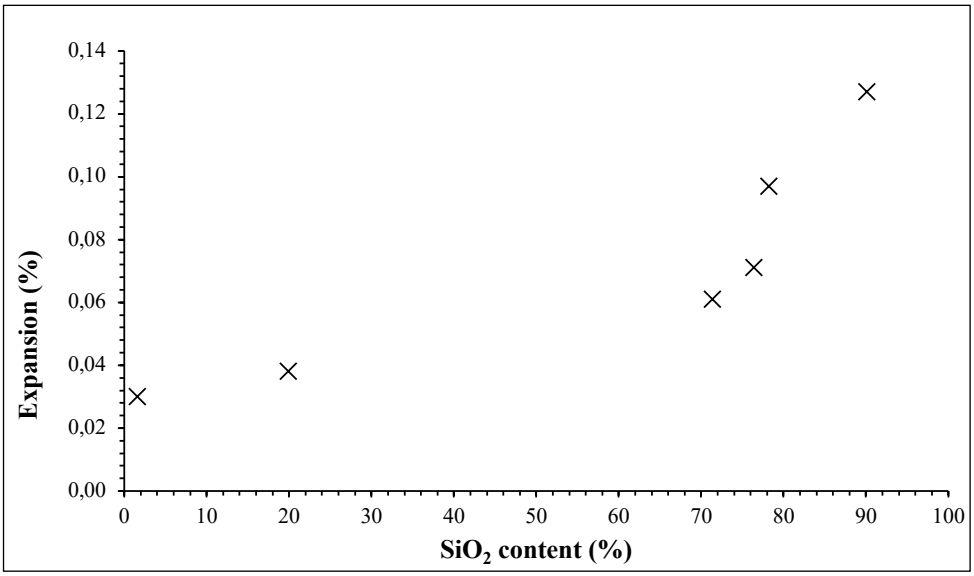


*Figure 5: Silica content versus percentage expansion after 14 days of immersion in NaOH*

a reduction in the Ca/Si ratio will increase the percentage expansion in the aggregates at 14 days and the percentage change in length from 5 to 14 days. Further studies, however, ought to be done to investigate this relationship in detail. Also, it can be observed that the high alkali content of the cement used in this study (i.e., 0.9521 Na2O eq) could contribute to the susceptibility to ASR; especially in instances where reactive or mildly reactive aggregates are used. Utmost caution ought to be observed while using this cement – especially in the construction of critical infrastructure such as dams which would be adversely affected by ASR.

## 4. CONCLUSIONS

The susceptibility of selected Namibian aggregates to ASR attack has been discussed. From the test results, the following conclusions can be made:

i. The silica content of Namibian aggregates varies widely depending on their geology.
ii. The susceptibility to ASR increases with an increase in silica content.
iii. The percentage expansion due to ASR increases with an increase in silica content.
iv. The susceptibility of the selected Namibian aggregates to ASR is generally low. All the aggregates under investigation, except for those from Windhoek, are non-reactive. Aggregates from Windhoek exhibited slow/mild potential of alkali silica reactivity.

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# The influence of steel fibre reinforcement on the ballistic resistance of concrete

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## ABSTRACT

This study involves research on the influence of steel fibre reinforcement on the ballistic resistance of concrete. Concrete panels were cast with varying thicknesses and fibre volumes and subjected to a kinetic energy related ballistic attack. A .30-'06 hunting rifle using specially loaded ammunition was used to simulate the kinetic energy of ballistic attacks performed by an AK-47. The failure mechanism has been identified to consist of the Crater and Crushed Aggregate regions which are dependent on the Compressive Strength of the concrete and the Scab region, which is dependent on the Tensile Strength of the concrete. The ballistic resistance of the concrete panels was determined by taking volumetric measurements of the failure regions. Ultrasonic Pulse Velocity tests were conducted to determine the crack formation and propagation caused by the ballistic attacks. By incorporating the use of steel fibres, the Compressive and Tensile Strength of the concrete panels were improved which led to an increase in ballistic resistance of the concrete panels as well as an increase in damage mitigation. It has also been found that an increase in the thickness of the concrete panels led to an increase in overall ballistic resistance of the concrete panels.

**Keywords:** Concrete Ballistics, Fibre Reinforcement, Impact Testing

## 1. INTRODUCTION

"Sweat saves blood" – Erwin Rommel.

Radicalized terrorist groups have become a problem as of late. These groups target the civilian population with mass shootings and explosives. It is therefore important to design and construct infrastructure to protect those who may be a target. Some countries experience a high crime rate consisting of criminal activities that includes gun related violence with drive-by shootings as an example. These activities influence the lives of innocent civilians and lives may be lost. It is thus important to find building materials that can withstand impact loading by absorbing energy without shattering under impact. Unreinforced concrete is normally deemed to be brittle, and it is known that steel fibres can be added to concrete mixtures to improve ductility and increase absorption before fracture [1].

There are existing standards for the development and standardization of ballistic protection, for both vehicles and body armour. NIJ [2], Alpineco [3] and NATO's STANAG [4] are but a few of the standards specifying the standardization of ballistic armouring, but none of them include the standardization, development and applications for the ballistic resistance of concrete. Although extensive research has been conducted on the impact resistance of concrete [1, 5-10, 12, 13], only limited design guidelines have been developed that can be used to design concrete exposed to high impact loading.

In this study, the effect of steel fibre reinforcement on the ballistic resistance of concrete was investigated. The study is of experimental nature. Research was conducted on the failure mechanism of concrete under high velocity impacts and the material properties that were sought after to increase the ballistic resistance of concrete, such as an increase of both compressive and tensile strengths. Experiments were set up and performed in order to determine any significant performance improvements of the concrete panels. The experiments were divided into two groups, the first comprised of a range of tests to determine the material properties of the concrete used to construct the panels and the second, to determine the ballistic performance and resistance of the concrete panels. The results were analysed, and various conclusions have been reached regarding the relationships between the material properties of the concrete and the ballistic resistance that the panels provided.

## 2. FAILURE MECHANISM OF CONCRETE UNDER HIGH VELOCITY IMPACTS

When a projectile traveling at a high velocity impacts a concrete target, it induces a longitudinal compressive wave. Depending on the thickness of the concrete, the compressive wave reflects back as a tensile wave once it hits the unconfined face at the back of the target. If the amplitude of this tensile wave exceeds the tensile strength of the concrete, it forms cracks in the concrete and propagate existing cracks [9].

The failure mechanism of concrete under high velocity impacts can be divided into three regions [9], as illustrated in Figure 1. The first region is the crater and crushed aggregate region. This region is dependent on the compressive strength of the concrete. Literature has shown that the crater is of conical shape and the volume of the crater is inversely proportional to the square root of the compressive strength [10]. The second region is the cracking region, which is dependent on the tensile strength of the concrete. The third region is the scab region. Scabbing is the loss of material at the back of the concrete target. This region is dependent on the tensile strength as well as the thickness of the concrete target. Due to the dependency of the scab region on the thickness of the concrete target, it may or may not occur. If the concrete target is of sufficient thickness, the longitudinal wave induced by the impact may dissipate and scabbing will not occur.

It is important to now clarify the definition of perforation. If the velocity of the projectile is such that it penetrates the target and the tip of the projectile protrudes from the back of the target, or the projectile leaves a hole such that light can shine through, the velocity of the projectile meets the U.S. Army's criterion for perforation [11]. If the velocity of the projectile enables it to pass through the target

but has no energy, the velocity of the projectile meets the U.S. Navy's criterion of perforation [11]. The use of the above-mentioned definitions for perforation depends solely on the practical application of the target. For the purpose of the study, the U.S. Army's criterion for perforation will be used.

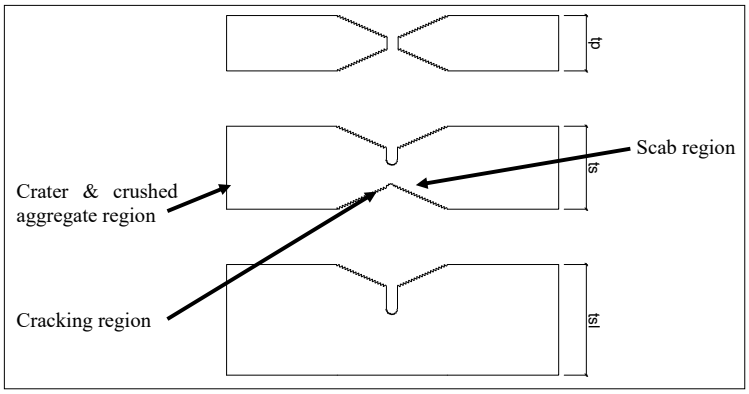


*Figure 1: Failure Mechanism of Concrete Under High Velocity Impacts [10]*

Various thickness definitions may be given to the concrete target, which consists of combinations of the three regions of the failure mechanisms as well as referring to perforation [12]. The Perforation Thickness ($t_p$) may be defined as the maximum thickness at which a projectile will perforate the target. All three failure regions are found in the Perforation Thickness, where the crater and scab regions may be directly linked together (given that the target is thin enough) or they may be connected via a "tunnel" caused by the penetration of the projectile. An increase in thickness leads to the Scabbing Thickness ($t_s$), which is the minimum thickness at which scabbing occurs without perforation taking place. An increase in thickness surpassing the Scabbing Thickness leads to the Scabbing Limit Thickness ($t_{SL}$). This is the minimum thickness of the target to prevent scabbing from occurring.

## 3. MIX DESIGN AND MATERIAL PROPERTIES

The mix design consisted of a CEM II 52.5N Portland Cement, Undensified Silica Fume, Fly Ash, Ground Granulated Blast Furnace Slag, Dolomite sand (< 4.5 mm), Dolomite stone (< 9.5 mm), Spring Steel Micro Fibres, Polypropylene Fibres and CHRYSO OPTIMA 100 Superplastisizer. A water-cement ratio of 0.4 was used. Spring Steel Micro Fibres with 2500 MPa tensile strength, 13 mm in length, 0.2 mm in diameter and aspect ratio of 65 were used. The amount of steel fibres varied for four different mixes. Mix 1, the control, had 0.0% fibres, whereas mixes 2, 3 and 4, contained 1.5%, 3.0% and 4.5% fibres respectively, with relation to volume. Polypropylene fibres were added to the mix to reduce the amount of initial shrinkage cracks that could propagate further during the ballistic testing. The mixing, casting and curing took place in the Civil Engineering Laboratory of the University of Pretoria. Table 1 contains the material properties of the various mix designs and Table 2 contain the respective standard deviations. The compressive strength as indicated in Table 1 is the average 28-day water cured strength obtained from three 100 mm cubes while the indirect tensile strength was obtained from four split cylinder tests conducted on 100 mm diameter cylinders. The direct tensile strength was taken from the average of 3 prisms in the shape of a "dog-bone" with a square cross-section of 50 mm sides. The "dog-bones" were pulled along the longitudinal axis until failure occurred. The direct tensile test also indicated that the failure mechanism of the fibres within the concrete matrix was of shear failure where the fibres pulled out of the matrix instead of fracturing. This was due to a weak bond-strength and indicated that the full tensile potential of the fibres was not utilised. The modulus of elasticity was determined by taking the average of measurements from two cylinders, 200 mm in length and 100 mm in diameter, cured for 28-days.

*Table 1: Summary of Material Properties*

| Fibre Percentage [%] | Compressive Strength [MPa] | Tensile Strength [MPa] | | Modulus of Elasticity [GPa] |
|---|---|---|---|---|
| | | Direct | Indirect | |
| **0.0** | 78.3 | 3.5 | 4.9 | 33 |
| **1.5** | 103.8 | 4.7 | 9.7 | 37 |
| **3.0** | 114.6 | 5.9 | 13 | 44 |
| **4.5** | 115.3 | 7.2 | 14 | 41 |

*Table 2: Standard deviations of Material Properties*

| Fibre Percentage [%] | Compressive Strength [MPa] | Tensile Strength [MPa] | | Modulus of Elasticity [GPa] |
|---|---|---|---|---|
| | | Direct | Indirect | |
| **0.0** | 4.22 | 0.40 | 0.34 | 0.71 |
| **1.5** | 6.56 | 0.56 | 0.17 | 0.62 |
| **3.0** | 5.55 | 0.32 | 0.88 | 1.05 |
| **4.5** | 2.79 | 0.39 | 0.49 | 1.60 |

## 4. BALLISTIC TESTING AND RESULTS

The ballistic testing was performed at the Bluegum Valley Shooting Range located near Bronkhorstspruit. It is an outdoor shooting range located within a plantation. The trees of the plantation as well as the embankments situated on the sides provide for excellent wind protection.

The targets were placed 20 m from the firing station and velocity measurements were taken at 10 m from the target. The method of exponential decay, shown in equation 1, was used to calculate the impact velocity of the projectile, assuming a constant drag coefficient, $C_d$, of 0.33 with $\upsilon_I$ as the impact velocity [m/s], $\upsilon_X$ the velocity at point of measurement [m/s], X as the distance from the target [m], $\rho_{air}$ the density of air at standard conditions (1.225 kg/m³), $m$ as the mass of the projectile [kg] and d as the projectile diameter [m]. The mean projectile mass was 9.23 g reaching an impact velocity of 780 m/s, producing 2 808 J of kinetic energy.

$$\upsilon_I = \upsilon_X * e^{\frac{-X*\rho_{air}*\pi*C_d*d^2}{8m}} \qquad \text{Equation (1)}$$

The firing station consisted of an elevated table and the rifle, a .30-'06 SAKO, was propped up with a special sandbag used for precision shooting. The rifle has a 1:12 twist rate. A Prochrone Chronometer was used for velocity measurements as shown in Figure 2 (a). A steel frame was constructed to hold the concrete panels in a fixed position. Pieces of threaded rod were used to screw the panels tightly in place. The threaded rods, however, did not screw directly to the concrete panels. Pieces of flat bar were used to distribute the forces evenly. The influence of the addition of steel fibre reinforcement with respect to the ballistic resistance of concrete panels is clearly illustrated in Figure 2 (b), (c). The unreinforced concrete panel was completely destroyed due to its brittle nature.

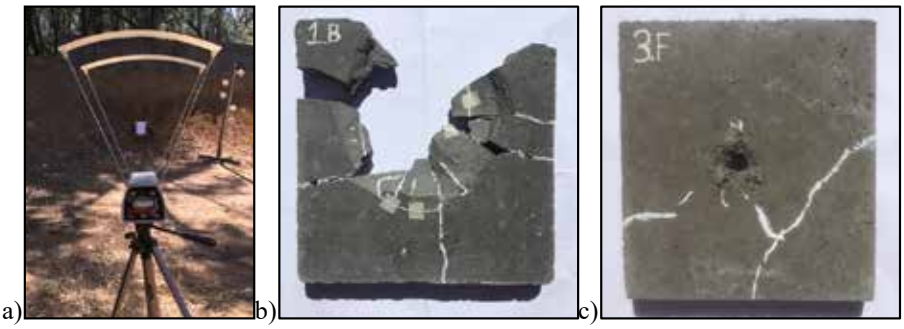


*Figure 2: a) Prochrono chronometer, b) unreinforced concrete panel, c) fibre reinforced concrete panel*

The following measurements were taken in order to gauge the ballistic performance of the fibre reinforced concrete panels: crater diameter and volume, perforation percentage and the Ultrasonic Pulse Velocity over the thickness of the panel both before and after being subjected to ballistic attack.

When examining the crater inflicted by the projectile, a general trend can be found. It can be seen in Figure 3 that for both the diameter and the volume of the crater, a decrease in size occurs with an increase in the percentage volume of steel fibres. It can also be seen from the same graphs in Figure 3, that with an increase in compressive strength, a decrease in crater diameter and volume occurs. This confirms that the crater and crushed aggregate region is indeed dependent on the compressive strength of the mix, as stated in the literature. When examining the crater diameter alone, it can be seen that the 50 mm panel experienced the least amount of damage. This is due to the 100% perforation that occurred for mixes 1 and 2 containing 0.0% and 1.5% volume steel fibres respectively, as can be seen in Figure 3. With 100% perforation, the projectile leaves the panel with residual velocity and therefore the panel has less kinetic energy to absorb. With mixes 3 and 4 containing 3.0% and 4.5% volume of fibres, an increase in compressive strength occurred. In conjunction with the increase of compressive strength, the increase of volume of fibres lead to the formation of a mesh that enabled the panel to capture the projectile, thus resulting in perforation percentages less than 100%.

When examining the 75 mm and 100 mm panels, both a decrease in crater diameter and volume occurred. This is due not only to the increase in both compressive strength and volume of fibres, but also due to the increase in thickness of the panels. An increase in the thickness leads to an increase in the energy absorption capability of the panels, due to the increased longitudinal wave dissipation that occurs.

Lastly, regarding the perforation percentage, panel thickness and compressive strength, it can be seen that for the thicker panels (75 mm and 100 mm) that neither the fibre percentage nor the compressive strength of the mixes have a significant effect on the perforation percentage. When concrete is subjected to high strain-rates, it experiences an increase of compressive strength [13]. This is caused by the combination of the lateral inertial confinement effect as well as material behaviour. This increase of compressive strength can be quantified by the Dynamic Increase Factor (DIF) and is dependent on aggregate properties and specimen size [13]. Therefore, an increase in specimen size will cause an increase in the DIF which results in a decrease in perforation percentage.

When examining the thinner panel (50 mm) in this regard it can be seen that a significant increase in compressive strength occurs with the addition of 1.5% volume fibres, but no decrease in perforation percentage occurs. When the volume of fibres was increased from 1.5% to 3.0%, a slight increase in compression strength occurred, but a significant reduction in the perforation percentage occurred. This suggests that the quasi-static compressive strength does not play a role in the perforation percentage of the concrete panels, but rather the volume of fibres present in the mix and the thickness of the panels. The explanation for this is the combination of the longitudinal wave dispersion that occurs as well as the mesh-formation that is provided from the fibres.

When considering the ultrasonic pulse velocity of the panels it can be seen from Figure 3 that after the ballistic attack, a general decrease in the difference in ultrasonic pulse velocity, ΔUPV, (from before being subjected to ballistic attacks) occurs with an increase in volume of fibres in the mixes. When examining the 75 mm and 100 mm panels, it can be noted that there is a slight increase in ΔUPV from 3.0% to 4.5% volume fibres. This is due to dispersion problems of the fibres within the matrix. Voids are formed within the matrix which increase the readings obtained from the ultrasonic pulse velocity tests. Furthermore, an increase in the modulus of elasticity occurs with the addition of fibres but tapers down from 3.0% to 4.5% volume fibres. This is due to dispersion problems of the fibres.

When observing the significant increase in modulus of elasticity that occurs with the fibre volume increase from 1.5% to 3.0%, it can be seen that the ΔUPV reading remains almost constant for the 100 mm panel and only decreases slightly for the 75 mm panel. This indicates that the modulus of elasticity is a weak indicator of the energy absorption capabilities of the concrete panels under high velocity ballistic attacks and that the volume of fibres yet again has the greatest effect. The ultrasonic pulse velocity readings of the 50 mm panels were neglected due to unreliable readings which was caused by the increase in damage experienced by the panels during the ballistic attacks.

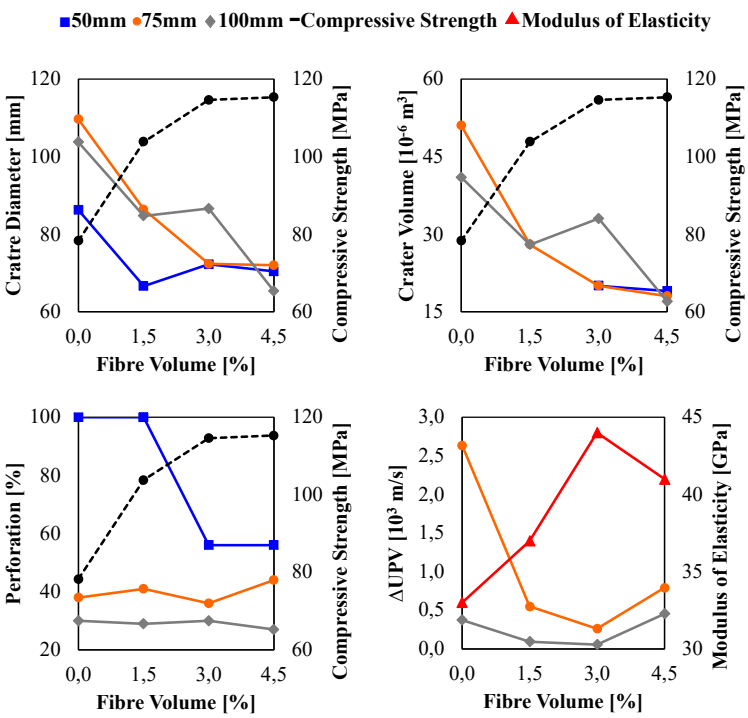


*Figure 3: Crater diameters and -volumes, perforation percentage and difference in ultrasonic pulse velocity for all panels whilst considering the compression strengths and modulus of elasticity of the mixes.*

## 5. CONCLUSIONS

It can be concluded that an increase in the volume of fibres in this specific concrete mix contributes to a positive influence on the material properties beneficial to the ballistic resistance of the concrete panels. An increase in the volume of fibres resulted in an increase in the compressive and tensile (both direct and indirect) strengths of the concrete mix. This led to a decrease in crater diameter and volume as well as penetration depth. It should be noted that a fibre volume saturation point was reached in the vicinity of 4.5% volume fibres. An increase in fibre volume past this saturation point will lead to a decrease in strength and ballistic resistance. An increase in the volume of fibres also contributed to an increase in damage mitigation of the concrete panels (i.e., crack formation and propagation), as can be seen from the results of the ultrasonic pulse velocity tests.

It was also found that the ballistic resistance of the concrete panels is dependent on the thickness of the panels. An increase in the thickness of the panels lead to better dissipation of the shockwave induced by the impact of the projectile. This increase of shockwave dissipation resulted in less damage occurring in terms of volume loss as well as in the formation and propagation of cracks in the concrete surrounding the point of impact.

It can be concluded that the crater diameter and volume are indeed dependent on the compressive strength of the concrete panels as suggested by the literature. The perforation percentage of thicker panels (75 mm and 100 mm) is solely dependent on the thickness of the panels and is not affected by the volume of fibre and compressive strength. The perforation percentage of thinner (50 mm) panels is dependent on the volume of fibres and not the compressive strength. Finally, the volume of fibres in the concrete panels have a greater contribution to energy absorption and damage mitigation than the modulus of elasticity. **CB**

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# The wonder of collosal Katse has not waned

by Jan de Beer

When the durability of concrete is discussed, the Colosseum in Rome tends to become a prime example. It's not surprising. The fact that so much of what was the biggest of the Romans' enormous amphitheatres is still intact - a staggering 1 942 years after it was built - is surely a decisive testament to the longevity of concrete.

If ever there is an example of iconic concrete right here in Southern Africa, it must surely be the colossal Katse Dam in Lesotho. This world-acclaimed spectacular structure is to many – more than a quarter of a century after its completion – still the finest showcase of the beauty, strength and durability of concrete yet built on the sub-continent, if not the entire Africa.

Katse is an awesome mega-reservoir that impresses even a new generation of blasé 21st Century engineers. Completed in 1997, the potential of the double-curvature dam at the heart of the Lesotho Highlands Water Project which generates massive volumes of hydroelectricity, was first identified back in the 1950s as a possible means to supplement the water supply of South Africa's industrial heartland in what was then known as the Witwatersrand. The World Bank subsequently arranged a treaty between the governments of South Africa and Lesotho, allowing the project to proceed. Construction started on Katse in 1991 on the Malibamatso River, a tributary of the Orange River.

Katse is not just another dam – its magnitude virtually transformed the appearance and status of the tiny country of Lesotho. The dam's flooded valleys extend for 45 kms and its wall is a staggering 185 m high – a high as a 50-storey skyscraper. This towering wall is over 700 metres long and when full, the 1 900-m deep dam can hold 2 billion cubic metres of water. It is the vital source of the Vaal Dam which, in turn, feeds Gauteng's infrastructure. The highest dam above sea level in Africa, Katse's water flows down from the "Roof of Africa" through enormous 4 m diameter concrete tunnels.

Building the dam was an incredible task which at the time almost defied belief.

Multi-ton trucks had to climb dozens of scary passes in the Maluti mountains daily to bring building materials from Ficksburg, 137 kms away. These huge trucks carrying tons of dry bulk cement had to climb up the winding and steep roads every 40 minutes - day and night. Top gear was never an option for the daring drivers. A staggering 687 000 tons of cement and fly-ash were hauled from Ficksburg by 26 trucks which drove over 7 million kilometres during the dam's six years of construction. The aggregate and fines used were crushed on site from the basalt rock.

Major critical components of concrete manufacture had to be duplicated, including the ice plant used for summer concrete curing and steam plant for winter, the batching plant (with dual computer systems), and the two cableway cranes used to deliver concrete day and night at a rate of 6 000 cubic metres per 20-hour shift.

At the end of the project, there was so much construction equipment on hand it took three years to auction it.

Looking out from the Visitors' Centre on a hill overlooking the dam wall, the sheer size and scope of Katse are overwhelming. The concrete wall way down below assumes Tower of Babel proportions even from so high above. The "teeth" in the huge spillway cast what seems like a monster's grinning shadow on the wall. It is by all accounts

*After Katse Dam was completed, a further dam at Mohale on the Matsoku River virtually doubled the Katse capacity. The 145-m high Mohale Dam – connected to Katse by a 30 m long tunnel – in 2005 won two CSSA Fulton Awards: Best Construction Engineering Project and Best Construction Technique. CSSA is now part of Cement & Concrete SA, the consolidated body established in 2021 to handle all matters relating to cement and concrete in South Africa.*

*Apart from its superb engineering attributes, Katse Dam's scenic lakes in the green mountains of Lesotho are a photographer's dream.*

*Water pictured spilling relatively gently into Katse's plunge pool. But when all the sluices are opened, the rising foam resembles Victoria Falls in full flood.*

unforgettable to see the diabolical deluge of water thundering through Katse's 10 overflow bays - each 16 metres wide - when all the sluices are opened. This seldom happens but the rising foam apparently rivals Victoria Falls and locals swear the earth moved – literally - when the dam was first filled.

Visitors to Katse Visitors' Centre are taken on tours through passages in the innards of the dam wall: the control rooms from where the emergency and control sluices are operated, the inspection and drainage galleries, and equipment for measuring stress and seepage in the dam wall. There's a bewildering array of hydraulics, dials, lights, and switches to see - and even more hidden from sight.

Take, for example, inverted and hanging pendulums in the curvature of the dam to monitor rotational foundation movement, and vibrating wire extensometers laced in the foundation rock to monitor the movement of pre-formed joints. Hundreds of vibrating wire meters to measure the three-directional movements of the joints in the structure and vibrating wire strain gauges monitor changes in the stress in the concrete. Vibrating wire piezometers measure the pore pressures in the foundation basalt and wire pressure transducers are in the pipework that feeds water to the pre-formed joint. Pairs of connected fluid-filled levelling vessels were installed in the lower part of the dam body to measure rotation over a long baseline. That's just a few of the awesome high-tech equipment that keeps the dam operational.

Katse is indeed amazing. So, it is not surprising that in 1998 it won the Concrete Society of Southern Africa's (CSSA) prestigious Fulton Award in the Civil Engineering Category for "the exemplary and excellent use of concrete in terms of structure and finish" achieved by the supervising engineers, Lesotho Highlands Consultants (LHC).

The dam's huge, scenic, and winding lakes set against the green mountains of Lesotho conjure up visions of the lochs of Scotland. It's a photographer's dream and it's easy to understand why the dam has become a major tourist attraction with spectacular walking tours and a variety of water- based activities including stunning sunset cruises on offer. There is even a botanical garden containing endemic vegetation nearby to visit.

For visitors, Katse Dam unforgettably reveals the power and creativity of concrete. As a reviewer on TripAdvisor posted: "When you see Katse's magnitude, it makes you feel so small...." **CB**

*Jan de Beer*

*Bongani Methula illustrating the use of a Schmidt hammer.*

# A look back into concrete testing history. Notes on the Schmidt hammer

## by John Roxburgh

It is with some amusement that I recently read technical tip 43 produced in 1975 by Dean Norton. For those of you that are enamoured with the Schmidt Hammer or may have an old one lying around, it gives a wonderful insight into its robustness, its intended use and the importance of keeping it clean.

### Technical Tip No. 43: NOTES ON (A) SCHMIDT HAMMER

Arising from a meeting with Ernst Schmidt the inventor of the Schmidt Hammer, the following points are of interest:

1. The spring of the hammer has never been known to weaken. Wear can take place on the seating which is slightly conical. If wear is apparent replace the rod.
2. The most likely cause of calibration curve change is dirt in the machine. Ernst Schmidt recommends very regular cleaning.
3. PCI/PE Schmidt Hammer had a calibration change recently and on opening up, it was found to be a dust problem.
4. It should never be necessary to buy a new hammer. Fancier shapes and carrying cases are made but Ernst Schmidt says he has no intention of changing the mechanism.
5. Calibration is best done on dry cubes. When asked how the calibration curve is drawn, Schmidt said that shots were taken, plotted and then a thick pencil used to draw in the best line. Those who favour a more statistically satisfying method have failed to realise what the hammer is all about.
6. The importance of regular cleaning cannot be over-emphasised. **CB**

# School of concrete technology planning several presentations of course with entrepreneurial potential

Cement & Concrete SA's School of Concrete Technology's "Making Concrete Bricks and Blocks", a relatively short training course with tremendous potential in starting small businesses producing affordable but essential building materials, will be offered regularly this year to help increase employment in South Africa.

*Matthews Magwaza*

Matthews Magwaza, lecturer at Cement & Concrete SA's School of Concrete Technology, says the half-day course, providing a basic understanding of how to manufacture masonry units that could become the cornerstone of a new business, will between March and the end of the year be offered six times in Midrand, as well as once in both Cape Town and Durban.

The Midrand dates are March 31, May 26, July 21, August 25, October 27, and December 1, with training also scheduled for Cape Town on August 4 and Durban on June 9.

Magwaza says the small-scale production of concrete bricks and blocks for masonry is ideal for small businesses. "Manufacturing can be carried outdoors, the process is simple, and the equipment required not exorbitantly expensive. Providing the economic feasibility of the venture has been fully and satisfactorily assessed, there are substantial opportunities for creating profitable small businesses with the training provided by the School."

The course curriculum includes:

- Requirements of masonry;
- How to strengthen masonry;
- How cement works;
- Blockmaking machines;
- Selection of materials and mix proportions;
- Curing of finished blocks;
- Storage of materials;
- Sand-cement mixes;
- Testing of masonry; and
- Building with masonry to control cracking.

For further information about the training course, contact Rennisha Sewnarain on email rennisha.sewnarain@cemcon-sa.org.za or phone 011 315 0300. A free publication on the subject can also be downloaded from the Cement & Concrete SA website www.cemcon-sa.org.za **CB**

# AfriSam empowers all to build homes (and dreams)

For people wanting to build their own homes over time, AfriSam has opened the door to more concrete possibilities. The company collaborated with its advertising and brand agency, Promise Group and leading architecture firm, BlackStudio, to produce its 'Plan (a)' campaign, an invaluable modular house plan. To ensure a wide reach, this has been published as a double page spread in community papers and is also available to download online at no cost to the consumer. The idea leverages AfriSam's vision to build a positive Africa future, empowering and inspiring homemakers to plan ahead when constructing their dream house.

In a creative collaboration that will undoubtedly change lives and an industry-first, construction materials leader AfriSam, with its advertising and brand agency, Promise Group, and leading architecture firm, BlackStudio, is inspiring modular, low cost homes that can grow as needed, foster lasting communities and create concrete opportunities.

AfriSam's 'Plan (a)' campaign helps people to build their own homes from an architect-approved plan. The modular design allows for the home to be expanded as needs change and financial resources allow. As part of its ongoing branding efforts, AfriSam has for many years provided practical guidance for customers on how best to use its cement and other construction materials. This has included Top Tips on working with cement and concrete, as well as Handy Guides on various aspects of building projects.

In the latest campaign, a carefully designed fit-for-purpose and architect-approved plan for a modular home is being published as a double page spread in popular community newspapers. The social significance of improved home design and quality is hard to over-estimate, according to architect Moremi Mowela, co-founder and architect at black-owned architectural practice BlackStudio – one of the collaboration partners in this initiative. He points out that many township areas are considered as transitory spaces by young people, and are still 'dormitory towns' serving the large cities.

"This leads to many people leaving townships as soon as they have the means, creating a drain on skills and capital," says Mowela. "This process can be reversed if those residential spaces can become aspirational, thereby playing a transformational role in shaping behaviour."

He argues that building a professionally designed home – by using AfriSam's flexible house plan – can be a crucial step in building attractive spaces. When people aspire to live and invest in these areas for the long term, he says, then thriving communities can be fostered.

The campaign concept was the brainchild of the Promise Group creative advertising agency. Nic Kostouros, integrated creative director at Promise, owed the concept's success to the way it addressed one of South Africa's burning social needs, supported by AfriSam's vision of building a positive African future.

"Credible research points to the importance of decent housing as an anchor – both financial and psychological – for people's progression as they seek a better life," says Kostouros. "With the backlog in housing provision around the country, many people are taking the initiative to build their own homes."

He highlights that many working people save diligently to initiate the building process, but that corners may be cut due to lack of knowledge or finances. By taking a broad view of what a first-time home builder needs to know, AfriSam's 'Plan (a)' campaign helps to improve project outputs while not necessarily adding to the upfront costs. The plan allows a home to be built in modules, starting off small and extending as families grow.

"The architect's plan adds value across a range of aspects from technical issues like foundation structures, to how the spatial design over time would accommodate changing family needs," he says. "There is a lot that can go wrong in a home building project, so our campaign helps readers to avoid these pitfalls. The ability to build according to a plan maximises the long-term fulfilment they can get from their hard-earned investment."

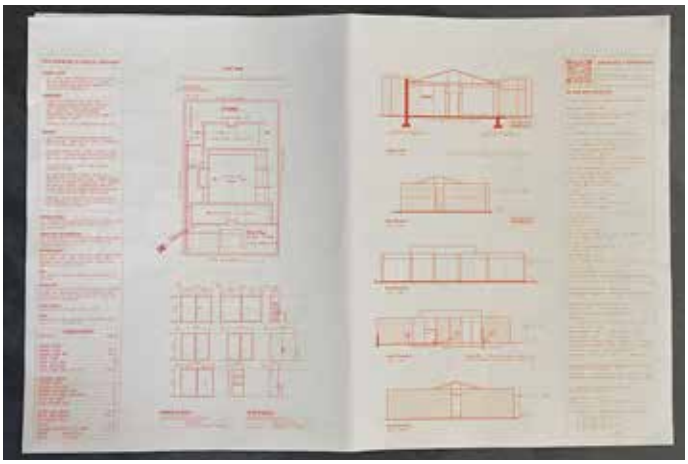
Bauba Maila, co-founder and architect at BlackStudio, notes that the company's experience with township clients has shown that a modular design was common, and stands were often similar in their sizes and orientation to the street.

"Working from these common elements allowed us to create a house plan that would be relevant to most people's conditions," says Maila. "What we finally achieved was a plan that has been designed and vetted by an architect, and a procedure for people to apply these ideas; this was previously out of their reach."

Group marketing manager at AfriSam, Ebeth van den Berg, adds that the sentiment behind the campaign was very much to 'pay it forward' for customers and the South African public.

"We look forward to developing this concept towards creating a hub for this kind of information," says van den Berg. "There is clearly a need for a highly credible platform where key segments of the housing market can be empowered with professional insights and tools."


*For people wanting to build their own homes over time, AfriSam has opened the door to more concrete possibilities.*

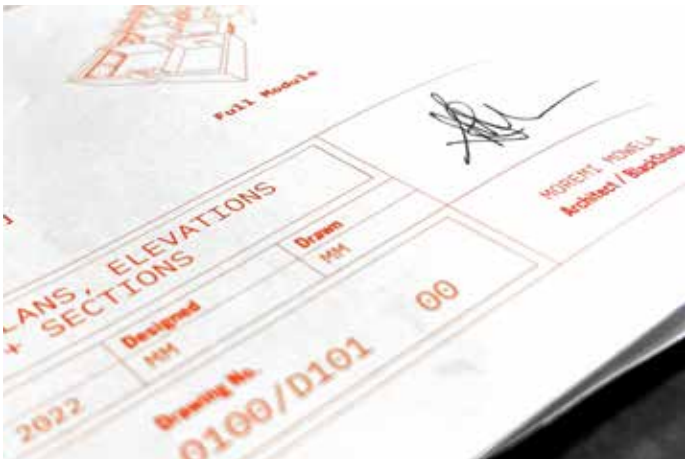


*AfriSam's 'Plan (a)' campaign helps people to build their own homes from an architect-approved plan.*


*To ensure a wide reach, this has been published as a double page spread in community papers and is also available to download online at no cost to the consumer.*


*A carefully designed fit-for-purpose and architect-approved plan for a modular home is being published as a double page spread in popular community newspapers.*

*Credible research points to the importance of decent housing as an anchor – both financial and psychological – for people's progression as they seek a better life.*




*The architect's plan adds value across a range of aspects from technical issues like foundation structures, to how the spatial design over time would accommodate changing family needs.*

From a creative perspective, the double-page advertisement containing the plan has already been recognised by peers in the media industry, says Kostouros. After launching in July, 'Plan (a)' was judged Ad of the Month by the Creative Circle – adjudicated by some of the sector's leading creative minds.

In addition, 'Plan (a)' scooped a coveted Gold Loerie at the recent 2022 Loerie Awards in the Print Category, as appreciation by the advertising and brand communication industry for this fresh and innovative campaign. **CB**

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# a.b.e. Launches wide range of waterproofing membranes especially developed for S.A. Market

a.b.e. Construction Chemicals has launched the abedex range, its own brand of torch-applied waterproofing membranes especially developed and formulated for the South African market.

a.b.e., which is this year celebrating the 90th anniversary of its founding, is part of Saint-Gobain Africa and the new abedex torch-on waterproofing membranes will be produced to a.b.e. specifications by Bituver Italy, which – with over 50 years of experience - is also a Saint-Gobain brand.

MD Rob Winter, says a.b.e. has extensive experience of the Southern African waterproofing market and its special requirements having distributed and established the Index range, also manufactured in Italy, in SA since the 1990s.

"From the beginning of this year, we will no longer be importing Index after a mutually-agreed separation. The Saint-Gobain Group has its own resources internally to supply torch-on membranes via its Bituver subsidiary and, based on our unequalled experience, technical

*a.b.e.'s torch-applied waterproofing membranes can only be applied by approved applicators.*

*Bituver Italy, like a.b.e. also part of the Saint-Gobain Group, is producing a.b.e.'s new abedex range of waterproofing membranes.*

*a.b.e.-approved waterproofing specialist, Sanika, completed this impressive Gauteng parking deck waterproofing using a.b.e. products.*

knowledge and specification of the South African waterproofing market, a.b.e. will now supply the market with its own brand of abedex membranes. The abedex products will still carry a.b.e.'s customary 10-year warranty and we will continue to offer site assistance, inspections and technical support as required."

Winter says the abedex polymer membranes are produced in Bituver's Chieti plant, under stringent quality control of the membrane mixes, their mutual compatibility, mechanical performances of the reinforcement, and the quality of the surface finishes. Bituver membranes have been CE-marked since September 2006 which means that the products conform with strict European health, safety, and environmental protection standards. Bituver, furthermore, produces "ECO" versions of its membranes, certified according to UNI EN ISO 14021: 2016 environmental standards. "With an exceptionally high content of recycled materials, the ECO versions are ideal when specifications call for sustainable design," Winter adds.

He says in formulating the new range, a.b.e. has developed an abedex waterproofing membrane for every possible site requirement which means that the abedex range of waterproofing membranes will be as wide-ranging as a.b.e. previously supplied.

The abedex range, used with bituprime, include:

* abedex unigum 4 mm and 4.5 kg mineral slate;
* abedex AR 4 mm (anti-root) and AT 4 mm (asphalt tolerant);
* abedex V-SR 4 mm (viscous single-reinforced) and F-SR (flexible single-reinforced); and
* abedex torch-on 4 mm and HM 4 mm (high movement).

abedex waterproofing membranes will add to the many widely applied and specified a.b.e. waterproofing systems that include brixeal, malthoid, super laycryl, duraflex, bituseal, super laykold, silvakote, hydroproof and abeproof.

Full details of the new abedex membranes and their technical specifications and drawings can be accessed through the company's website, www.abe.co.za. **CB**

*Contact: 011 306 9000*

# Quality shortcuts not good for future of construction

Prolonged pressure on contractors is leading to a 'buying down' trend in the readymix sector which could have long term consequences, according to construction materials specialist AfriSam. One indicator of this has been the growing use of lower-value 'brown material' – where traditionally the more competent 'blue material' or aggregate would be specified.

Weak economic conditions in construction have led contractors to find new ways of surviving, and some strategies could undermine the longevity of roads and buildings, says AfriSam Construction Materials Executive Avi Bhoora.

"On the aggregates side, we find that the call for 'brown' material – as opposed to the high-value 'blue' material like quartzite, tillite and dolomite – is rising," he says. "While some brown materials can be modified by additives, they cannot match the quality of competent rock."

In the past, G1 aggregate was the main base course for roads, with G2 as the sub-base, and G4 and G5 used for the selected layers. Bhoora says that recently there are efforts to substitute these, using products with names like G4A or G4A Special, for instance. Specifications are being adapted possibly because of cost pressure, but have not yet stood the test of time.

"During my 40 years in construction, I have been involved in projects building roads that have outlasted their expected 25 year lifespan by a decade or more," says Bhoora. "It is uncertain whether the new specifications will be as effective, especially with the much heavier loads on our roads today. My personal view is that going this route might be short sighted in the long run."

In terms of the readymix market, he says the average strength of concrete supplied has been gradually declining. AfriSam has long been known in the sector as a specialist in high strength products for demanding applications like high-rise buildings – with concrete strengths up to 100 MPa for high-rise projects.

*Avi Bhoora, AfriSam Construction Materials Executive.*

"There are fewer projects like this currently, but there are also signs of users 'buying down' when it comes to readymix," he says. "Whereas 35 MPa was the average strength we supplied until recently, that average is now closer to 28 MPa. This is concerning, as skimping on concrete strength is certain to have long term consequences for buildings' longevity."

He notes that there is still insufficient work entering the project pipeline throttling, holding back the potential of the construction sector to create jobs and build valuable infrastructure. Contractors and their supply chain remain under pressure, with low margins leading to the demise of amalgamation of important industry bodies. **CB**

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*With good quality materials, roads have outlasted their expected 25 year lifespan by a decade or more.*


*AfriSam has long been known as a specialist in high strength readymix products.*

# AfriSam champions the use of slag to reduce clinker factor

As part of its three-decade sustainability journey, AfriSam has over the years championed the use of extenders to reduce clinker content in its composite cements. Through its Vanderbijlpark, Gauteng-based slagment operation, the company has pioneered the use of blast furnace slag, a by-product of the steel industry, to promote more sustainable products in the market.

The use of extenders in AfriSam's composite cements has over the years resulted in a substantial reduction in its clinker factor without compromising the quality of products. Blast furnace slag, a by-product of the steel industry, remains central to the company's efforts to substitute clinker in its products.

Since 2008, the South African cement industry has seen a year-on-year reduction in emissions per ton of cement, largely driven by the increased focus on clinker substitution. According to the Association of Cementitious Material Producers (ACMP), clinker substitution rose from 12% in 1990 to 23% in 2000 and a substantial 41% in 2009. The industry is pressing for a 60% rise by 2030.

Over the years, AfriSam has accelerated its efforts to substitute clinker through the development of composite (extended) cements. In 2000, the company launched Project Green Cement to increase the use of extenders to promote more sustainable products. The use of extenders, says Hannes Meyer, executive cementitious at AfriSam, has resulted in a substantial 20% reduction in the company's clinker factor since 1990.

Composite cements, he explains, contain not only clinker, but other cementitious materials such as pulverised fly ash (PFA) from coal-fired power stations and ground granulated blast-furnace slag (GGBS) from steel-making plants.

GGBS has been used in the manufacture of cements since the second half of the 19th century. Back then, the practice was to intergrind the blast furnace slag with clinker. However, in the 1950s, AfriSam's slagment operation pioneered the use of separately ground slag for the construction industry.


*AfriSam's Slagment operation was established in 1955 had has supplied product to many flagship projects such as the Gariep Dam.*

The use of this product has grown steadily in South Africa, with AfriSam among the frontrunners. The company's slagment operation plays a crucial role in the production of its composite cements. Established in 1955, the plant was previously owned by three companies, before AfriSam acquired 100% shares in 2004. The raw material is sourced from steel producer, ArcelorMittal South Africa, which is strategically located some few metres away from the plant.

Blast furnace slag has good cementitious properties, providing enhanced strength and durability. By evolving its chemical and mechanical activation methods, AfriSam has achieved a more reactive product allowing the company to progressively replace more and more clinker while retaining high cementitious quality and strength performance.

"Re-using waste products from other industries reduces the amount of limestone that we have to mine and clinker that we have to produce, thus reducing carbon emissions from those processes, as well as minimising waste to landfill," says Meyer. "We are therefore constantly searching for new extenders and additives to further reduce our carbon footprint and our impact on the environment at large. The end result is less clinker produced per ton of each final product, resulting in less $CO_2$ generated from our operations." **CB**

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*Hannes Meyer, Cementitious Executive at AfriSam.*

*The company was the world's first construction materials supplier to carbon footprint all its production operations, including cement, aggregate and readymix.*

# ROOTS OF GREEN CONSTRUCTION

Aggregates are the foundation of every construction project and require the sourcing of legally compliant suppliers of sand and stone to be at the very heart of planning for green building developments.

While these materials make up the foundations of our buildings, they also form the bases of our roads, railways and infrastructure, as well as making up the largest component of concrete for all other aspects of construction. Rather than turning a blind eye to illegally mined materials, the construction industry should embrace true sustainability and find suppliers who are responsible and comply with legal requirements.

Letisha van den Berg, director of surface mining industry association, ASPASA, says the simplest way of sourcing these materials is to procure building materials from a mine or quarry that is already a member of ASPASA, which means they are fully compliant to undertake operations at their sites.

"We call upon green building practitioners to look at the bigger picture in terms of environmental, economic and social practices. Concrete suppliers should also prove that they procured their dry mix from a legal mining operation or its supply chain," she says.

Green building practitioners should have the ability to follow paper trails of all materials brought on to a site. It is important to remember that in most instances illegal operations will not provide proof of purchase and will avoid responsibility and accountability for environmental damage if found out.

When manufacturers, builders or concrete suppliers support illegal mining in an attempt to make money the blame should be shifted to those who support illegal work. As a result Aspasa strongly encourages green building practitioners and end users to request proof that they obtained building materials from legal operations. **CB**

# Coreslab joins global mission to promote excellence in precast-concrete technology

Coreslab, a leading South African precast-concrete specialist, recently participated in the eighth edition of CSG Engineering's Missione Tecnica in Italy. These technical missions are geared at imparting knowledge of best practice in precast-concrete technologies and promoting excellence in the field.

CSG Engineering always strives to ensure widespread participation in its technical missions, which attract representatives from leading prefabricators from all over the world.

Delegates of this year's event spent a week visiting state-of-the-art Italian prefabricators, considered to be among the world leaders in the design and application of precast-concrete technology. This provided an opportunity to learn more about how these companies organise their production cycles; automate their manufacturing processes; and integrate the various components of the precast concrete value chain using state-of-the-art technology. Moreover, delegates had an opportunity to learn about the latest cutting-edge technologies for the production of high-quality precast-concrete elements and witness their performance in the field.

As part of the mission, delegates were also shown innovative structures that have been built using precast-concrete technologies in the country. Specific focus was on showcasing the innovative use of architectural prefabricated concrete. The exceptional thermal performance and acoustic properties of precast-concrete technologies and the important role that they have to play in eco-sustainability were also a major motivation of these site visits.

CSG Engineering is a world leader in precast-concrete technologies. The company provides engineering and consultancy services to global prefabricators. This capability spans assisting companies with the optimal layout of new precast-concrete factories; construction management; through to the study of new building methods that involve the use of prefabrication technology and improving business performance of these operations. The company also provides design and structural, as well as project management services to precast-concrete companies. Moreover, CSG Engineering is the developer of state-of-the-art Building Information Management software that has been designed specifically for the unique needs of the precast-concrete industry.

Hennie Meyer, Managing Director of Coreslab, attended the technical mission on behalf of this leading South African precast-concrete specialist in October 2022.

"We visited the operations of Nuova TesiSystem, Cestaro Gustavo, Truzzi and Qeurzoli, as well as Itinera, a large Italian construction company that has built many precast-concrete structures. It was, therefore, a very informative mission, especially in terms of being able to compare our own processes to leading Italian manufacturers of precast-concrete technologies. These ranged from basic products, such as pipes, pavers and blocks, through to extremely sophisticated systems for large and complex property developments and civil-engineering infrastructure. It was very encouraging to note that as a country we do not lag far behind in terms of international best practice in the field. This is despite the preference for in-situ construction methods in South Africa, with the real potential of prefabrication yet to be harnessed in the country. In some areas, I believe that we are actually pacesetters in the field. A case in point is the extensive quality controls in our factories considering the lower skills levels of South Africa's labour versus that of more developed economies," Meyer says.

The technical mission also informed Coreslab's research and development (R&D) programmes. For example, delegates visited various precast-concrete warehouses in the country at a time when Coreslab is refining its very own solution for this application. Precast concrete provides a more durable method of constructing warehouses. They, therefore, require less maintenance, lowering total operating costs for owners of these assets. Warehouses can also be constructed faster with precast-concrete technology. Some of the facilities that Meyer visited were built using beams with spans of up to 36 m to reduce the number of columns inside the warehouse to free up space. The precast-concrete roof panels of these facilities are between 50 mm and 60 mm

*AfriSam's Slagment operation was established in 1955 had has supplied product to many flagship projects such as the Gariep Dam.*

thick. Meanwhile, the wall panels have an exceptionally high finish quality with exposed aggregates of different colours. Coreslab's R&D in the field is based on the company's stellar work manufacturing structural systems on behalf of Corestruc.

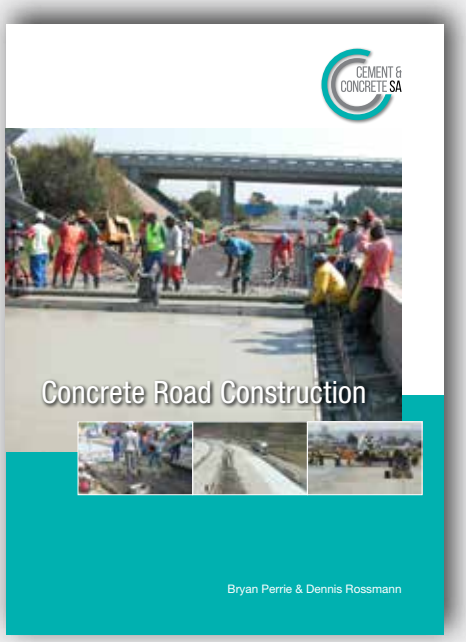
A case in point is the unique precast-concrete elements that Coreslab manufactured for a hotel that Corestruc built in Sibasa. A standout feature of the structure is its façade consisting of about 800 m2 of wall panelling and coping with a very high finish quality. Coreslab also manufactured the precast concrete elements that Corestruc used to expand a hotel at OR Tambo International Airport. Prefabrication provided a faster and less intrusive method of upgrading the hotel which had to remain operational throughout the project. Precast concrete technology also proved to be a better method of undertaking the upgrades in this heavily built-up area. Coreslab was also appointed by Corestruc to manufacture the structural precast-concrete systems that it used to expand a civic centre in Limpopo.

The delegates also visited Eucentre, which undertakes earth-quake and risk engineering. Meyer says that it was interesting to note that precast-concrete technology performed as well or even better than in-situ structures during earthquakes, demonstrating high elasticity and structural tolerance.

"I was particularly impressed with the ongoing R&D into the field of precast-concrete technology. At present, there seems to be no end in site in terms of the possibilities for precast-concrete technologies. I am proud that Coreslab is also at the forefront of this innovation and that this could be shared with the many other delegates who attended the technical mission," Meyer concludes. **CB**

*Contact: www.coreslab.co.za*

# CCSA Updates important manual on construction of concrete roads




Cement and Concrete SA (CCSA) has published a third and updated version of its highly respected manual, "Concrete Road Construction", authored by Bryan Perrie and Dennis Rossman, two of South Africa's leading authorities on concrete pavements.

Perrie is CEO of CCSA, and Rossman is a retired SA National Roads Agency (SANRAL) executive.

Originally published by a CCSA predecessor, the Cement & Concrete Institute, "Concrete Road Construction" has for the past 13 years proved invaluable to contractors and supervisory staff with the construction of concrete roads using the most modern slip-form paver or rudimentary equipment for low-volume township streets.

In the new edition, the revisions mainly deal with the new Committee of Transport Officials (COTO) Standard Specifications for Road and Bridge Works for South African Road Authorities, as well as updates on all standards and specifications applicable to suppliers of materials and services to national and provincial roads agencies, as well as metros and municipalities.

The new COTO Standard Specifications for Road and Bridge Works for South African Road Authorities were approved as a Draft Standard in October 2020 and have now officially replaced the 1998 Standard Specifications for Road and Bridge Works for State Road Authorities by the Committee of Land and Transport Officials (COLTO).

SANRAL in March 2021 already made the new COTO Standard Specifications mandatory for use in its procurement documents.

Among the important points covered by Perrie and Rossman in the updated CCSA publication are "Maintenance and Repair of Concrete Layers" for which the structure is now completely different to the old COLTO specifications in terms of both materials are construction techniques. The revised handbook will also familiarise practitioners with the new specifications and highlight significant changes between the old and new specifications and explain the new COTO regulations on maintenance and repair.

Hanlie Turner, Business Development Manager of CCSA, says the revised manual will be welcomed by all practitioners involved in road pavement design, investigation, construction and testing. "Included among these are road authorities, consulting engineers, compilers of procurement documentation, contractors, tendering and pricing departments, and road laboratories. Commercial suppliers of concrete and concrete materials will also gain knowledge of the new material specifications," Turner adds.

For more information and details on acquiring the publication, go to the CCSA website https://cemcon-sa.org.za/information-hub/books-for-sale/. CCSA members can order directly from info@cemcon-sa.org.za, or visit the Information Centre, Block D, Waterfall Park, Bekker Road, Midrand. **CB**

*Contact: www.cemcon-sa.org.za*

# Design service opens more doors to using fibre in concrete

**With the growing popularity and versatility of fibres in concrete, CHRYSO works with local fibre specialist Oxyfibre to offer customers a professional technical design service. This relates to custom applications of CHRYSO® Macro polypropylene fibres, which are considered as structural elements in construction. Oxyfibre's Izak Louw says this design offering ensures that contractors get the most from this innovative technology.**

The use of fibres in concrete goes back to Roman times, but modern fibre technology now offers contractors and end-users almost limitless possibilities, which can be brought to life by the specialised design service from CHRYSO Southern Africa and Oxyfibre.

Izak Louw, operations manager at Oxyfibre, explains that CHRYSO® Macro polypropylene fibres compete with the conventional steel mesh as a reinforcement for concrete. As such, these macrofibres are considered as structural elements, and must pass stringent tests to prove the strength and integrity of their physical properties.

"This creates the basis for us to offer a specialised engineering design service for the application of our macrofibres, not only for ground supported slabs but also for precast concrete," says Louw. "We use the customer's data on loadings, ground conditions and the kind of activities that will be carried out on the concrete surface – such as rolling loads and racking loads."

CHRYSO Southern Africa has been the official distributor for Oxyfibre since 2016, with the two firms having built a strong working relationship for many years before that. Oxyfibre makes available both microfibres and macrofibres supplied by Adfil Construction Fibres, who Oxyfibre represents in sub-Saharan Africa. ADFIL Construction Fibres bases its manufacturing facilities – as well as its research and development laboratory – in Belgium.

"Most of our customised fibre designs relate to civil engineering applications, such as roads and industrial slabs," he says. "However, we also provide the design service in smaller

*With CHRYSO's tailored design service, the company works closely with the customer to supply the required fibre calculations and technical specifications.*

*Fibres used in the concrete mix design for an ore stockyard hard stand at a mine in Rustenburg.*

contracts for driveways, residential homes and requirements on farms."

Working closely with CHRYSO, the Oxyfibre engineering team considers the customer's needs and provides feedback on aspects like fibre dosage, the size of saw-cuts on a slab and the optimal thickness of the concrete. A good example of the fibre design offering was for a building project where the contractor was looking for an innovative solution.

"The building had a large number of service conduits to be installed between the hollow core planks and the structural topping," he says. "It was clear that there would not be enough space to use conventional steel mesh reinforcement."

The contractor asked CHRYSO and Oxyfibre to find a solution that would allow space to install the service conduits and prevent cracking of the topping's surface. The use of macrofibres did the trick, also saving on the time and cost of placing steel mesh reinforcement. Moreover, the fibres could be added to the concrete mix at the readymix plant, so there was no need for the storage or mixing in of fibres on site.

*CHRYSO® Macro polypropylene fibres serve as an alternative to steel mesh reinforcement in concrete.*

"With our tailored design service, we work closely with the customer to supply the required calculations and technical specifications," he says. "We also produce a detailed commercial proposal that sets out the benefits of CHRYSO® Macro fibres; our service comes with professional indemnity.". **CB**

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# Iconic Msikaba bridge makes steady progress

**Construction of the Msikaba Bridge near Lusikisiki in the Eastern Cape – which started in earnest in late 2019 – is advancing steadily and the project should be complete in the last quarter of 2024. The cable-stayed bridge – which is described as "iconic" – is probably the most complex structure of its type ever to be built in South Africa and probably in Africa.**

Construction of the Msikaba Bridge near Lusikisiki in the Eastern Cape – which started in earnest in late 2019 – is advancing steadily and the project should be complete in the last quarter of 2024.

The Msikaba Bridge, which will span the 198-m deep Msikaba River gorge, forms part of the South African National Roads Agency Limited's (SANRAL) N2 Wild Coast project and is being constructed by the CME JV, a partnership between Concor and MECSA, both 100% black owned Grade 9CE South African construction companies.

The bridge's four huge anchor blocks are now at a very advanced stage of construction, over 50 % of the concrete for the bridge's two 127-m high pylons has been poured and the complex deck construction phase of the project is about to start.

The project is also maintaining its impeccable safety record. It recorded 3 million Lost Time Injury (LTI) Free hours on 21 October 2022, a major achievement given the challenges that construction presents, including working at both at extreme heights and at depths of up to 20 m in excavations.

Commenting on Msikaba, Concor's Laurence Savage, who is project director, says the cable-stayed bridge – which he describes as "iconic" – is probably the most complex structure of its type ever to be built in South Africa and probably in Africa.

"At 580 m in length, it will the longest cable-stayed bridge – in terms of main span – in Africa and it will have the second longest main span of any bridge on the continent. At 192 m above the floor of the gorge, it will also rank as one of the highest bridges in Africa, only exceeded by the Bloukrans Bridge at 216 m and, once it is completed, Mtentu at 223 m," he says.

The bridge is being built from both the north and south banks of the gorge and comprises two identical 'halves', each spanning 290 m, which will meet mid-point over the gorge. Each half is supported by 17 pairs of cables attached to 127 m high inverted Y-shaped concrete pylons, one on each side of the gorge. The pylons are back-stayed into the anchor blocks by 34 pairs of cables – 17 on either side of the gorge.

With the anchors blocks approaching completion and the legs of the pylons – which make up the first 20 m of the pylon structures – already complete, the focus of the project going forward will be on the construction of the circular pylon spires and the composite steel and concrete bridge deck.

*Preparation for the deck segments.*

*The steel fixing on the bifurcation lift progressing in October 2022.*

The spires taper from a diameter of 6 m at the point where they start (the top of the inclined legs) to 4.5 m at their full height. To construct them, the JV is utilising a custom designed, four-level, 15-m high climbing formwork system. The pylons are both expected to be fully complete in September 2023.

Construction of the bridge deck is an exercise which has to consider the significant wind loads that can sometimes occur at the site, where winds can gust up to 80 km/h.

The first 24 m of the deck on either side of the gorge is a reinforced concrete ladder deck that is cast into the first steel deck segment, known as deck segment zero - DS0. Because of crane access restrictions, DS0 will be slid laterally into place before reinforcement is installed and concreted. The remaining segments, DS1 through to DS17 on either side, will be installed using the free cantilevering method, with each segment being installed in sequence.

To place the deck segments in position, two gantries will be used, one on either side of the gorge. These are large 160-ton assemblies, each roughly the size of a tennis court in surface area. They will launch the deck segments – which have an average weight of 84 tonnes – out over the gorge and then rotate 90degrees, lower, align with and then connect them with the previous segments. Closure at the mid-point of the deck is expected to be achieved in Q2-2024.

An interesting aspect of the project is the close ties that have been forged by the CME JV with local communities. "We have worked very hard – and at considerable cost – to ensure that the project has the full support of surrounding communities and that the benefits stemming from construction are localised to the greatest extent possible," says Savage.

Not only has the CME JV recruited about 70 % of its workforce locally – all of whom have been subjected to intensive on-site training – but it has also identified and supported a host of local SMMEs, around 40 in all, who have been appointed as sub-contractors and suppliers. **CB**

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*The South pylon structure with formwork and steel fixing activities for spire lift in November 2022.*

*The South area preparing for the arrival of the deck segment in November 2022.*

# Surface miners get energetic new leader

New ASPASA director, Letisha van den Berg, will be living her dream since she took the helm of the association in January bringing a positive new dynamic to the well-established and respected surface mining organisation.

She recalls a conversation several years ago when she startled Collin Ramukhubathi, who had been interviewing her for a position at Afrimat, revealing that her ambition was to head up ASPASA one day. As an up-and-coming multi-skilled manager that was evidently not the answer her soon-to-be colleague and mentor had expected.

Now, having fulfilled most of her ambitions in various roles, including various managerial safety roles within some of the smallest and medium mines locally, she could not turn down the opportunity to apply when her name was put forward as a possible candidate by her peers. And her successful application is penned in history.

## Fighting fit

It would be hard to ignore the passion for ASPASA that exists within Letisha. Since her first interaction with the then newly established association in 1998, she has attended hundreds of meetings and workshops along the way and become known for her in-depth knowledge of everything surface mining as well as no-nonsense approach to issues that affect the industry.

Those who have misjudged her petite stature and friendly smile when dealing with controversial topics or challenges to the sustainability of the industry have done so at their own peril. Letisha is a fighter when she needs to but is otherwise known as a keen strategist, hard worker, industrious leader and a fair and uncomplicated character.

These traits will surely be displayed when she takes on the new role and gets to grips with all the opportunities and threats the industry is facing and will face in years to come.

## Solid foundation

"I plan to build from the strong base that was laid before me. We will assess where we stand in terms of our members and how we can add more value and broaden our appeal to the surface mining market including smaller role players.

*Letisha van den Berg of ASPASA*

"Having started my career on a small mine I understand the challenges and how difficult it is to reach compliance with limited resources and being measured with the same legislation and processes. We need to find the small non ASPASA members and get them onboard. Cost is also a factor for these mines and we will relook at the levy model so that we can make it affordable at all levels.

"Lobbying on behalf of the industry and ensuring we always compete on a level playing field still remains a priority. We will intensify our efforts in dealing with issues like illegal mining, technicalities regarding the payment of Royalties and other issues. Importantly, we want to ensure that legislation is written specifically for our mines rather than the current one size fits all approach as this has a direct impact on members abilities to comply.

## Team work

"To do this ASPASA will work closely with state, tripartite structures nationally and regionally to make our voice heard. I also plan to work more closely with related industry bodies such as the Institute of Quarrying, Minerals Council, construction industry bodies and others.

"Once we have reviewed our services and communications we will also look at regions including the tripartite forum of the Mine Health and Safety Council. There will be more collaboration with members including roadshows and visits - I like getting my boots dirty.," Letisha smiles.

"Developing SMME's and bringing up-and-coming youngsters will also be a focus. Plans are already being developed to package compliance and quality documents that will assist SMME's to meet requirements. Simultaneously, the development of the next generation of surface miners is being planned with learnerships already being investigated and planned for the near future."

## Challenging times

She continues that there are many challenges that still need to be met and many opportunities that need to be covered and made available to ASPASA members. The safety of women in mining, one size fits all mines legislation and the tough economy spring to mind, as well as opportunities that exist in working with Government and industry to unlock upcoming construction contracts.

"I am bringing in a lot of energy and want to incorporate the expertise of every generation into our organisation to share information and build knowledge for the future. With the interaction of all role-players in the association we will grow from strength-to-strength." **CB**

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ASPASA

# Parks boulevard building marks 7-up for Concor at Oxford Parks

Concor continues to notch up successes at the Oxford Parks precinct, where it has been making rapid progress on 5 Parks Boulevard since July. This is the seventh building that the company will have built in this popular mixed-use development, and is being constructed to a high Green Star rating. Contributing to this rating will be environmentally responsible bulk concrete with a low $CO_2$ footprint supplied by AfriSam.

After beginning construction this July, Concor is well on track to soon top out another elegant office block in the Oxford Parks precinct – with environmentally responsible readymix with a low CO2 footprint from AfriSam.

The modern 5 Parks Boulevard building is one of Intraprop's latest projects in this fast-growing mixed-use development in Rosebank, Johannesburg. Such has been Concor's success at Oxford Parks that the building is its seventh contract there.

"Like our previous Oxford Parks projects, this building is designed to achieve a high Green Star rating by the Green Buildings Council South Africa (GBCSA)," says Martin Muller, contract manager at Concor.

The office block will comprise four basement levels and five office levels, offering about 7,300 square metres of gross leasable area (GLA). The design includes a triple-volume atrium in the reception area to make the most of natural light and reduce energy. This feature extends from the ground floor through to the second floor. Further utilising the natural light is a double-volume area on the third and fourth floors.

"The structure is based on conventional reinforced concrete slabs from the basements to the roof, with a lift core to accommodate three lifts down to the lowest basement," says Muller. "As the bulk concrete supplier, AfriSam is providing between 150 m3 and 250 m3 of readymix concrete for each slab."

He highlights that, as a Green Star rated building, the concrete mix designs are required to reduce the overall CO2 footprint of the structure. This has been achieved by using more fly ash in the mixes, thereby reducing cement levels by 30%. He notes that the quality and

*One tower crane facilitates the quick pace of construction.*

*The office block will comprise of four basement levels and five office levels.*

consistency of AfriSam's mixes have allowed Concor to reduce the cycle time of each slab pour from the normal 11 days to nine or 10 days.

"On a fast track project like this one, this enables us to speed up our cycle times as we can de-stress the slab and recycle formwork to the next level more quickly," he says. "This will help us to top out the structure before the builders have their Christmas break this December."

Quality assurance on the concrete is done both by AfriSam and Concor. After every concrete slab pour, concrete cubes are cast – then are crushed to test their strength after seven days, 14 days and 28 days. While 25 MPa strength concrete is used for the slabs, higher strengths from 35 MPa to 60 MPa are used for the columns and verticals.

The anchor tenant plans to occupy the third and fourth levels of 5 Parks Boulevard, and the schedule will see them take beneficial occupation in February 2023 to fit out the new building. **CB**

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# Study on resource preservation in cement and concrete production

Alongside climate and species protection, the preservation of natural resources is one of the major ecological challenges of our times. The production of cement and concrete is an area of particular relevance in this respect, accounting for roughly one fifth of the primary raw materials used in Germany. "We are well aware of the enormous demand arising from our industry and are prepared to take responsibility for an even more careful use of natural resources", explains Christian Knell, President of the German Cement Works Association (VDZ). The new VDZ study "Resources of the future for cement and concrete – Potential and action strategies" describes a possible 2050 scenario aimed at further reducing primary raw material utilisation.

Resource preservation is by no means uncharted territory for the German cement and concrete industry. Depending on their availability, the various by-products and recycled materials already employed today enable more than 10 million tonnes of primary raw materials to be saved each year. "Blast furnace slag from ironmaking and fly ash from coal-fired power gen-eration in particular play a major role", explains VDZ General Manager Dr Martin Schneider. "In the light of the ongoing process of decarbonisation in the industrial sector, these two materials will however no longer be available in the future, or only to a far lesser extent. We are therefore going to need alternatives".

On the basis of an ambitious scenario, the study illustrates the amounts of natural resources which could be saved along the cement and concrete value chain by the year 2050 under certain conditions. It would accordingly be possible to employ 41 % fewer mineral primary raw materials such as limestone, gravel and natural stone. One key to achieving this goal is the use of recycled materials obtained from the dismantling of building structures and the concrete contained in these. The fine crushed sands occurring in the material treatment process could be utilised in the production of clinker and cement. The coarser constituents can be re-used as recycled aggregates in concrete production.

In the scenario under consideration this aspect also offers the greatest potential for preserving natural resources along the cement and concrete value chain.

The study sets out a number of central areas of action as prerequisites for resource-saving concrete construction. For example, there is a need for sustainable material flow manage-ment to permit the systematic recording of materials used in buildings and the return of these to the cycle. An effective combination of political instruments is also essential to pro-mote both a continuous supply of recycled building materials and the demand for resource-saving construction work. "Alongside the technical and political framework, the decisive fac-tor will be a joint, concerted approach to these issues along the entire construction value chain. This is the only way to create mutual understanding for the particular challenges and opportunities associated with resource preservation", stresses Martin Schneider. The secur-ing of domestic primary raw materials is a further important area of action, not least because even with an ambitious circular economy, natural resources will continue to make up the largest part of the raw materials required for cement and concrete.

Christian Knell is confident that the industry will succeed in making a significant contribution to both resource preservation and climate protection in the years ahead. "Both goals go hand in hand. Cutting our use of materials will also enable us to reduce CO2 emissions ac-cordingly", says the VDZ President. Furthermore, efforts under the auspices of VDZ are providing great impetus for progress in both areas, as Martin Schneider also points out: "We and the rest of the industry are fully committed to fulfilling our responsibility for resource preservation. The many research projects conducted by VDZ can make an important contri-bution in this respect". **CB**

An executive summary of the new VDZ study in English is available for download at:
***https://www.vdz-online.de/en/cement-industry/raw-materials-and-biodiversity***

The full VDZ study "Resources of the future for cement and concrete – Potential and action strategies" (in German) is available for download at:
***https://www.vdz-online.de/ressourcenschonung***

*ABOUT VDZ:*
*VDZ was founded in 1877 as the German Cement Manufacturers' Association. In our capacity as a joint organisation of the German cement manufacturers, we have been actively promoting environmentally compatible cement production and high-quality concrete construction for more than 145 years. As a centre of research and expertise in the field of cement, concrete and environmental protection, VDZ has acquired a worldwide reputation and respect for its practical research work and comprehensive range of services throughout the entire value chain.*

# Chryso gets best results from concrete at Gauteng Reservoir

**Construction has been completed on a 210 Mℓ reservoir in Gauteng where good use was made of CHRYSO's innovative additives to ensure the best concrete results. CHRYSO Southern Africa assisted the contractors to achieve good concrete consistency, reduced water content and minimal shrinkage. Its leading admixtures also helped reduce the permeability of the concrete in the floor, walls and columns.**

There was no room for error in the construction of an extremely large cylindrical post-tensioned concrete reservoir in Gauteng– with CHRYSO Southern Africa ensuring optimal concrete performance.

Completed at the end of 2022, the reservoir will hold over 210 Mℓ of potable water and is a key part of the Gauteng Department of Water & Sanitation's service delivery improvements.

The scale of the concrete works on this reservoir project has been impressive, indicated by the 1,800 m3 floor slab layer of 200 mm thickness. This required the 35 MPa concrete to be pumped in 13 sequenced pours of between 250 m3 and 360 m3 each. The reservoir's internal diameter of 154 m is roughly the length of one and a half football fields. Inside are 272 round reinforced 35 MPa concrete columns, 600 mm in diameter, to support the roof slab. The outer concrete walls are almost 12 m high, reaching about three storeys. They taper from 1,1 m at the base to 300 mm at the top, and comprise post-tensioned 45 MPa concrete.

Included in the construction was a permeable groundwater drainage system comprising three layers of 15 MPa no-fines concrete. The first layer comprised 8,000 m3 of no-fines concrete with a 50 mm thick layer of 9,5 mm stone mix. This was followed by a 245 mm layer of 19 mm stone mix, and then a 125 mm layer of 26 mm size stone mix.

When a good consistency could not initially be achieved with these challenging mixes, CHRYSO® Easydrain was introduced. By adding 140 g of this additive to each cubic metre of concrete, the issue was solved. CHRYSO® Easydrain mechanically and hydraulically binds the aggregates with a uniform cement paste coating. Once dried, the bonded aggregates will not loosen. The additive also fluidises the concrete, which assists with a homogeneous mix and improves curing to reduce the chances of cracking.

In all its concrete mix designs, the project has made use of CHRYSO® Plast Omega 178, a high-performance water reducing plasticiser. This reduces the water content of each mix to 175 ℓ per cubic metre while

*The reservoir will store 213.4 million litres of potable water.*

ensuring workability and strength. This admixture also increases the slump – or flow – without affecting the water content of the mix.

All concrete in the reservoir's floor slab, wall footing and roof slab was augmented with CHRYSO® Serenis shrinkage inhibitor – to reduce shrinkage of the concrete. CHRYSO® CWA 10 crystalline integral waterproofing agent is also used to reduce the permeability of the concrete in the floor, walls and columns. When moisture is present, this agent creates a reaction – creating long narrow crystals that fill and plug the pores, capillaries and hairline cracks of the concrete mass. These crystals prevent water penetration into the concrete, protecting the concrete and reinforcement against corrosive groundwater and chemicals. **CB**

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*The largest cylindrical post-tensioned concrete reservoir in the country.*

*5 mm plaster layer above 145 mm no-fines concrete groundwater drainage layer.*

*The post-tensioned outer concrete walls are almost three storeys high.*

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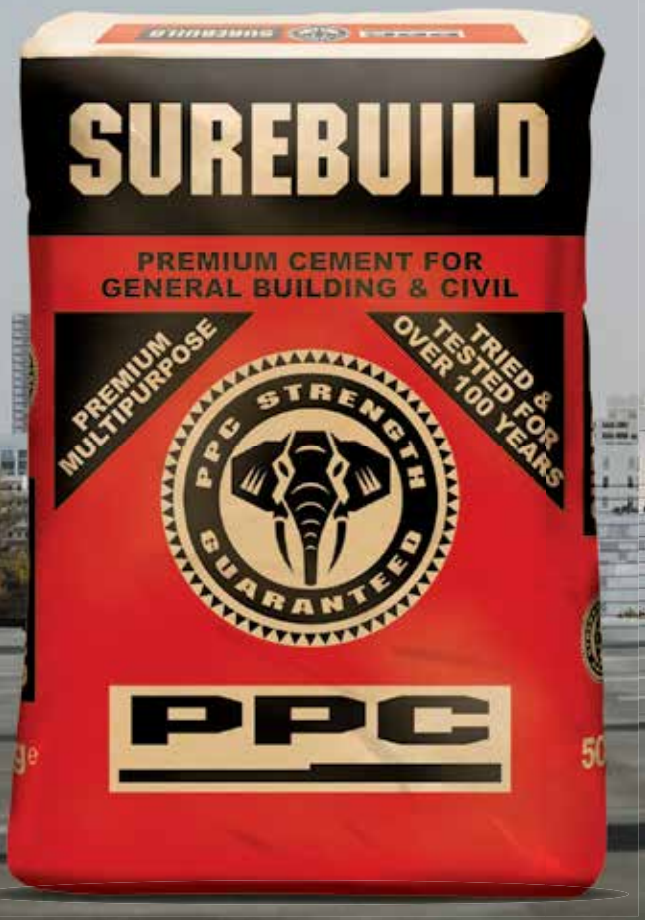



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