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CONCRETE SOCIETY
OF SOUTHERN AFRICA

CONCRETEBETON



Hybrid concrete used at Sasol Shondoni Colliery
Suppressing Alkali-Silica expansion
Economic evaluation of SCC versus normal concrete

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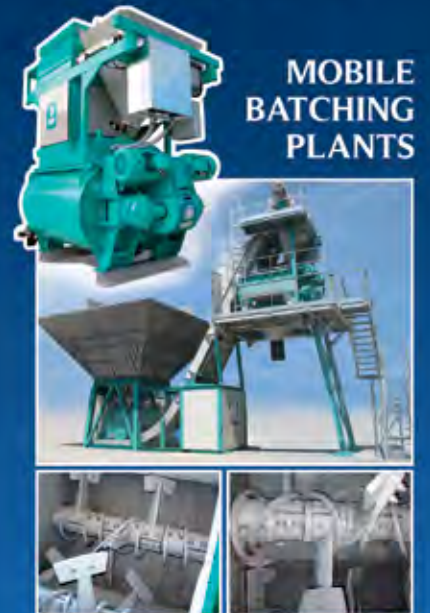
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COVER: The coal bunkers at Shondoni Colliery are an excellent example of "hybrid" or "composite" reinforced concrete structures as the benefits of precast are combined with in-situ concrete. The number of precast elements was reduced in the design to reduce the number of costly moulds and the design of an innovative precast sleeper foundation for the conveyor resulted in increased efficiencies in the precast yard. The design used resulted in significantly less scaffolding at working at height during construction. The quality of both the precast and in-situ concrete were of a very high standard and these massive structures were worthy of a judges' commendation in both the Civil Engineering and Innovation in Concrete Categories.

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If we worked together
as one industry, some
synergy would be
enjoyed by all

Concrete bodies seek synergy

Just over three years ago, through an article I wrote in the SAICE publication 'Civil Engineering', I appealed to other concrete-related associations to work together with the Concrete Society to take up the challenge of finding a long-term solution to the lack of consolidation and cooperation between the different bodies.

Some form of consolidation of organisations in our field is thought by many stakeholders to be a sensible direction to go, but with all the different member-bases, structures and funding mechanisms, it is not an easy task to arrive at a workable solution. Thus, not much progress has been made.

Each organization, in a relatively small market, is still competing for members, sponsorship, advertising, support at events, audiences, etc., and this cannot be sustained in the long-term, nor does it make sense for stakeholders, particularly sponsors.

Sometimes small steps taken are better than one giant leap, and so it is with the Southern Africa Readymix Association, the Concrete Society of Southern Africa, The Concrete Institute, the Southern Africa Readymix Association, the Aggregate and Sand Producers Association and the Concrete Manufacturers Association, who are currently discussing ways in which they could all work together to reduce duplication of services and encourage more judicious use of funds, etc.

Education and training, publications, awards, research and standards development are just a few of the activities where, if we worked together as one industry, some synergy would be enjoyed by all.

Industry Vacancies Notice Board

The Society launched this initiative last year, but despite some initial interest being shown, very little use is being made of it. In view of the relatively slow activity in the industry, it was perhaps not a good time to introduce such a facility for companies to advertise for new or replacement staff.

However, the free-of-charge service is there, and I appeal to any member company that is seeking to fill positions at this time, to make use of the Notice Board, access to which is through our website. A user name and password will need to be issued to a company (unless an individual member uses it, in which case their existing access codes apply), before access can be made.

The site is intended for listing of vacancies by employers within the cement, concrete and related industries. The CSSA will not facilitate any contact between employers and candidates, and will not enter into any correspondence or discussion regarding listings. Try this as your first step in recruitment before you get involved in hefty placement fees.

Enjoy this edition of Concrete Beton and, as always, input and suggestions to improve your reading enjoyment are always welcome.

For the love (and growth) of concrete!

John Sheath

Editor

CEO, Concrete Society of Southern Africa

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From a very early age children are entertained by the activity of connecting the dots. Sadly as professionals we often forget this most basic skill and fail to see the full picture.

Connect the dots

From a very early age children are entertained by the activity of connecting the dots. Sadly as professionals we often forget this most basic skill and fail to see the full picture. We compartmentalize our lives to the extent that a new position, a new firm or a new appointment are all unconnected events. Not to mention the unconnected dots between our professional and personal lives.

Success lies in bringing the full picture into focus. Answering the following questions will give a good indication as to whether you have the required balance for a successful and sustainable life.

- are my studies / academic record suitable to secure the position I am aspiring to?
- is my continuous professional development (CPD) at a standard to accommodate developments in my field?
- is my RQ (relevance quotient) in sync with the fast pace of innovation and change?
- is my EQ (emotional quotient) strongly developed to cope with the demands of the modern work environment?
- do I have the appropriate networks?
- are my support systems in place in times of professional and /or personal need?
- do I take my health seriously enough to ensure ultimate performance levels in all spheres?
- do I invest enough time to nurture a sound family life?

While only you can determine how to rectify “no” answers pertaining to your personal life or time-management issues, active membership of the CSSA can help towards taking care of many of the career related issues, and assist in ‘joining the dots’.

CSSA seminars, technical meetings and site visits keep the professional up-to-date with developments in the field of concrete. CSSA membership also supports a strong network ethos and provides a support system for like-minded professionals.

I have connected the dots and have succeeded in seeing the bigger picture. I invite you to do the same, using the Concrete Society as a starting point.

For the love of concrete,

Hanlie Turner

President – Concrete Society of Southern Africa

OUR VISION

To be the most relevant forum for those who have an interest in concrete.

OUR MISSION

To promote excellence and innovation in the use of concrete and to provide a forum for networking and for sharing knowledge and information on concrete-related matters.

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In-situ columns with overhead, tower and mobile cranes

Precast bunkers and overland conveyor foundations at Sasol Shondoni Colliery

Sasol is engaged in a series of major new coal mining development projects at Secunda in Mpumalanga. The aim of these projects is to supplement and eventually replace the current coal supply to Sasol Secunda petrochemical plant as the older mine reserves supplying the plant become depleted. This article refers to the Shondoni Project only.

Sasol Secunda coal mining operations require major material handling and storage facilities which include inclined conveyors from underground to surface and surface overland conveyors for the transportation of coal to the process plant. To control the coal flow and co-ordinate the mine supply with the plant demand, it is necessary to include buffers and transfer towers which connect the conveyors in a continuous transportation line from mine to user, in this case Sasol Secunda gasification plant. (See Sketch SK1.)

The main civil engineering challenges of this project were the buffers: two large bunkers of 15 000 tons and 4 000 tons live storage capacity, a 15 000-ton emergency stockpile, and the foundations for the 22 km overland conveyor. The designer provided innovative solutions to comply with the owner's requirements in terms of cost, quality, performance, shorter duration of construction and contractor's needs regarding constructability and safety. All objectives were achieved by the design and construction teams working in close co-operation in a design and construct project.

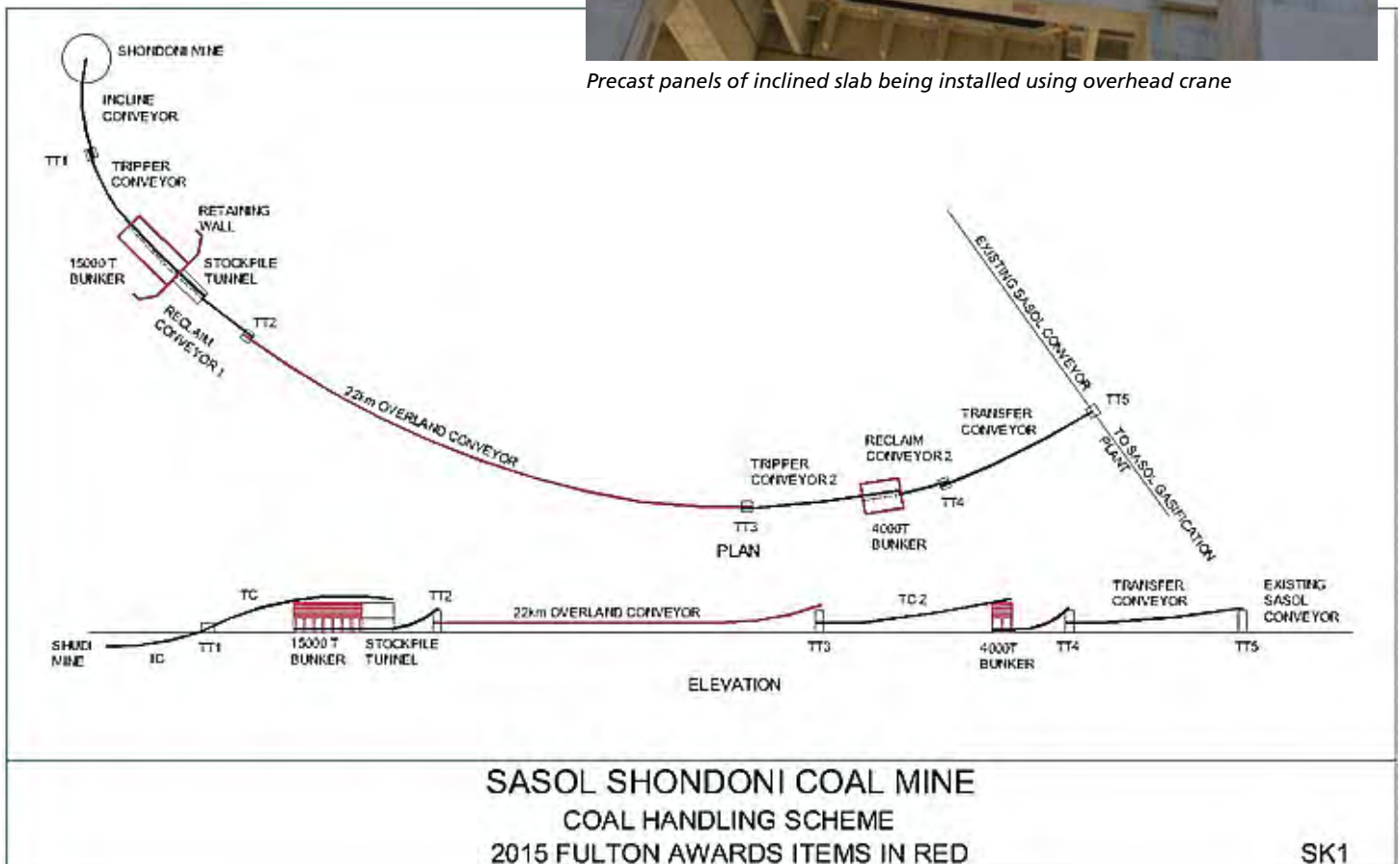
Concrete construction for large storage capacity containment structures (bunkers, silos, tunnels, retaining walls, etc.) as well as for foundations of material handling equipment, is the most advantageous and therefore the most common type of construction. Compared with other materials (steel or reinforced earth, for example) concrete, for this application, was superior in terms of cost and durability, technical performance, and ease of operation and maintenance. Actually, in this case, the choice was not between concrete and other materials, but between various types of concrete construction.

To date, the conventional type of concrete construction for large coal bunkers and overland conveyor foundations has been in-situ construction.

However, in 2005, an 8 000-ton capacity precast coal bunker was built for Anglo Coal Isibonelo Colliery and has been operating continuously since 2007. This presented a number of advantages of precast over in-situ concrete construction particularly relevant to bunkers, such as: -



Precast panels of inclined slab being installed using overhead crane



- Vastly improved constructability
- Superior durability to abrasion and corrosion
- Improved discharge flow
- Safer construction as less labour was used at heights
- Shorter construction duration
- Cost savings

The Isibonelo concept was applied on a larger scale to the new generation of Sasol coal bunkers at Shondoni and Impumelelo, and a more advanced technology of pre-casting and erection was developed. It is well known that the advantages of pre-casting for modular structures increases with repetition. As the precast concept proved to be advantageous for the Anglo Coal 8 000-ton bunker, it was evident that the above advantages would increase substantially for the combined construction of the 15 000-ton and 4 000-ton bunkers at Shondoni. The precast concept was therefore proposed at tender stage. In addition, a large number of overland conveyor sleepers were added to the repetitive work, thus increasing the efficiency of the precast yard.

The owner, after inspecting the first precast bunker in operation and realising the advantages of precast over in-situ construction, chose the precast construction concept and it was adopted for the new bunkers at Shondoni.

During the construction phase, all predicted advantages of precast construction were confirmed and the result was excellent, state of the art use of concrete.

Description of Works

Shondoni Coal Mine Project includes the following main civil engineering structures: -

1. 15 000-ton and 4 000-ton coal surge bunkers

The 15 000-ton bunker is a reinforced concrete structure 76 m long by 20.5 m wide and 28 m high. It has 10 bays, each of 7.5 m span. On the top of the bunker is a steel beam grid which supports a feeding tripper conveyor enclosed in a structural steel conveyor house. Another 15 000 tons of storage capacity is added to the 15 000-ton bunker by extending the tripper conveyor run beyond the bunker on a steel gantry, to feed into an open stockpile. A reclaim conveyor runs beneath the bunker and under the stockpile in a tunnel, then discharges coal into the overland conveyor. The 4 000-ton bunker has the same structure as the 15 000-ton, but with only 3 bays of 7.5 m and no open stockpile facilities.

In a cross section, it can be seen that the bunker consists of a lower trapezoidal containment portion with side sloped slabs and beams at 50° fall. These allow for expanded funnel flow of coal through a deck with 10 openings for steel luffing chutes which discharge into the reclaim conveyor. The deck is supported by two inner rows of 11 columns each at 6.5 m centres across and 7.5 m centres along the reclaim conveyor centreline. The sloped slabs and beams are supported on one side by the inner columns and on the other by the outer ones.

On top of the sloped slabs are two longitudinal vertical containment walls, at 17 m clear distance face to face, supported directly on the two outer columns which are at 7.5 m c/c along (in line with the inner columns) and at 19.5 m c/c across.

The steel grid on top of the outer columns, in addition to providing longitudinal support girders for the rails of the feeding tripper conveyor, also includes tie beams across the bunker, structurally connecting the outer columns at the top and also supporting the tripper conveyor gantries and access platforms.

The end wall on the mine side is provided with a slide concrete chute, 10 m wide, to reduce the height of the fall and consequently

degradation of coal fed into the empty bunker. The wall at the other end of the bunker is flat and is continued laterally with two folded 24 m high retaining wing walls to contain the stockpiled coal.

2. Overland Conveyor

Coal transportation from mine to process plant is achieved through a chain of belt conveyors linked by transfer towers. The main conveyor in this chain is an overland one, 22 km long, on a 3D curved route, with a transport capacity of 2 000 tons per hour.

The 44 km, 1 800 mm wide belt is supported on idlers on structural steel frames at 3 m centres which are in turn supported on sleeper foundations. Conventionally this founding system is based on usage of "gravity" concrete (in-situ or precast) sleepers, which, through their large mass, provide stability to the frames. This is not the most economical founding system, particularly for long running distance conveyors.

Considering the large amount (over 7 000) of conveyor frame supports the designers developed an alternative founding system based on light precast sleepers on augured minipiles.

This innovative system, tested at full scale on prototypes, proved to be not only more economical and easier constructible, but also provides more stability and durability than the conventional gravity sleeper system.

Structural Concept

1. Bunkers

The structural concept of the bunkers is based on a combination of two types of concrete construction namely, precast and in-situ structural elements, selected for each type on constructability criteria and integrated into a "composite" reinforced concrete structure. Thus: - The foundation, columns and the end and internal partition walls, which do not need supporting scaffolds but just access staging, and are easier to shutter, reinforce and cast, are in-situ elements.

The deck beams and permanent formwork, sloped bunker slabs and beams, and vertical bunker walls, are precast, avoiding any scaffolding which is required for casing in-situ of such elements.

Precast elements are not only self-supporting but also act as supports to the other precast or in-situ elements on top during construction. The precast and in-situ elements are fully structurally integrated into the "composite" structure through monolithic in-situ concrete connections and in places by pre-stressing, thus using the full structural capacity of all elements.

2. Overland conveyor

The conveyor precast-sleeper-on-minipiles concept is based on creating a portal frame with the minipiles as columns anchored in the founding soil and the precast sleeper as horizontal beams, using lateral and vertical soil support and distributing the lateral loads almost equally between the minipiles. The superior structural behaviour of the precast-sleeper-on-minipiles frame, was proved by load testing on full scale prototypes, as part of an internal R & D project.

Outstanding design aspects

- By structurally integrating precast with in-situ elements and creating a "composite" structure, an economic structural system supporting itself at various erection stages with minimum amount of scaffolding was achieved. Structural analysis at various construction stages was performed, considering the temporary concrete and re-bar configuration and early concrete strength, starting from the pre-casting until the final construction stage.



View below precast discharge chutes deck showing installed chute



Placing 10t precast wall element using remote controlled overhead crane



Industrial mountaineer installing stitching concrete formwork



View inside bunker

- The number of precast element types was minimized to reduce the number of costly moulds.
- The connections required accurate geometric design, not only of the concrete part of the precast elements, but also of the protruding re-bar which had to interlace at low tolerances with the re-bar of adjacent precast or in situ elements, thus forming a monolithic connection. This was achieved with 3D CAD and, for every connection, concrete and re-bar geometry was checked in the design office for precision fitting. In this way, clashes were avoided on site with the result of improved constructability.
- Essential for a project of this high technical level and repetition scope, was attention to design checking. The target of no design



Precast yard high precision dismantled steel moulds



Precast block being loaded prior to 20km journey to site

and draughting errors was achieved with no rejection of precast parts or misfitting.

- Site supervision and reporting was also provided by consultants, at a level consistent with the complexity of this project
- Animated 3D models were produced to demonstrate sequence of erection to site personnel, and receive comments, as part of design and construct method.
- 3D Printing was used for presentations to owner, contractor and other engineering disciplines including full models and individual precast assembly parts.
- Detailed erection and connection sequence schedules were most useful for this type of sophisticated construction process.
- Special attention was paid to the bunker discharge geometry in order to provide 100% coal discharge.
Considering the discharge chutes spacing module of 7.5 m and the size of the chutes at deck level of 4.0 x 4.0 m, 700 partition haunches needed to be provided. These partition haunches extend, with vertical walls, to 4m above the deck, allowing pre-stressing across the bunker. They thus function not only as geometric partitions, but also have a structural role, tying the two inclined opposite bunker slabs together as pre-stressed tie walls and supporting the deck and the whole lower framing system.
- The outside coal retaining wing walls, 24 m high at the peak, were designed as "folded "plates with no counterforts, a geometry which proved to be economical and, for structures of such large magnitude, easier to construct.
- The overland conveyor precast sleeper on minipiles frame innovative founding concept was load tested on full scale prototypes on a separate internal R & D project to confirm the structural analysis results, before engaging in the precast mass production.

Outstanding construction aspects

- The 15 000-ton bunker consists of a total of 481 precast elements which the construction team managed to install at a peak of 22 elements per day without any major or minor incidents or accidents.
- Concrete for this project was supplied by a readymix plant located some 20 km away from Shondoni project construction sites. The precast yard was located next to the readymix batch plant and the precast elements transported to the erection sites by truck. The advantage of having the batch plant next to the precast yard was manifold:
 - instant supply of concrete in quantities as demanded
 - no delay in time and change in concrete workability due to transport duration resulting in superior quality concrete.
 - off-site operation not subjected to the tight rules of mining operation sites as applied on owner's construction site.
- Pre-casting has the following advantages: -
 - It allows for the production of high quality elements in the most advantageous and safe fabrication conditions of a precast yard outside the construction site.
 - High precision steel moulds, CAD designed by specialist subcontractors, assured the specified precision of the precast elements.
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22km overland conveyor precast sleepers on minipiles

- The high quality 60 MPa strength concrete used for all surfaces in contact with coal was tested and proved to provide a high resistance to abrasion, thus increasing the durability of the structure and eliminating costly and difficult to install steel linings. A fact also successfully proved at Isibonelo bunker after 7 years of continuous operation.
- 60 MPa concrete was used for all precast elements, allowing for early removal from the moulds and therefore a rapid turnover cycle in the precast yard and a reduction in the number of moulds.
- The combination of precast and cast-in-situ activities reduced construction time as the two systems progressed in parallel. The precast yard supplied the precast elements for erection in advance of the erection programme, eliminating standing time.
- Notable was the consistent attention to precision in both precast and in-situ works which is essential for this type of advanced concrete technology.
- An innovative method of precast erection was used in this project for the first time, with excellent results in increased productivity and safety. The cast-in-situ outer columns were used to support steel gantries for an overhead crane, which was used successfully by remote control to erect the precast elements ranging from 10 to 20 T. The remote control was operated by the riggers at the very points of precast placement locations allowing thus to erect the heaviest



Elevation of bunker completed composite concrete structure

elements, with speed and excellent precision and in safer conditions than using conventional lifting equipment. Lighter cast-in-situ elements, such as the permanent shutters, were lifted by a 5-ton tower crane. Mobile heavy cranes were also used in the areas out of reach for the O/H crane.

- Employment of Industrial Mountaineers, an innovative approach in precast erection, proved beneficial in terms of speed, costs and safety for this type of construction and substantially reducing the amount of access staging.

Other aspects

- **Environmental**

The bunkers of this project are massive industrial structures, prominent from large distance with important visual impact on the environment. Attention to appearance was considered in the design to minimize negative environmental effects.

- **Programme**

The precast concept for both bunkers and overland conveyor allowed the contractor to comply with the overall construction programme, and even be able to hand over structures to the next discipline ahead of schedule.

- **Safety**

Minimizing in-situ construction at heights and replacing it with pre-casting, resulted in increased safety.

- **Training**

The high level technology in concrete construction applied in the Shondoni project, required training of design and construction personnel at all levels. The aims were to become familiar with the specific requirements of "composite" construction - to understand the precision of this technology, uncommon to the construction industry at large and to consistently implement the specifications and controls.

All those involved in this project benefitted by a unique experience, valuable in future concrete projects.

A total of 12 people were trained in new skills in the drawing office on this project, as well as 65 more on site.

Conclusion

This "Composite Construction" innovative concept, namely structurally integrated pre-casting with cast-in-situ at all construction phases, proved to be superior in performance compared with traditional in-situ construction, considering all criteria of cost, time, quality, operation, maintenance and safety. This "Composite Construction" concept is ideal for any large modular structures with repetitive type of components.

This project, which is part of the beneficiation of South Africa's mineral resources, contributes not only to improvement of the country's economy, but, through the use of innovative concepts and methods, to skills development and the progress of the South African construction industry. ▲



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Suppressing Alkali-Silica Expansion

Using ECC for extended infrastructure service life.

by **Mustafa Şahmaran and Victor C. Li**

The term “durability” does not stand for a special attribute of a concrete material in general but it rather signifies a conclusion reached after the material has been exposed to certain environmental conditions in which the structure serves. The material itself is called “durable” if, in its environment, it survives a desired service life without necessitating excessive costs for repair and/or maintenance applications caused by degradation or deterioration. The reason durability is being perceived vitally important for different infrastructure types is that it has a close intimacy with the basic mechanical properties—the lacking of which could result in structural breakdown at exorbitant deterioration levels.

Alkali-silica reaction (ASR)—one of the most commonly encountered problems contributing to the rapid loss in overall durability of concrete—is particularly important because the deteriorating effects of the mechanism may not be traceable for a very long time (10 to 30 years). This is a significant issue for critical infrastructure components such as highway bridges, pavements, and barriers¹; airport pavements²; and railway ties.³

ASR is a deterioration mechanism that takes place between the individual components (cementitious paste and aggregates) of concrete. To be more precise, reactions occur when the siliceous constituents of reactive aggregates come in contact with alkali ions released into pore solution as a result of hydration reactions and/or provided externally into the cementitious system. The final product of ASR is the alkali-silica gel (Fig. 1(a)) surrounding the aggregate particles and/or

propagating through cementitious paste. In cases where the reactive aggregates happen to be porous, ASR gels may form inside as well as on the surfaces of the aggregates. This gelatinous material, which might have variable composition and characteristics, is hygroscopic and swells as it imbibes water. The resulting pressures can produce internal stress levels of typically 3 to 4 MPa. In some cases, the hygroscopically induced pressure has been reported to reach 8 MPa,⁴ sufficient to cause cracking in most concrete structures.

When ASR damage takes place, concrete, as a characteristic feature, displays a network of cracks commonly labeled as “map cracking” (Fig. 1(b)). Alkali-silica gel can also emanate from the cracks and be seen as white residue on the surface of concrete.

For ASR to take place in a hardened concrete element, alkalis of cementitious paste, reactive siliceous aggregates, and water must be present simultaneously. Absence of one of these contributing factors would terminate ASR. Likewise, anything amplifying any of the three factors would lead to acceleration of ASR-originated deterioration. Cracks create preferential pathways where extra moisture and alkalis can be transported into concrete and therefore have very high potential for worsening ASR-based damage. Although, as of yet, it seems unrealistic to manufacture crack-free concrete, it is apparent that a material that possesses self-control of cracking will have reduced risk of ongoing and accelerating ASR deterioration. In addition, cracks initiated by ASR will be more difficult to grow in length and width in such a material, resulting in space confinement for the gel, and slowing the continuing deterioration.⁵

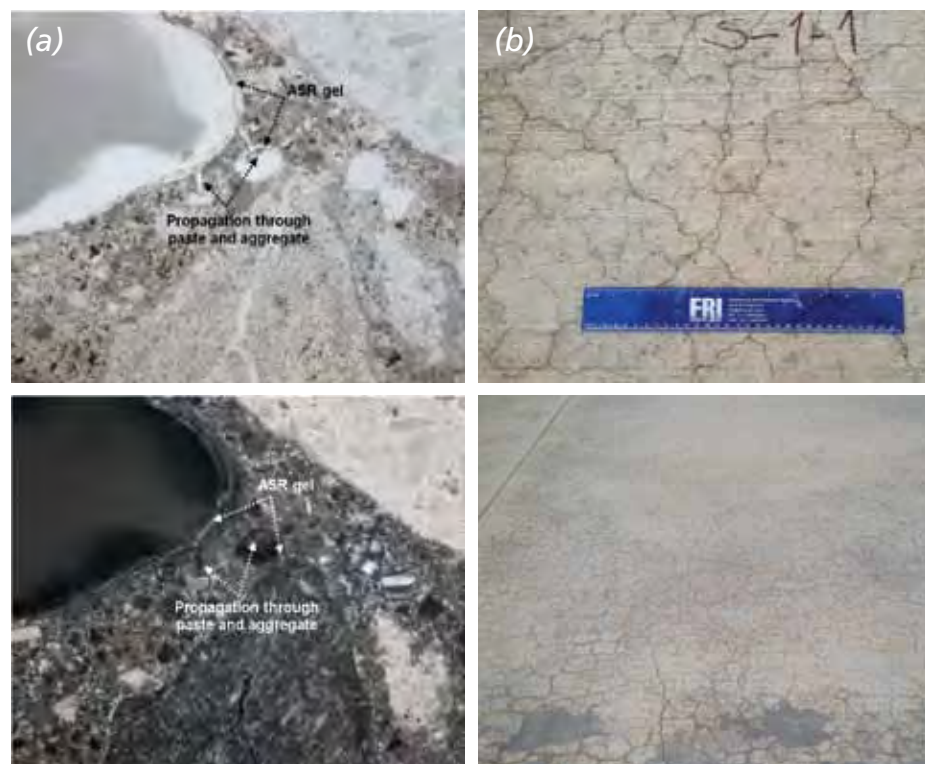


Fig. 1: ASR deterioration: (a) petrographic examination of 10-year-old ASR-damaged airport pavement (plane-polarized light image [top] and crossed-polarized light image [bottom]; and (b) typical severe map cracking as a result of progressive ASR in 10-year-old airport pavement

Engineered Cementitious Composites

As one of a special kind of materials having controlled cracking behavior, engineered cementitious composites (ECCs) have been under development at the University of Michigan, Ann Arbor, MI, over the last two decades.⁶ In contrast to conventional concrete, ECCs exhibit superior tensile ductility—several hundred times that of conventional concrete as well as exceptional energy absorption capacity that is similar to that of some metals.⁷ Also, the average crack width for ECCs is self-maintained to less than about 60 μm under imposed strain of up to several percent. Figure 2 shows a typical tensile stress-strain relationship and associated crack width development for an ECC.

The exceptional ductile behavior and crack control of an ECC is grounded on the synergistic interactions among its individual components, namely fibers, cementitious paste, and the interface between the two. Even with multiple microcracks, ECC has been reported to remain durable under severe environmental exposures; this behavior has

been attributed to the fact that the material has an intrinsic ability to keep crack width tight.⁸ Intrinsic microcracking behavior of ECC could also be the key for enhanced durability in terms of ASR. The outcomes of an experimental study on ASR performance of ECC are reviewed in this article, in light of field experiences.

ASR Testing

Mortars with different amounts of PVA fibers

While ECC can be produced with different fiber types (for example, polyethylene or polypropylene), in the present study, the focus was placed on ECCs with polyvinyl alcohol (PVA) fibers. The influence of PVA fiber content on ASR performance of mortar mixtures (not ECC) including reactive silica sand with maximum aggregate size (MAS) of 4 mm was evaluated for mixtures with fiber volumes of 0, 1, and 2%. The PVA fibers were 8 mm long and 39 μm (0.002 in.) in diameter and had nominal tensile strength of 1320 MPa and a Young's modulus of 42.8 GPa (6210 ksi). Mortars were prepared and tested according to ASTM C1260, "Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)." Results obtained after exposure to sodium hydroxide (NaOH) solution at 80°C (176°F) for 30 days are shown in Fig. 3 in terms of percent length changes of prism-shaped specimens.

The horizontal reference lines included in the figure indicate the standard's nonmandatory ASR expansion limits at 14 days after immersion in the solution. Expansions less than 0.10% (labeled

"Harmless") are indicative of innocuous behavior in most cases; expansions of more than 0.20% (labeled "Harmful") are indicative of potentially deleterious expansion; and expansions between 0.10 and 0.20% (labeled "Repetition") include both aggregates that are known to be innocuous and deleterious in field performance. In the latter case, additional testing is recommended.

ASR-induced expansion is observed immediately, regardless of the amount of PVA fibers. The resultant damage after 30 days reveals the typical map cracking in specimens without PVA fibers (Fig. 4).

However, it appears that incorporation of PVA fibers in mortar bars with reactive aggregates has a positive influence on the ASR resistance. The specimen without PVA fibers had expansion in the "Harmful" zone at 14 days after immersion, while the specimens with 1 and 2% PVA fibers had expansion in the "Repetition" zone at 14 days. These findings are in line with several studies showing reduced cracking intensity, narrower crack widths, and lower maximum crack depths of ASR-susceptible mortars reinforced with fibers.^{5,9-11}

Mortars with different aggregate types

For ECC mixtures to exhibit superior tensile ductility and multiple microcracking behaviors, they are typically produced using powdery silica sand (microsilica sand), although aggregates with different types and sizes can also be used.¹² To better understand the effect of this component on ECC mixtures, mortar specimens produced with microsilica sand with MAS of 400 μm (0.02 in.) and mortar specimens produced with reactive silica sand with MAS of 4 mm (0.2 in.) were tested per ASTM C1260. No PVA fibers were used in the mortars. Mortar specimens produced using reactive sand had expansions within the "Harmful" zone at 14 days of exposure, while mortar specimens produced with microsilica sand exhibited low levels of expansion, even after 30 days of NaOH solution exposure (Fig. 5).

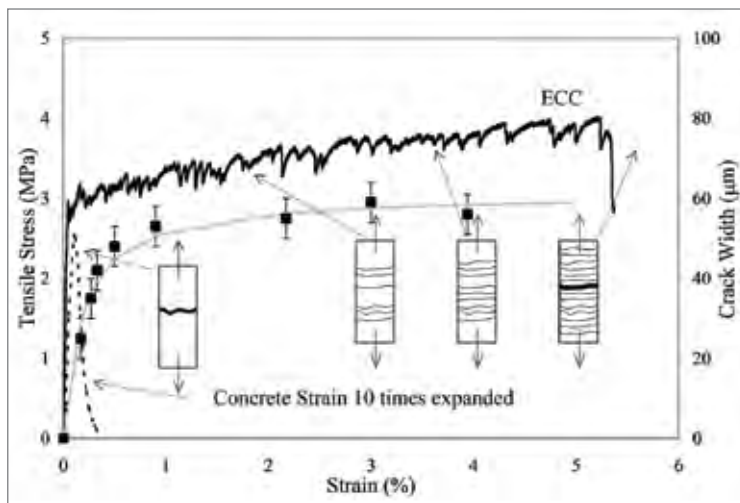


Fig. 2: Crack width in ECC self-controls to less than 60 μm (Note: 1 MPa = 145 psi; 1 μm = 0.00004 in.)



Fig. 4: Typical formation of map cracking due to ASR damage in mortars without PVA fibers after 30 days of high alkaline exposure

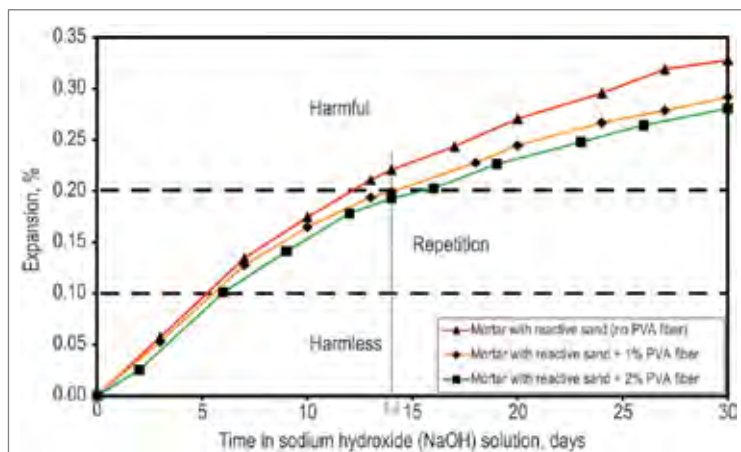


Fig. 3: Microfibers help to restrain ASR-based expansion of mortar specimens

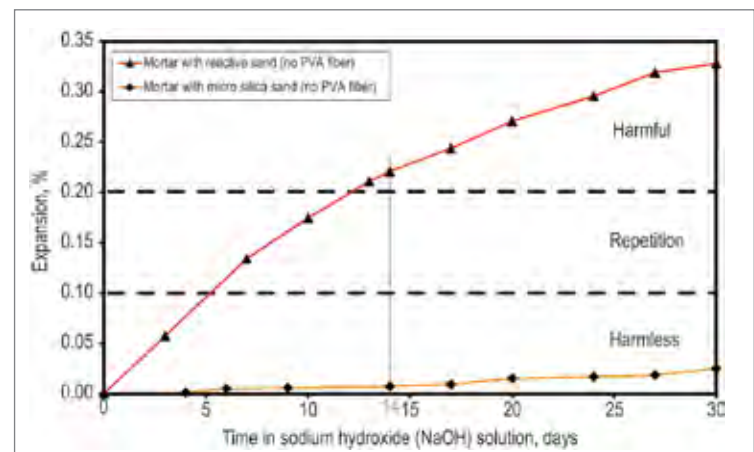


Fig. 5: Mortar specimens made with microsilica sand show substantially lower ASR expansion than that of mortar with reactive sand

Mortars with different fly ash types

Incorporation of supplementary cementitious materials such as fly ash, slag cement, and limestone powder in ECCs will lower the cement content and thus reduce the cost and environmental impact of ECC production. Two fly ash types were evaluated for their effects on ASR expansion in ECCs. Class C fly ash with high lime content (FA-C) was used to produce C-ECC mixtures, and Class F fly ash with low lime

Table 1: Composition and physical properties of portland cement and fly ashes

Chemical composition, %	PC	FA-C*	FA-F*
CaO	63.3	25.7	7.8
SiO ₂	19.6	31.4	58.8
Al ₂ O ₃	5.9	18.5	17.7
Fe ₂ O ₃	3.4	5.2	5.4
MgO	0.95	6.4	—
SO ₃	2.5	2.4	0.8
K ₂ O	0.54	0.48	0.56
Na ₂ O	0.47	2.2	1.5
Loss on ignition	3.0	0.2	0.3
Physical properties			
Specific gravity	3.18	2.78	2.35
% retained on No. 325 sieve	—	13.8	24.3

* Both fly ash Classes FA-C and FA-F contained considerable amount of alkalis

Table 2: ECC mixtures with fly ash for ASR testing

Mixture ID	Portland cement (PC)	Silica sand	Reactive silica sand	w/cm*	FA/PC	PVA, kg/m ³	HRWRA†, kg/m ³
F-ECC-1.2	1.0	0.80	—	0.27	1.2	26	4.2
F-ECC-2.2	1.0	1.16	—	0.27	2.2	26	3.0
C-ECC-1.2	1.0	0.80	—	0.27	1.2	26	4.6
C-ECC-2.2	1.0	1.16	—	0.27	2.2	26	3.5
F-ECC-1.2R	1.0	—	0.80	0.27	1.2	26	4.2
F-ECC-2.2R	1.0	—	1.16	0.27	2.2	26	3.0
C-ECC-1.2R	1.0	—	0.80	0.27	1.2	26	4.6
C-ECC-2.2R	1.0	—	1.16	0.27	2.2	26	3.5

* cm is cementitious materials (portland cement + fly ash)

† HRWRA is high-range water-reducing admixture

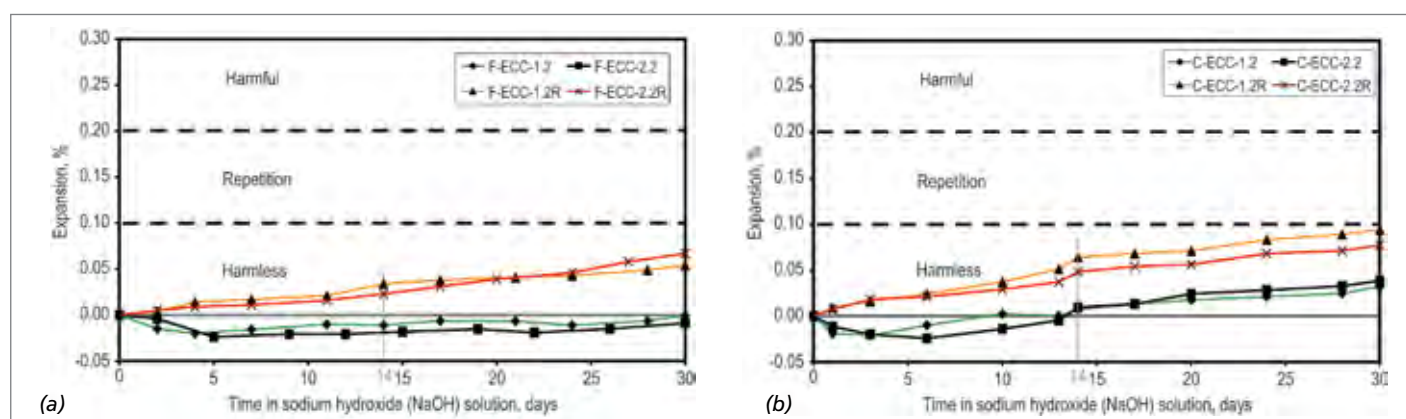


Fig. 6: ECC with different fly ash types shows little ASR-based expansion: (a) Class F fly ash; and (b) Class C fly ash

content (FA-F) was used to produce F-ECC mixtures. The composition and physical properties of the portland cement and fly ashes used in the study are shown in Table 1. Two different amounts of each fly ash type were used in the mixtures. The fly ash-portland cement ratio (FA/PC) in the ECC mixtures was either 1.2 (55% fly ash by weight of total cementitious material) or 2.2 (70% fly ash by weight of the total cementitious material); refer to Table 2. All ECC mixtures were prepared with a water-cementitious materials ratio (w/cm) of 0.27 and two different sand types (microsilica sand and reactive silica sand). Mixtures produced with reactive silica sand with MAS of 4 mm include "R" in the mixture ID (Table 2). Figure 6 summarizes the results of tests conducted per ASTM C1260 on mortar bars produced using the ECC mixtures.

Figure 6 clearly indicates that ECCs, even after 30 days of severe alkaline exposure, are safe against ASR, regardless of the amount and type of fly ash used in the mixtures. Moreover, negative effects of reactive silica sand use on ASR damage seem to be inhibited to a great extent when fly ash was incorporated in ECC systems. When microsilica sand was used in the production of ECC mixtures, reductions in the percent expansion results became even more evident. In some instances, especially those with Class F fly ash, contraction took place in specimens. This contraction can be attributed to the autogenous shrinkage of the mixture's highly packed cementitious pastes with very low w/cm . The remarkable effect of different fly ash particles (especially Class F fly ash) in decreasing the ASR-based damage can be due to the reduction of calcium hydroxide amount as a result of further pozzolanic reactions.¹³ The high fly ash content is also expected to refine the pore structure, reducing alkali diffusion from the host solution into the sample and binding the alkalis into pozzolanic calcium silicate hydrates.¹³⁻¹⁵

Although Fig. 6 shows that all mixtures performed well, ECCs with Class F fly ash performed better than ECCs with Class C fly ash. Compared to the FA-C particles, the FA-F particles have lower total alkali content and higher pozzolanic capacity. Therefore, specimens incorporating Class F fly ash particles are more likely to have reduced alkalinity of the pore solution, particularly at the later ages of the test.

The superior performance of ECC mixtures with Class F fly ash can also be due to the fact that F-ECC specimens tend to exhibit narrower crack widths,¹⁶ restricting the ingress of alkaline solution during ASR testing. The ASR mechanism may be further suppressed when space is not available for gel generation due to intrinsically tight crack widths in ECC, consistent with the observations of Ostertag et al.⁵ Moreover, narrower cracks have been reported to be sealable, with the effect of self-healing even under severe alkaline environment.¹⁷

Field Application of ECC

One of the first field applications of ECC was its use as a patching material to repair a concrete bridge deck in Michigan. The project was completed in cooperation with the Michigan Department of Transportation (MDOT) in 2002. A complete summary of this work can be found in Li and Lepech.¹⁸ Repairs were made using ECC as well as a commercially available concrete patching material commonly used by MDOT (Fig. 7). The two patching materials were installed side by side

and at about the same time (1 day apart), and thus they were subjected to identical environmental conditions and traffic loads. Between 2002 and 2007, the condition of the ECC patch was continuously monitored. Only minor microcracks, with widths limited to less than 50 μm (0.002 in.), were found. Figure 8 shows the recorded maximum crack width and surface conditions of the two patches during this period. No signs of ASR were found in the ECC. In contrast, the concrete patch showed ongoing increases in maximum crack width, reaching widths exceeding 3.7 mm by 2005. The concrete patch was re-repaired in 2005. By 2007, MDOT determined that deterioration of the deck was sufficient to warrant a complete deck replacement.

Another field application of ECC is a “link slab” in a two-span bridge. The first application of this type was completed in cooperation with MDOT in 2005 (Fig. 9(a)). In this use, the material ductility of ECC is leveraged to replace problematic expansion joints between adjacent simple spans with a ductile ECC slab linking the spans.¹⁹ In the 2005 project, about 32 m³ of ECC were mixed and placed using standard ready mixed concrete trucks.²⁰ With a strain capacity exceeding 2%, the link slab material fully accommodates the thermal and live-load deformations of adjacent bridge spans. After 10 years of service, the link slab (Fig. 9(b)) continues to function as intended, without repair or maintenance. No signs of ASR are evident.



Fig. 7: ECC patch repair placed alongside concrete patch on Michigan bridge deck

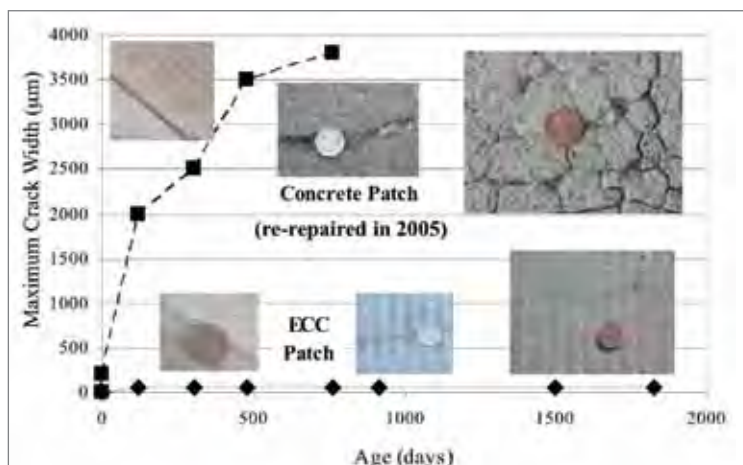


Fig. 8: Maximum crack width development in concrete and ECC repair reveals no ASR in the ECC patch (Note: 1 μm = 0.00004 in.)



Fig. 9: After 10 years of service, the ECC link slab on Grove Street Bridge, MI, shows no ASR damage: (a) immediately after construction in 2005; and (b) in 2015

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Note: Additional information on the ASTM standard discussed in this article can be found at www.astm.org

Selected for reader interest by the editors after independent expert evaluation and recommendation.

Summary

Due mainly to the limited durability of conventional concrete, concrete structures tend to have a shorter service life than expected. At the root of this problem is the brittle nature of concrete. To overcome this persistent problem, ductile ECC can be effective in eliminating the need for repeated maintenance. Given that cracks tend to accelerate the deterioration by creating additional pathways for aggressive agents, many durability problems can be reduced and/or overcome by the high ductility and self-controlled microcracking behavior of ECCs.

Along with many other mechanisms affecting the durability of infrastructures, ASR has been shown to be harmful, especially for concrete structures subjected to prolonged service periods. While ECC applications in the field have been relatively recent, the limited experience indicates that ASR is not a concern for structures comprising ECCs. This is corroborated by laboratory test results that demonstrate the ASR suppression mechanisms of ECC—high pozzolanic material content, nonreactive aggregates, and microfibers. ECCs therefore exhibit small pore sizes and low alkali concentrations in the pore solution; ECC aggregates are less likely to form hygroscopic gels; and ECCs exhibit self-control of crack widths to less than 60 µm, reducing the potential for intrusion of damaging water. The evidence shows that ECC can serve as a durable material for repairs, airport pavements, railway sleepers, and other structural elements prone to ASR attack. ▲

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An economic evaluation methodology to compare the use of self-compacting concrete with normal compacting concrete

Construction & Engineering Management, Department of Civil Engineering,
Stellenbosch University, South Africa.

by **Janus Malherbe and Jan Wium**

ABSTRACT

The factors that influence the cost of Self-Compacting Concrete (SCC) and how these factors influence the construction costs are known, but the contribution of the different cost constituents are currently poorly defined. This paper introduces a systematic methodology that can be used to construct a cost model to calculate the financial impact of using self-compacting concrete on a construction project. The results are presented as cost based key performance indicators (KPI's) on a concrete related and project specific cost dashboard. The paper provides a description of the mathematical model and the results of an investigative case study. The model enables a project stakeholder to identify the optimal SCC implementation strategy for a project. It was found that SCC usage can lead to an increase in the overall construction cost, mostly due to the increased cement content, but the time saving of SCC can potentially outweigh the increased material cost due to the reduction in overheads and project duration.

1 INTRODUCTION

The implementation of SCC in South Africa is still limited despite the wide usage of the technology in developed countries. By 2007 it was only used for a relatively small number of applications and the acceptance of SCC by the South African construction industry was described as limited (Geel, Beushausen & Alexander, 2007). Not much has changed, SCC has remained a specialized concrete material and the implementation thereof in South Africa is lagging behind that of the developed world.

The fact that South Africa is not implementing SCC in the same order of magnitude as developed countries, despite the published perceived advantages, was one of the aspects that inspired this research. With the growing demand for engineering skills and decreasing resource availability, the question of why SCC is not implemented regularly, became even more apparent. It was therefore decided to investigate the financial impact of implementing SCC.

The perceived published advantages of using SCC include overall project savings on cost and time, whilst improving the quality of the hardened concrete. This study tested the first two claims on a quantitative basis.

The primary objective is to describe an accurate cost implication model that should be used to quantify the impact of the decision to implement self-compacting concrete on a construction project.

The model presented in this paper was designed to provide a better understanding of the cost breakdown of using SCC and to quantify the costs in terms of defined metrics that can be used as decision making criteria. The benefits of this model include:

1. It takes all the cost into account in the concrete and concrete placement related supply chain

2. It incorporates and quantifies the impact of time and cost related uncertainty into the final answer by means of a Monte Carlo simulation
3. The output is highly interpretable visual results that enables a reader to immediately understand the different cost constituents and their relationships with element geometry, construction environment, material costs etc.
4. The model can accommodate almost any type of concrete construction activities
5. 'Fine-grained' cost comparisons are possible since the costs for using SCC and NCC are calculated on a per element basis

A case study was used to test the proposed model and to demonstrate the value of the results and to evaluate the effects that SCC implementation can have on a project. Although the numeric values of the case study results are informative, the focus of the paper is on the type of information that is presented by the results and the ease with which the cost breakdown can be understood if the proposed calculation methodology is adhered to. This enables effective cost and even risk management since the financial impact of a decision can be fully understood.

The model output information can be used to optimize and prioritize concrete construction related cost management strategies.

2 THE COST COMPARISON MODEL FOR SCC VS. NORMAL COMPACTING CONCRETE (NCC)

The model consists of two parts, namely:

- A set of static deterministic calculations, forming the static model part, and
- a set of stochastic calculations in which a Monte Carlo analysis is used, forming the heuristic model part

The static model does not incorporate any variance and all the input variables are single data points. The static model is used to simulate the real value chain on site that exists with regard to concrete placement. The variance is simulated using the Monte Carlo method to create the heuristic model that supplements the information of the static model. This variance within the data simulates possible variations in the value of specific uncertain input parameters.

2.1 General Approach

The ideal is to perform static deterministic calculations as far as possible. The uncertain parameters of the static model are then statistically analyzed. The overall results are presented as a combination of static and probabilistic results.

Table 1: Role of static and heuristic modelling

Information required	Cost impact and cost impact breakdown of using SCC	Possible variation in cost results due to inherent uncertainty
Input parameters and required information relationship (between inputs and outputs)	Results based on single value input parameters (assume fixed input data)	Results include the possible variation in the values of uncertain input parameters
Model part created to obtain the required information	Static model	Heuristic model
Input characteristics	Fixed value inputs	Variable inputs (variability defined by a statistical distribution of possible values)
Mathematical calculation method	Static deterministic calculations	Statistical/stochastic calculations by means of a Monte Carlo simulation
Result characteristics	Fixed value results	Resulting distributions

Table 2: Sixty extractable KPI's

		Critical Performance Areas (CPA's)					Additional performance areas	
		Material cost	Placement labour cost	Formwork cost	Rework cost	Other costs implication	Total cost	Time impact
Elemental breakdown (KPI classes)	Overall project specifics	SCC and NCC	SCC and NCC	SCC and NCC	SCC and NCC	SCC only	SCC and NCC	SCC only
	Slab elements	SCC and NCC	SCC and NCC	SCC and NCC	SCC and NCC	SCC only	SCC and NCC	SCC only
	Beam elements	SCC and NCC	SCC and NCC	SCC and NCC	SCC and NCC	SCC only	SCC and NCC	SCC only
	Wall elements	SCC and NCC	SCC and NCC	SCC and NCC	SCC and NCC	SCC only	SCC and NCC	SCC only
	Column elements	SCC and NCC	SCC and NCC	SCC and NCC	SCC and NCC	SCC only	SCC and NCC	SCC only

The uncertain input parameters are modelled as static values in the first phase and then modified with statistical distributions in the second phase. The role of the static and heuristic modelling in the calculation procedure can be seen in Table 1.

Five critical performance areas (CPA's) are calculated to enable the extraction of sixty key performance indicators (KPI's). Different subsets of the sixty KPI's are of importance to different project stakeholders. The extractable KPI's are shown in Table 2.

The Monte Carlo analysis is performed after the main influence parameters have been identified for the KPI's under consideration. The distribution type to be assigned in the Monte Carlo analysis depends on the type of uncertainty associated with the specific influential input parameter that has been identified.

2.2 Model Structure

Two values are calculated for the concrete related construction cost of every planned element cast, namely the total cost when using NCC and the total cost when using SCC in the construction procedure. These costs are calculated as shown below:

$$T_{SCC} = M_{SCC} + L_{SCC} + F_{SCC} + R_{SCC}$$

$$T_{NCC} = M_{NCC} + L_{NCC} + F_{NCC} + R_{NCC}$$

With:

$$T = \text{Total element cost (R)}$$

$$M = \text{Material cost per element (R)}$$

$$L = \text{Labour cost for element placement (R)}$$

$$F = \text{Formwork cost per element (R)}$$

$$R = \text{Rework cost per element (R)}$$

The subscripts SCC and NCC refer to the concrete type. The implication of other costs, represented as A , will have a negative value due to its definition being an additional saving due to the use of SCC, such as savings on overhead expenses. The total cost implication of using SCC for a specific element can then be calculated as:

$$\Delta TC = T_{SCC} - T_{NCC} + A$$

The mathematical relationships in the model are illustrated in Figure 1. A sensitivity analysis is then used to isolate the most influential input parameters and a subset is chosen from the influential input parameters, based on an uncertainty criterion. The subset of uncertain and influential input parameters is used in the Monte Carlo analysis to simulate all the possible outcomes if SCC is the chosen construction material.

The model delivers a large data set as a result that can be subdivided according to the needs of the specific project stakeholder. Three types of information are contained within the results, this include:

- Total cost breakdown, into the 5 CPA's, for every KPI class (Pie chart showing total cost, and each CPA's cost contribution)
- KPI change summary to show the effect on every KPI if SCC is implemented (Bar chart showing the relative change that SCC implementation realizes)
- Total cost difference and its elemental composition

3 BRIDGE Nr. 5895 OVER THE MODDER RIVER, NEAR GEORGE: AN INVESTIGATIVE CASE STUDY

A case study was done to test the economic evaluation methodology by quantifying the decision to implement SCC on a project. The chosen project was the construction of a new bridge.

The structural design was subdivided into the basic structural elements to use the developed calculation methodology, these elements are:

- 4 concrete types (based on characteristic strength)
- 10 slab element types
- 6 column element types
- 10 wall element types

A single type of element in a specific class (such as one of the ten wall element types) comprises of all the elements in the structure with similar geometric and construction constraint characteristics.

Forty concrete casts were executed and the total volume of concrete used was 1 223 cubic metres.

Eight influential and uncertain input parameters were identified through the sensitivity analysis and included in the Monte Carlo analysis. These include:

- The percentage of concrete casts that are expected to take place in a penalties period

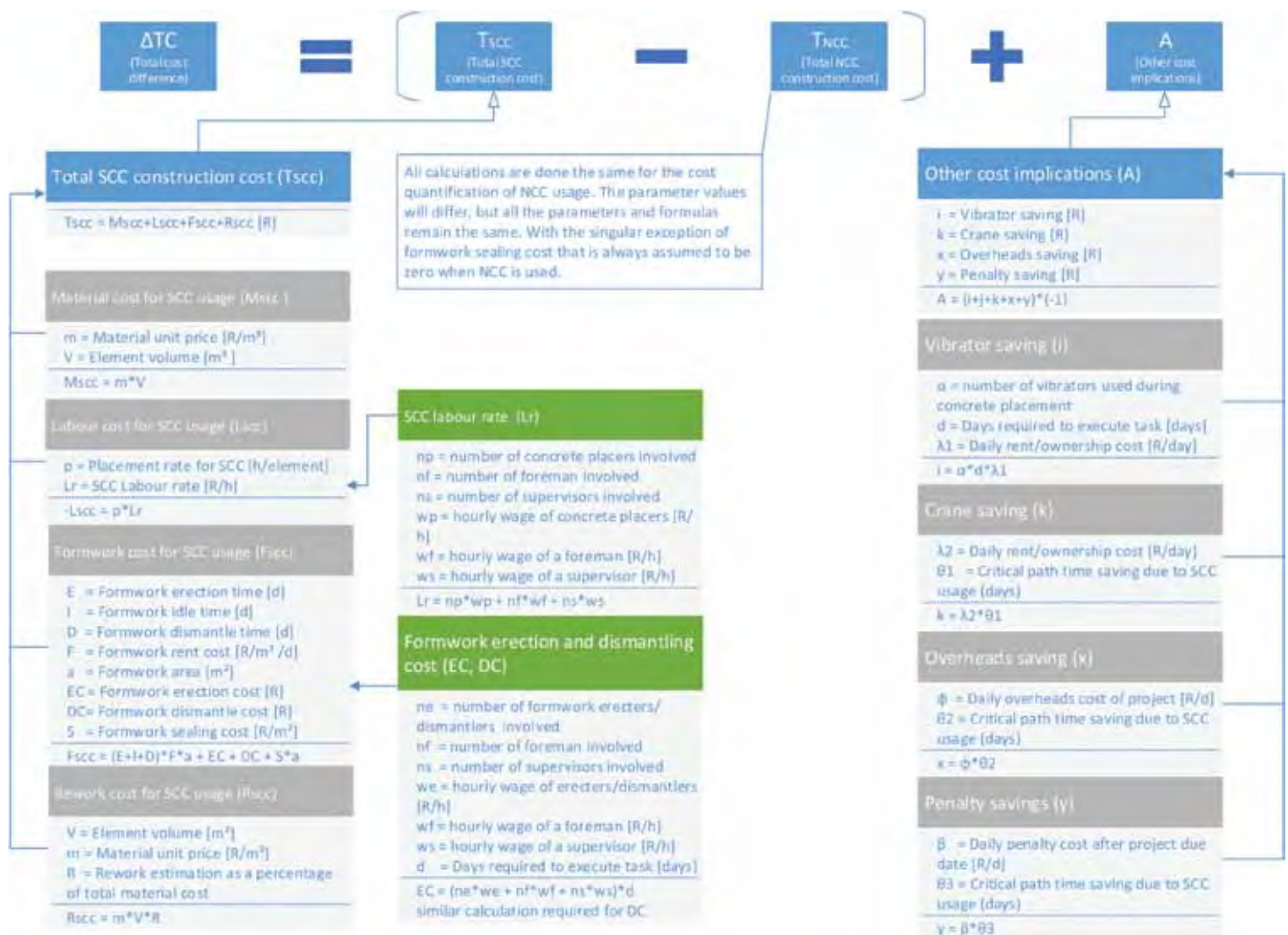


Figure 1: Mathematical relationships in the model

- The unit costs at which the four concrete mixes can be procured
- The renting time of the formwork (this includes the formwork erection time, support time and dismantling time)

4 FIRST ORDER RESULTS AND DIRECT INSIGHTS

All the results should be interpreted with two considerations in mind; what does the calculated value mean and why is it useful? The meaning of the calculated value is self-explanatory, but the value of the proposed calculation method will become evident by analyzing the type of answer obtained.

The first consideration is applicable to the results that were obtained from the case study. The calculated results are then used to show the insights that the proposed calculation method leads to and the applicability thereof.

4.1 Static results

The static results are represented in terms of the KPI's as calculated with the static model. The KPI's are the material cost, placement labour cost, formwork cost, rework cost, other cost implications, time impact and the total cost.

The overall cost implication KPI is the highest level KPI considered. This KPI comparison can be utilized by a decision maker who needs to know the total financial impact of implementing SCC on a project and

then use the information as a decision criterion. Figure 2 shows the overall cost implication of using SCC, represented by the R 364 600 cost difference between SCC and NCC for the case study. The breakdown of the overall cost, into the different CPA's, can also be seen.

The calculated time saving for the whole case study project amounted to 14 days on an original construction duration of 277 days.

In a lowest bid tendering process, a contractor might reject the use of SCC based on the increase in the overall cost KPI, but a client can benefit from this information and specify SCC for a different reason. A client can opt for SCC at the increased cost since the accelerated schedule can provide a quicker return on investment (ROI). The quantification of the cost-benefit trade-off is thus important to enable a client to accept or reject the expected cost impact on construction if SCC is used.

The 17.5% cost increase has a basic economic justification that can be of interest to clients and contractors. The increased price is paid for increased ease of use, better site conditions, a potentially more durable finished product, the ability to accelerate the construction phase and eventually an increase in return on investment and improved capital turnaround times.

The cost increase can be reduced by means of managerial and logistical decisions or variations in the sequence of construction tasks. More task relationship options are made possible by using SCC and the reduction in scheduling constraints can lead to increased financial viability. The reduction in material cost by the addition of cement extenders can further reduce the cost difference.

The change in the cost composition is used to identify the focus areas for cost reduction efforts. The following observations can be made from Figure 2:

- 1) The notable reduction in the placement labour cost contribution is attributed to the improved workability of SCC and will be a generic result for the use of SCC in most concrete applications
- 2) The implication on 'other costs' is not included as a cost constituent on the SCC chart (due to the definition of the KPI)
- 3) Rework cost is negligible in both cases due to the assumption that 0.25% of the total concrete cost is representative of the rework expense associated with NCC and SCC rework is assumed to be 0%
- 4) The percentage cost contribution of formwork stays approximately constant, this means that total formwork expense will increase in the same order of magnitude as the total expense
- 5) The decrease in rework and placement labour cost is outweighed by the increase in material cost
- 6) Material cost is the largest cost contributor at more than 75% of the total cost.
- 7) Any cost reduction in material will translate to a noteworthy saving on the total expense
- 8) A 14-day time saving would be the result of SCC implementation
- 9) The total expected cost increase is R364 611
- 10) If R26 050 per day (R364 600/14) was saved on overheads due to the accelerated schedule, SCC usage would have lowered the total project cost

The use of SCC would have been the more expensive option for this case study, but it would have saved time (and overhead savings are excluded from the calculations). The cost increase could have been reduced by negotiating better material unit prices or by investigating the use of cement extenders.

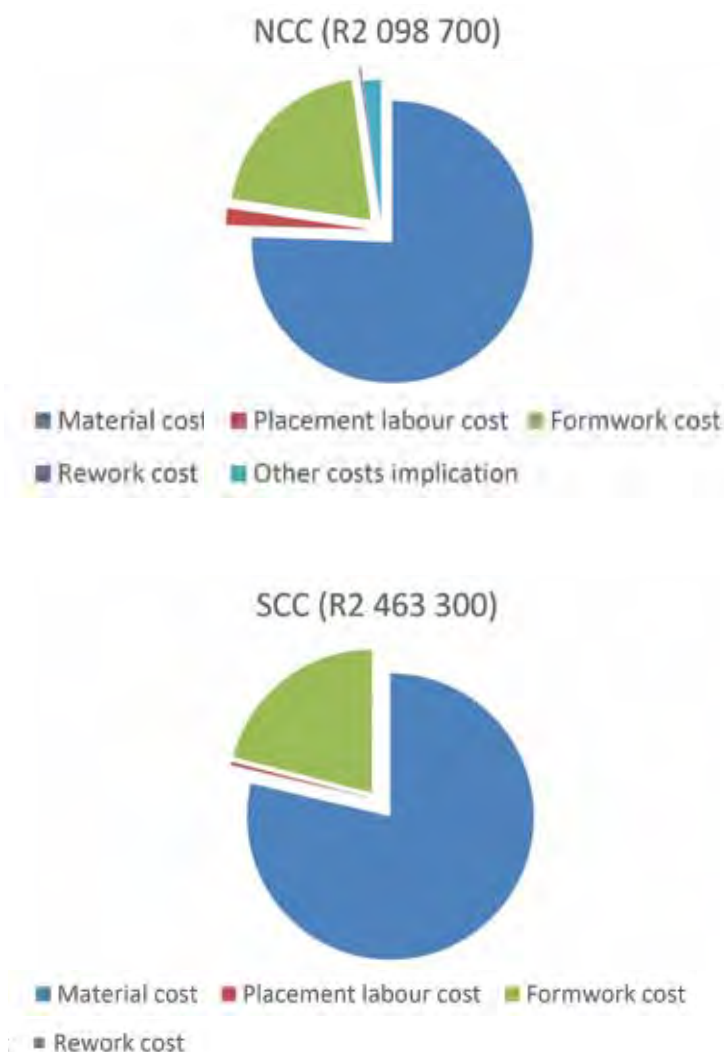


Figure 2: Overall cost comparison for SCC vs NCC

4.2 Heuristic results

After the static results have been calculated the following considerations can assist in choosing the data (inputs and KPI's) that should be included in the Monte Carlo analysis:

- 1) Can the input data be altered? (data such as element volume is fixed by design and cannot be altered)
- 2) Is there uncertainty in the source of the input data? (items such as construction time can be uncertain while formwork renting cost may be certain)
- 3) Does the input parameter have a large influence on the KPI? (does a 10% variance in the input parameter lead to at least 1% change in the KPI value?)
- 4) Is the specific project participant interested in the value of the chosen KPI? (contractors might be interested in the cost KPI's while clients might also be interested in the time KPI's)

If all four statements are true, then the KPI and the relevant input parameters should be included in the Monte Carlo analysis.

Eight parameters were identified as influential input parameters and were assigned statistical distributions. Ten thousand iterations were performed in the Monte Carlo analysis. The applicable output KPI's are calculated using the varying input values. Figure 3 shows the resulting distribution for the total cost difference of the overall project.

The estimated cost impact of using SCC is an increase of between 14% and 21% (R294 800 and R438 200), with a 90% confidence interval.

The resulting distribution can be used as part of a risk assessment for the implementation of SCC. It can help a project team to decide if they are able to accept the increased construction cost associated with using SCC for a specific concrete structure or element.

It is useful to analyze specific concrete casts to identify which elements are most suited for SCC use. The sensitivity of the individual concrete casts can be of interest to precast manufacturers or other organizations that construct small elements and who are looking for a method of optimizing the cost-quality-time trade-off.

This method of analyzing a specific KPI with the included variance in the input parameters can be done for any KPI of interest.

4.3 Case Specific Information

The parameter sensitivity analysis as calculated from the static model and the results from this analysis is case dependent and will change with varying project characteristics.

The sensitivity analysis is done to identify the input parameters that have the largest effect on the output KPI's. Three types of information can be extracted through the sensitivity analysis:

- 1) Identifying the top ten input parameters that have the most influence on the output KPI under investigation (cost management can be enhanced by focusing on these parameters);
- 2) The sensitivity of the KPI with regard to these ten influential inputs and if it is possible to lower the expected cost by managing these inputs (cost management efforts can be further prioritized);
- 3) Identifying the uncertain and influential input parameters to include them in the Monte Carlo analysis (Enhancing the accuracy of the results that are used to decide if SCC should be used at a project).

The results of the sensitivity analysis can be shown as tornado graphs for the evaluated KPI's. The sensitivity analysis yielded the following results for the specific case study:

- Five of the ten most influential input parameters are material unit costs;
- The SCC unit cost of externally supplied 'Mix1' is the most influential input parameter with regard to the total cost difference (Mix1 is used to construct the bridge deck, the element for which the most concrete is used in the case study);
- Mix 2, Mix 3 and Mix 4 are less influential because a smaller volume of these concrete mixes are used on site (compared to the volume used in the deck);
- The total number of concrete casts assumed to take place in a penalty period are influential to the total cost due to the savings in overheads and penalties that are dependent on its value.

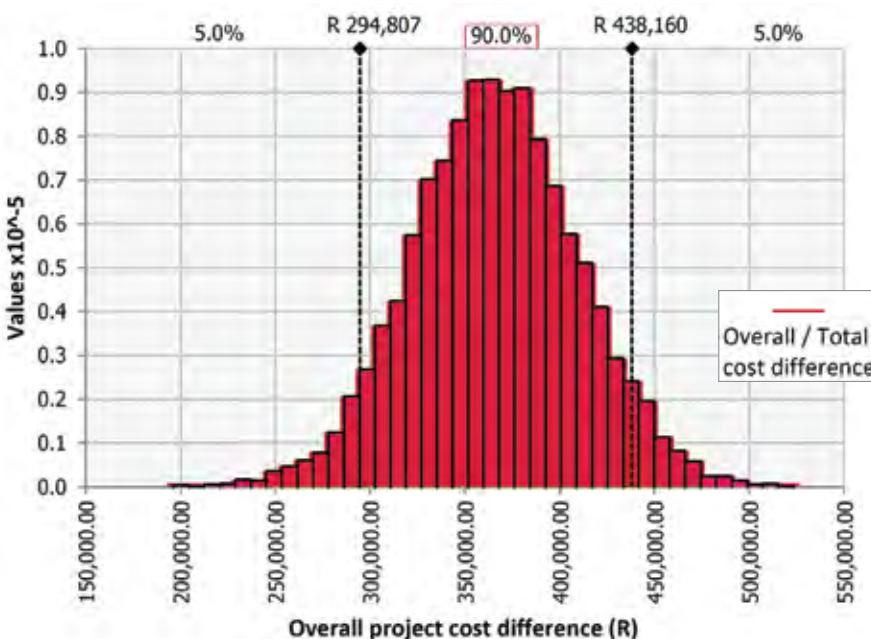


Figure 3: Probabilistic result for the total cost difference KPI

Continuing with the overall project cost difference KPI as an example, the results of the sensitivity analysis on this KPI is shown in Figure 4.

In a similar way, this can be done for any other KPI if the need should exist.

- A 10% reduction in the material unit price (from R1 565 to R1 408.50 per m³) of SCC Mix1 (used to construct the bridge deck) leads to a 32.3% reduction in the cost difference (R364 611 to R246 972);
- A 10% reduction in the material unit price of SCC Mix2 (used to construct the piling columns) led to a 13.4% reduction in the cost difference (R364 611 to R315 825);
- If a 10% cost reduction in all SCC unit prices can be achieved, it will lead to a reduction in the cost difference of approximately 55% (32.3% for Mix1 plus 13.4% for Mix2 plus 6.41% for Mix3 plus 3.01% for Mix4).

Note: A 10% reduction in the unit price of SCC is considered since the product has higher profit margins than NCC and a smaller market base.

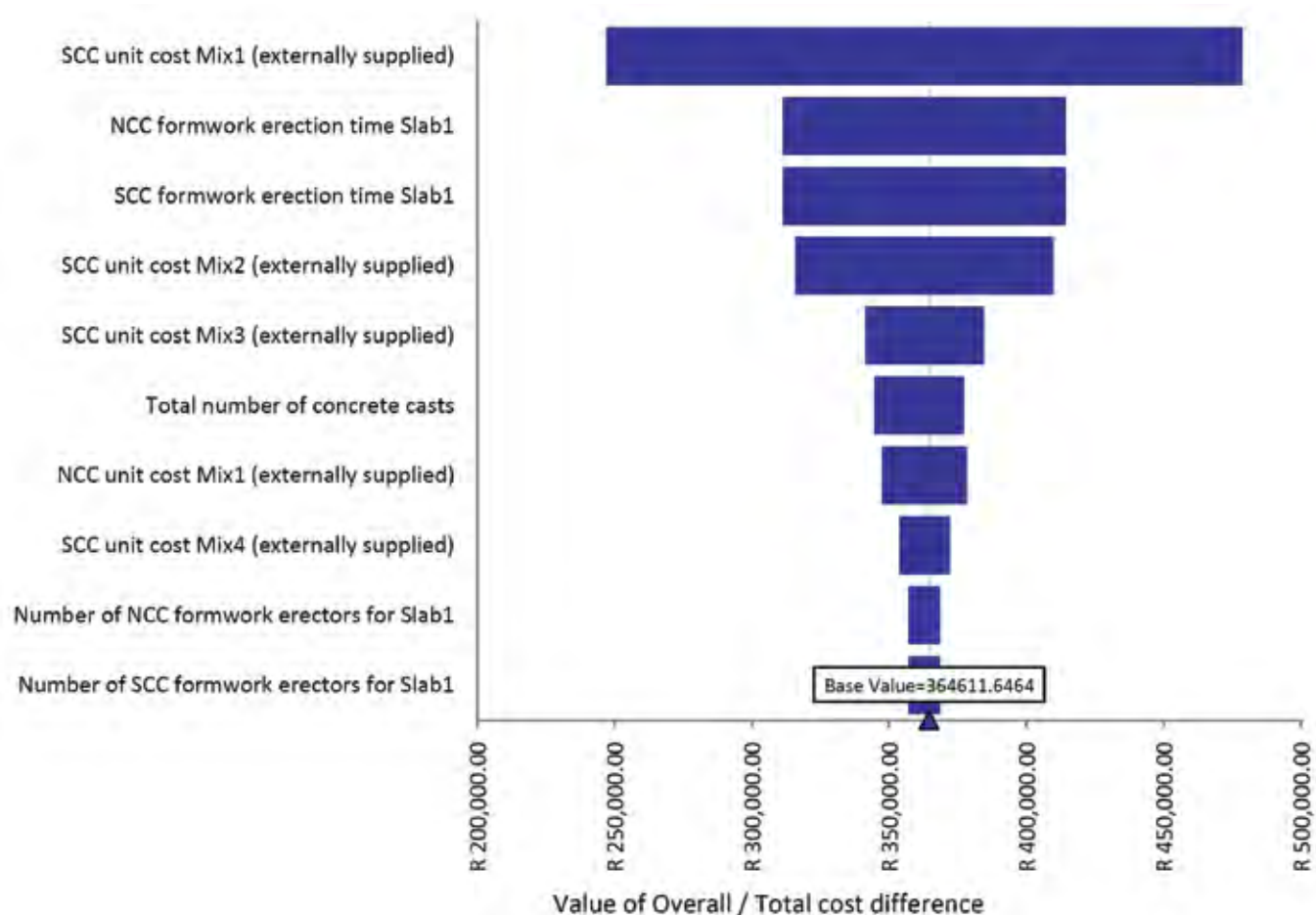


Figure 4: Sensitivity analysis of the overall project cost difference

This creates the opportunity for price negotiations, unlike NCC where profit margins are much lower and there is no room for further discounts.

- The two formwork erection rates should be disregarded (for the sensitivity analysis) due to the irregular use of the parameter in this case study
- The large cost contribution of slab elements towards the overall project cost difference (51%) is highlighted by the fact that six of the ten influential input parameters are related to the construction of Slab1, the six bridge deck spans

4.4 Generic Information

The value of breaking down the cost into the different constituents is the clarity that the breakdown provides about the following factors:

- The size of the cost contribution of every constituent towards the total cost (the total cost of an element or of the entire project).
- The extent and manner in which the size of the cost contributions changes for each constituent when SCC is implemented.
- How the cost impact information can be used to reduce the total project cost difference when choosing to use SCC.
- Identifying the results that are based on uncertain input variables and which should be included in the Monte Carlo analysis that forms part of the heuristic model.

The first point is addressed by the results presented in the pie charts (Figure 2). The second point is only to some extent addressed by the pie chart representation. The exact change that will occur for every cost constituent when SCC is implemented remains unclear. The KPI change

summary shown in Figure 5 shows the exact calculated change of each cost constituent when SCC is implemented on the case study project.

The information about how and to what extent a cost constituent change can be extracted from this KPI summary. The material cost difference for slab elements, the material cost difference for the overall project and the total cost difference of a slab will be evaluated as examples. The data table and the figure (Figure 5) show a 21% increase in the material cost of slab elements if SCC is implemented. This figure is a result from the model and it is based on the quoted unit prices of NCC and SCC as received from the concrete supplier.

The calculated material cost difference for the overall project is 22% if SCC is used, as shown in the data table of Figure 5. This figure is the weighted average of the change in the material cost of slabs, columns and walls (21%, 25% and 25% respectively). It is weighted in terms of the cost of the concrete volume used for each element type (based on the portion of the total concrete used to construct different element types and the cost of the specific mix design used in the construction of each element). The large portion of concrete used to construct slabs in the investigated project results in the 22% material cost increase for the overall project.

A 12.6% increase was calculated for the total slab cost of the investigated case study. This figure is also a weighted average. It is the weighted average of the cost difference in the formwork, labour, material, rework and 'other costs' as calculated for slab elements (0%, -81%, 21%, -100% and -2% respectively).

The pie charts (Figure 2) show the size (base value) of each cost constituent and the KPI change summary shows the exact change that can be expected if SCC is implemented.

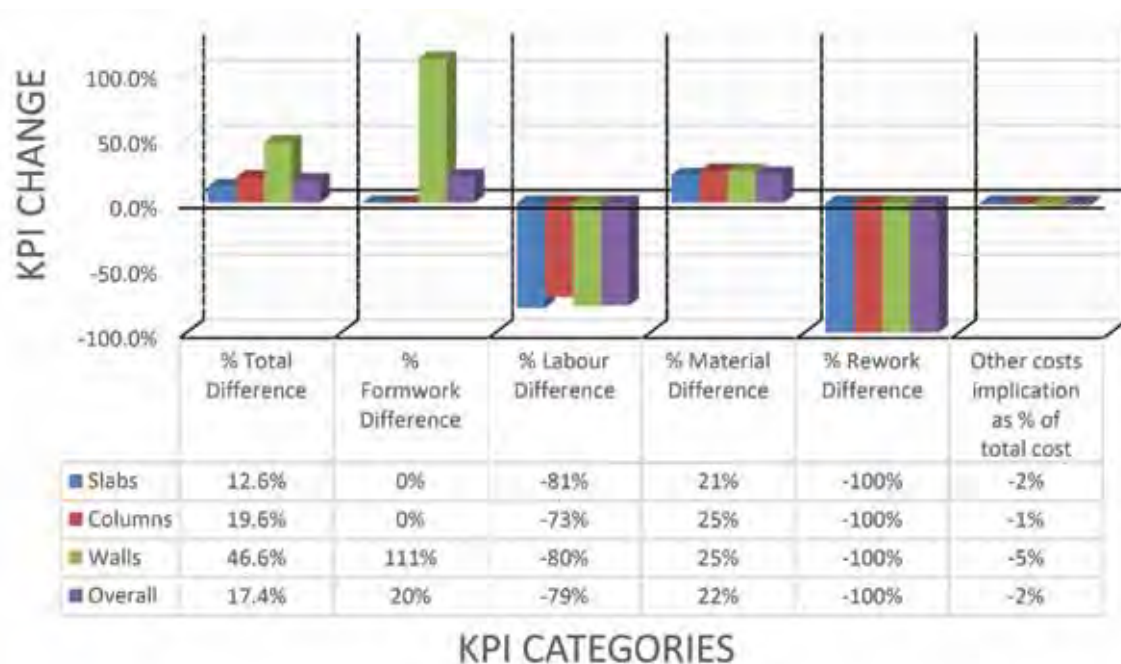


Figure 5: KPI change summary

The third point, how to reduce the total project cost difference with this information, can be addressed in the following ways:

- Based on the large contribution (refer to pie chart information in Figure 2) of material and formwork cost, as well as the increase in the percentage cost contribution if SCC is implemented (KPI summary), cost reduction efforts should be focused on these KPI's;
- Formwork costs can be reduced by negotiating lower unit prices for renting the formwork;
- Material costs can be lowered through unit price negotiations and/or the addition of cement extenders.

5 SECONDARY DEDUCTIONS AND CONSIDERATIONS FOR SCC USAGE

The following observations and deductions can also be made from the results and evaluation methodology:

- The labour intensity (man-hours per cubic metre of concrete placed) required to construct an element will indicate whether or not reductions in labour costs is worth pursuing (higher man-hours per cubic metre of concrete placed means a higher significance of labour cost reductions);
- The labour intensity usually rises as the size (volume) of an element reduces;
- A small element with a high labour intensity will render reductions in labour cost the most significant since these elements have the highest labour cost per cubic metre of concrete. This element type thus provides the highest financial incentive to be constructed with SCC since it will provide the most financial benefits in terms of labour savings;
- The outer surface to volume ratio will indicate whether or not reductions in formwork costs is worth pursuing;
- A larger outer surface to volume ratio indicates a larger contribution of formwork cost to the total cost and hence an increased importance of managing the formwork cost;
- The time that the formwork supports the fresh concrete will provide an additional indication of whether or not reductions in formwork costs is worth pursuing;

- If the formwork support time is short, then the percentage that the formwork cost contributes to the total cost is lower since the formwork is rented for a shorter time (e.g. vertical elements);
- The outer surface to volume ratio and the formwork support time should be considered together to make a final estimation on whether or not to pursue cost reductions for formwork;
- Any reduction that can be realized in the material cost will significantly enhance the economic viability of SCC;
- Off-shutter and high-quality concrete finish specifications will increase the contribution of rework cost to total cost. SCC can be used if a contractor is inexperienced with these specifications;
- The construction of smaller elements is more labour intensive (more man-hours per cubic metre of concrete used) than large elements. As elements get smaller, the contribution of labour cost increases;
- Projects with small and repetitive elements will show a higher labour cost contribution and a lower overall cost difference if SCC is implemented.

These findings are supported by the regular implementation of SCC in the precast industry in South Africa.

Considering the connection between element size and financial viability, hybrid-concrete construction projects can benefit from SCC implementation. The repetitive placement labour saving on small elements, manufactured in the precast yard, will lower the total cost of a project.

6 CONCLUSIONS

The results of the proposed economic evaluation methodology can be used to investigate the overheads that will render SCC advantageous due to the acceleration in the project schedule. The break-even figure for the investigated case study for overheads was R26 050 per day. If the overheads of the project were higher than R26 050 per day, SCC implementation would have reduced the total concrete related project cost.

A sensitivity analysis showed that a 10% reduction in the unit price of SCC would halve the total cost difference between the SCC and NCC options.

The low usage of SCC in the South African construction industry, compared to certain developed countries can be attributed to the material cost increase that SCC usage incurs for a contractor. When this increase is considered, together with the lowest tender award scheme and the fact that the client is the long term benefactor of SCC usage, it is understandable why SCC is not regularly used in South Africa. The relatively cheap labour and the absence of other restrictions (such as noise limits and strict equipment restrictions for urban areas) is a structural difference between the South African industry and those countries with higher SCC utilization. The structural differences, combined with the lowest tender awards structure in the South African construction industry, deprive the industry of incentives to harness more time-efficient and higher workability materials at an increased cost.

The cost difference between NCC and SCC can be minimized by means of cement extenders and logistical changes in the construction process. This can lead to increased SCC usage in the South African construction industry.

The methodology explained in this article can be used to identify the areas where cost management and cost reduction efforts can be focused for the greatest advantage, and the minimum risk, on a specific project.

7 ACKNOWLEDGEMENTS

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AfriSam contributes to growth of concrete product manufacturers

South Africa is home to a vibrant concrete product manufacturing industry, ranging from small to large scale manufacturers, with many of these turning to an independent third party to advise them on best practice in terms of concrete technologies.

AfriSam's Centre of Product Excellence has been assisting the country's leading concrete product manufacturers (CPMs) to optimise their concrete mix designs while at the same time reducing their total manufacturing costs by advising them on the best selection of materials for their production processes.

Mike McDonald, Manager of AfriSam's Centre of Product Excellence, says having access to this level of technical input and knowledge transfer is a significant advantage for many of these companies that do not have internal cement technologists. It is a given that this type of knowledge transfer allows these companies to gain a competitive edge in the industry.

"AfriSam, as the leading concrete solutions supplier, has the necessary depth of experience and access to skilled technologists who have an intimate understanding of concrete product manufacturing processes. Leveraging this, we are able to provide all CPMs with quality technical support," he says.

Importantly, the AfriSam Centre of Product Excellence has also helped many new players establish a presence in the market by imparting essential knowledge on the cement, aggregates and sand required to manufacture a quality product, and particularly early on in the conceptualisation stages of these factories.

McDonald says incorrect selection of materials not only has a significant impact on the quality of the end concrete product, but also on the cost of manufacturing. "For example, a poor quality aggregate could increase both cement and water usage," he says.



AfriSam's value-add to concrete precast manufacturers include on-site technical service, SANS accredited laboratory services and product deliveries around customers' requirements.

One of AfriSam's strengths is its vast footprint with 17 aggregate quarries countrywide that produce materials according to the South African National Standards (SANS) 1083 specification. McDonald says this has provided many of these CPMs the flexibility needed when locating their plants.

Based on its close interaction and collaboration with this market, AfriSam has also developed a cement that meets the unique requirements of the sophisticated Gauteng CPM market. AfriSam's Rapid Hard cement meets the high early and late strength requirements of the industry.

"Users of this constituent product, with its high reactivity rate and sophisticated mineral components, benefit from shorter setting times and quicker stripping capabilities, allowing quicker turnaround of moulds and optimal performance during the winter periods with their low ambient temperatures," McDonald says.

By using this AfriSam cement, CPMs have also reduced their cement consumption, while achieving better finishes and durability traits of their concrete products.

McDonald says it also facilitates the incorporation of downstream materials, such as slag. AfriSam has a regular supply of this material that is well known for its ability to enhance the performance of readymix concrete, while substituting as much as 50% of cement in the mix design.

The CPM industry continues to grow as professional teams realise the gains achieved by these technologies which often allow for faster, safer and more aesthetically-pleasing builds, and AfriSam's expertise is at the core of this trend. ▲



AfriSam is the only company that manufacture 52.5 Rapid Hard Cement as a standard product, ideal for applications such as highway barriers, roof tiles, retaining wall systems, culverts and concrete pipes.

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Thrifty cars floored by Sika

To completely revamp the severely cracked showroom floors at Thrifty Cars in Boksburg, Gauteng, Sika's Chad Tosen confidently specified four of its high performance products for Phase Two of the project.

Besides repairing the vast floor areas, the key focus of the project was to provide effective surface preparation to the poor condition of the concrete panels. Contractor, Daniel Masango Epoxy Coaters applied an enormous amount of Sikadur-52 ZA to fill and seal the numerous voids and cracks.

Sikadur-52 ZA is a solvent-free, two-part, low viscosity injection liquid, based on high strength epoxy resins. It provides good adhesion to concrete, mortar, steel, stone and wood, and not only forms an effective barrier against water infiltration and corrosion-promoting media, but also structurally bonds concrete sections together. Advantages in using Sikadur-52 ZA include its suitability for both dry and damp conditions even at low temperatures; shrinkage-free hardening and high mechanical and adhesive strengths. It is a hard but not brittle product, and may be injected on either horizontal or vertical surfaces using single component pumps.

Joint-sealing followed the surface preparation, with the application of Sikaflex PRO-3 iCure (Black), a one-part, moisture-curing, elastic joint sealant. Unlike many sealants and adhesives, products incorporating Sika's advanced iCure technology exhibit unsurpassed adhesion to porous and non-porous substrates, are solvent-free and completely odourless. Suitable for interior and exterior applications in a variety of situations including surfaces in the food industry, Sikaflex PRO-3 iCure can also be applied in cold temperatures. With a movement capability of 25% and bubble-free curing this sealant is in a class of its own.

The project proved a challenging one for the contractor; tasked with the renovation of vast floor areas measuring 3 600 m² and 1 400 m², working simultaneously with painting, window and roofing contractors, whilst the Thrifty Cars' business continued trading.

Once the floor areas were successfully prepared, they were primed with a coating of Sikafloor-161, a two-part, low viscosity, solvent-free epoxy resin. An economical, multi-purpose primer, it is easy to apply and provides good penetration, excellent bond strength and short waiting times. The final layer was a coating of Sikafloor-263 SL Plat grey, (at 2 mm thick) - a self-smoothing, broadcast system for concrete screeds

with normal to medium/heavy wear. Meeting multiple international standards, Sikafloor-263 SL is an economical, two-part, multi-purpose binder based on epoxy resin. It is highly fillable and liquid-proof with good chemical and mechanical resistance.

Although the project involved excessive preparations under difficult working conditions, the excellent flow characteristics of Sikafloor-263 SL were of great benefit and, after receiving a total Sika renovation, the showroom floors at Thrifty Cars are now as good as new. ▲

For more information on Sika products and systems, visit: www.sika.co.za



SIKA AG is a globally active specialty chemicals company with its South African Head Office based in Durban, and branches in all major SA cities. Sika AG, located in Baar, Switzerland, supplies the building and construction industry as well as manufacturing industries (automotive, bus, truck, rail, solar and wind power plants, facades). Sika is a leader in processing materials used in sealing, bonding, damping, reinforcing and protecting load-bearing structures. Sika's product lines feature high-quality concrete admixtures, specialty mortars, sealants and adhesives, damping and reinforcing materials, structural strengthening systems, industrial flooring as well as roofing and waterproofing systems. Sika has subsidiaries in 93 countries around the world and manufactures in over 170 factories, with some 17 281 employees link customers directly to Sika and guarantee the success of all partners. Sika generated annual sales of CHF 5.49 billion in 2015.

Many misconceptions about sustainable building, says The Concrete Institute

Concrete has a low embodied energy which is an important factor for 'green building', says Bryan Perrie, managing director of The Concrete Institute.

Perrie says embodied energy is the energy consumed for the raw material extraction, transportation, manufacture, assembly, installation, disassembly and demolition of a product system over the duration of the product's life. In the case of concrete, the embodied energy as a result of these processes is low and the total energy - when full life-cycle analysis is assessed - also low.

"The current average worldwide consumption of concrete is about one ton per year for every living human being which, cumulatively, is massive. It should, right at the outset, be remembered that buildings are not constructed out of cement but rather from concrete, of which cement is but one ingredient. While the embodied energy of a pure cement is very high at around 900kg/ton, when used in concrete with secondary materials, the embodied energy of concrete can be as low as 90kg/ton.

"In any event, the concern about cement's environmental footprint also stems from ignorance. Despite the extensive use of concrete, worldwide, the cement industry only accounts for about 5% of man-made carbon dioxide emissions: about 40% of this comes from burning coal and 60% from the calcination of limestone," Perrie states.

He says there are generally many misconceptions - and inadequate assessment ratings in place - when it comes to establishing true sustainability in the built environment.

"The Green Star system of the Green Building Council in South Africa and the LEED system in the USA, for example, award points for various sustainability initiatives during the design and life of the building. Unfortunately, this incentive often leads to chasing points for a particular rating rather than concentrating on real sustainability."

Perrie says aiming for zero levels in primary energy consumption, carbon emissions during construction, waste and water consumption, coupled with the total elimination of unsustainable building materials, would be more appropriate sustainability measures. "This has now become the quest of a few major corporations globally and, to me, is a far more pragmatic approach as it focuses on sustainable issues by setting targets rather than just scoring points. The 'zero' target may not be easy to achieve but it is a worthwhile target to strive for."

The Concrete Institute also believes that not enough attention is being paid to the "use phase" of a building or structure, which stretches from the initial extraction/production/construction phase right through to the end of life of the structure. "Research has shown that the long-term, cumulative benefits of considering the whole life cycle of structures are staggering. This is a factor that simply cannot be ignored when it comes to assessing true sustainability in building," Perrie adds.▲

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Concrete's low embodied energy contributes to sustainable building, says The Concrete Institute.



Setting targets on sustainable issues rather than just scoring 'green' points would produce a greener planet, says Bryan Perrie, MD of The Concrete Institute



CHRYSO's Jet Park 'green' manufacturing facility

Chryso drives future sustainability by investment in innovative product and service development

Innovation is necessary to develop products and services that underline environmental stewardship, according to Andries Marais, General Manager – operations at CHRYSO Southern Africa.

Marais believes that in order to create a sustainable future for Earth's inhabitants, it is critical that organisations contribute positively to the preservation of non-renewable resources.

He suggests that organisations allocate a predetermined percentage of turnover for research and development into products that focus on energy reduction in their manufacturing process. The CHRYSO Group invests approximately 4% of all global sales in the investigation of green product innovations that are based on bio sourcing, renewable resources and biodegradability principles.

The goal is to emphasise product lines that assist customers in promoting their energy efficiency while simultaneously reducing their carbon footprint. Marais says that ongoing review of CHRYSO's existing product portfolio and a customer needs analysis results in the development of approximately 30 new CHRYSO products each year with an average of 12 product patents filed annually.

Marais suggests organisations take a critical look at the way in which they operate their processing and manufacturing plants to ascertain how they handle natural resources. He cites the CHRYSO Group's Green Factory Model which has been adopted by the Cape Town, Durban and Jet Park plants. Careful thought has been given to a wastewater management system, a rainwater catchment programme and a sludge waste management system to minimise negative environmental impact.

In addition, CHRYSO places great emphasis on the use of non-hazardous materials and the implementation of recycling initiatives. Marais says that companies should consider demarcating a specific area in their facility where collection bins for glass, paper, plastic, metal and wood are placed and employees are encouraged to participate. The recycling initiative is echoed in CHRYSO's use of recycled packaging

wherever possible, and bulk deliveries of products to maximise load capacities and reduce the use of non-renewable fuel resources.

Some examples of products that are underpinned by good environmental stewardship are CHRYSO® Dem Bio 10, a biodegradable vegetable based demoulding oil; CHRYSO® Deco Lav P, a range of aqueous based surface retarders; CHRYSO® Environmentally friendly cleaning agents and EnviroMix®, a technology engineered to boost the use of cement extenders reducing the use of clinker without comprising on the quality of the concrete or cement product.

Marais points out that sustainability should also extend to the development of an organisation's employees and the communities adjacent to manufacturing and processing plants.

"In addition to bringing all stakeholders on board with environmental awareness programmes, there should be an emphasis on accountability to encourage safe practice both in the workplace and at home. Together with commitment to environmental compliance and certification programmes such as ISO 14001, these elements will make a great contribution to preserving resources for the future," Marais concludes. ▲



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Andries Marais

Ordering concrete responsibly

A family on their way to school in the mornings gets crushed by a runaway concrete mixer, a shopping centre collapses onto shoppers, or aquatic life in a river upstream from a national Park gets destroyed by effluent from a rogue readymix concrete plant.

These are scenarios that may happen if specifiers and builders deal with unscrupulous readymix concrete suppliers who have no regard for health and safety standards, environmental protection and quality controls. Even during the toughest of economic times it never pays to cut corners when procuring readymix concrete, as the implications may have far-reaching consequences for businesses and individuals.

By insisting on only using readymix suppliers who are accredited by the Southern Africa Readymix Association (Sarma), one is immediately assured of the fact that the company conforms to all requirements for the safe and sustainable supply of concrete, as well as meeting strict requirements for quality and road safety as laid down by the association.



Testing should be done according to procedure

Insist on sustainability

According to Sarma general manager, Johan van Wyk, unless standards are specified by professionals, there are no regulations in place to govern the manufacture and supply of quality readymix concrete in South Africa, and that is precisely why Sarma was established in order to formalize and self-regulate the industry. Through its system of annual auditing and accreditation of plants, the association is able to provide

Johan van Wyk of Sarma



buyers with assurance of compliance with its standards that are based on international ISO measures.

He explains that while anyone can mix and manufacture concrete, it needs to be done in a measurable and sustainable way to ensure consistent quality. High levels of technical expertise are also required in order to mix and manufacture more specialized types of concrete to ensure products are made to specifications and are fit-for-purpose in the application involved.

Readymix manufacturing plants should also have the correct equipment, skills, access to quality materials as well as acceptable procedures, to ensure the quality of concrete. Furthermore, health and safety requirements need to be in place and adhered to by everyone on the site. Vehicles operating from the site need to comply with all local and national road regulations and drivers need to be properly licensed and trained to operate these type of vehicles.

Growing trend

Equally importantly the plant may not negatively impact the environment and needs to conform with all regional and national regulations relating to the environment as well as water usage requirements etc. It should also be a good neighbour and not negatively impact on surrounding communities.

As a result of the Association's ongoing efforts to regulate the industry, large construction companies, roads agencies, municipalities, utilities and provincial Government departments have come to recognize the value of insisting on Sarma-accredited concrete and currently specify Sarma accredited concrete on their sites. Others are following suit and as awareness spreads among industry stakeholders, an increasing number of organizations are adopting the same principles.

Johan explains the system used for accreditation and ongoing verification through annual audits which are supported by unannounced audits from time-to-time to ensure standards are always upheld. Only once these criteria have been fully met will a company receive accreditation on an ongoing basis. "Our concrete goes beyond just meeting SANS 878 specification and outlines some of the procedures that Sarma-approved readymix goes through before being delivered:

1. Material control is conducted on all required raw materials including cement which has to be SABS approved; extenders also need to be certified by the SABS; admixes need to comply with SANS 878; water must be within acceptable limits and aggregates to specification. Material history also needs to be established to ensure that it is traceable in the event of problems occurring.
2. Once mixes have been formulated and concrete mixed, the plant will then undertake yield testing of a cubic metre of concrete in compliance with SANS 61250 test procedures. Checks are done for masses and densities on aggregate.



Sarma members' plants need to comply with all relevant legislation as well as meeting Sarma's own strict requirements

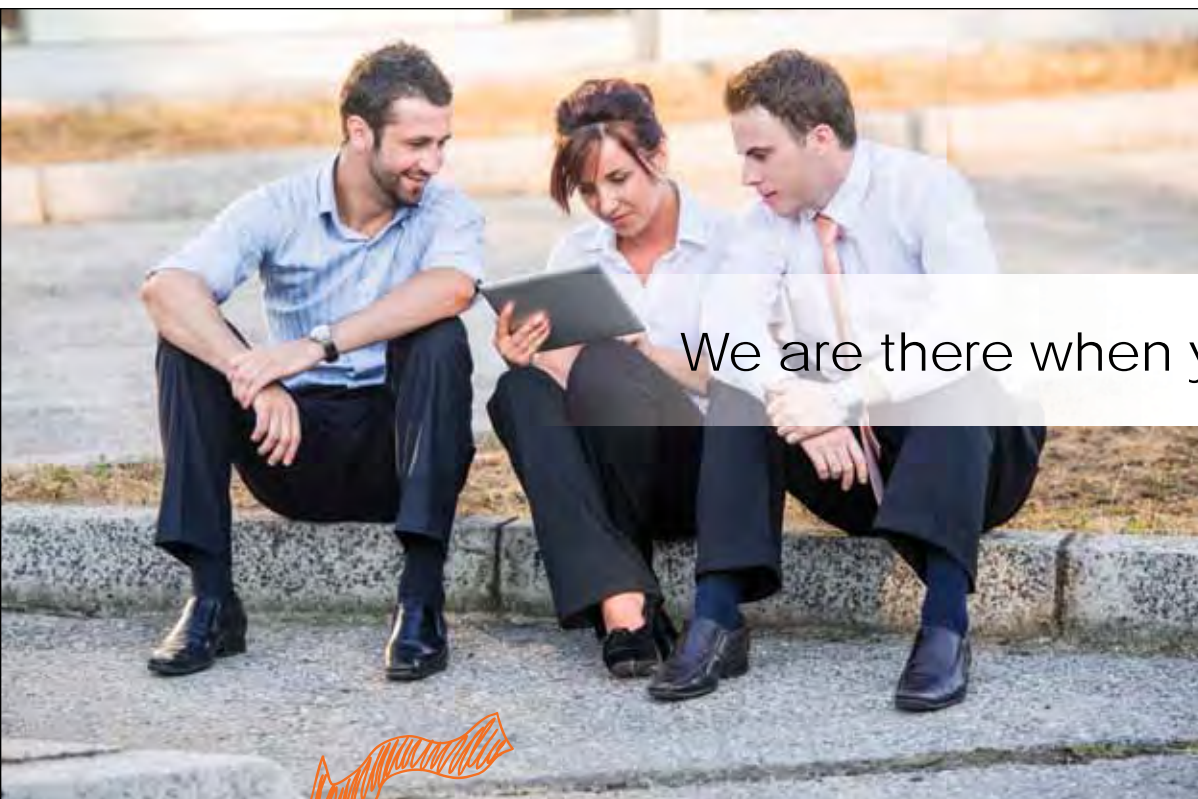
3. The means and accuracy of measurement is predefined and needs to be carried out according to procedures. All readymix in South Africa is mass-batched and therefore needs to adhere to accuracy level tolerances of 2% for cement, admixtures and extenders and 3% tolerances for aggregates. Moisture checks also need to be done according to procedures and all measuring equipment needs to be calibrated and recorded. Machinery and equipment on the plant also needs to be carefully maintained and checked to prevent intermingling of materials, leakages, spillages and spoilage.
4. Records of all mixing needs to be kept and filed for several years in accordance with legislation. Information required will detail mix designs, moisture readings, slump tests and strength testing results of the concrete. Sampling and testing needs to be done according to prescribed procedures at internal laboratories or outsourced laboratories. Cast cubes of concrete per batch need to be cured according to standards and records made and kept for future reference after testing. Other tests may be specified for different types of concrete.
5. Meanwhile, the plant manager will gather and use statistics gathered from the manufacturing process to hone the site to ensure that quality remains consistent and that any deviations are rectified. In addition, the statistics can be used to maximize acceptable deviations, so as to improve the efficiency of the plant. In doing so, the plant manager strives to produce the highest possible quality of concrete that is produced in an efficient manner in order to ensure the product is competitively priced.
6. Upon receipt of an order the company staff are also required to record information relating to the order to ensure that the client's requirements are met, and to record any changes that may be required later on. They will provide a quotation that contains the required specifications, delivery requirements, workability etc. and will require the client to sign-off on the quotation before processing the order. This is in line with transparency requirements of the association and to minimize conflict at the point of delivery.

Order responsibly

"These are just some of the requirements that need to be met for each load of concrete delivered by accredited members. They also need to work within the close confines of approved management systems, all relevant legislation and our own association wide requirements. In addition, we suggest that customers ordering concrete from our members be as specific as possible and make the fullest possible use of our members' expertise to ensure they get the very best from their concrete.

"Rather than saving a few rand per load of concrete delivered we urge specifiers and buyers of readymix concrete to look at the bigger picture and insist on approved concrete from Sarma members. The lives of loved ones, quality of life of surrounding communities and success of construction projects may be at stake," concludes Johan. ▲

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Revelstone's Worcester split cladding provides an attractive backdrop at the entrance to one of Mayfair's parking basements.



One of the elevated courtyards where Revelstone's Ravine and Random Edge pavers were used to delineate and embellish gravel sections.



Kent Random Edge pavers interspersed between lawn and flower beds create an attractive and durable path.



A combination of Revelstone paving, tiling and cladding products make for an imposing staircase.

Concrete pavers enrich Century City development

Revelstone has supplied a selection of paving, tiling and cladding products, for the landscaping and beautifying of Mayfair, a Rabie Property Group mixed residential and office park development in Century City, Cape Town.

The project was jointly designed by Tim Hughes of Tim Hughes Architect and Michael Borgström of Archilab and the landscape architecture was handled by Jacques Dohse of Planning Partners. Big Ben Construction was the main contractor.

The Revelstone product suite was specified by the professional team to enhance external building façades and to provide linear aesthetic expression to two garden courtyards which form part of the development's residential component.

"We used Revelstone's Ravine and Kent Random Edge pavers to create linear bandings to contain and delineate the gravel sections and to provide stepping stones in some of the soft landscapes," explained Jacques Dohse.

"We chose Revelstone pavers due to their consistent quality. Moreover, because the pavers were loosely packed on a layer of Bidim rather than on a concrete haunch, the extra weight of the Revelstone pavers was an added advantage. Over time the courtyards will be fully hedged and this will add a further linear dimension to them," added Dohse.

A combination of Revelstone products was used to beautify the residential blocks' external staircases.

Ravine tiling was employed to finish off the top of the concrete balustrade and Worcester split cladding gave the balustrade walls a rock like facade. The actual stairs were paved with Ravine Bullnose pavers. Another smaller external staircase was tiled with Ravine Bullnose.

Commenting further, Dohse said the two garden courtyards were raised 700 mm to a metre below the finished patio level of the first residential block, and retaining walls were built around the perimeters.

"We felt that dropping the courtyard to the same level as the parking basement would have meant locating it in a sea of parking. Moreover, the value of the courtyards would have been lost to the homeowners because the gardens would have been situated two metres lower than the patio levels of the ground floor units.

"Raising the courtyards allowed direct visual interaction with the ground-floor units and gave us the elevation needed to create natural water features comprising ponds, waterfalls and streams.

"Rabie prefers its landscaped areas to be quite soft using lawn and indigenous plant life. However, the back ends of the courtyards at The Mayfair are shaded and this prevented us from grassing these areas. So we decided to create a hard landscaping experience using gravel and Revelstone pavers," concluded Dohse. ▲

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AfriSam contributes towards learning possibilities for Johannesburg youth

Leading concrete materials company, AfriSam has sponsored concrete to the value of R100 000 for the construction of a skate park in central Johannesburg. The skate park forms part of a unique Skate School built by the award winning non-profit organisation, Skateistan, which provides programmes combining skateboarding and education to empower youth.

The objective of the Skateistan Skate School is to provide at-risk youth, between the ages of 5 and 17 from low-income families, with a safe space to learn and play. The Skate School offers students the opportunity to play and learn as part of the Skate and Create programme, or to access homework help and career advice as part of the Back-To-School programme. Exceptional youth will have the chance to join the Youth Leadership programme to help organise events and assist with sessions.

The Skateistan Skate School opened to registered students on 1 August 2016 and will offer weekly programmes to over 300 students in 2016, and more than 400 by the end of 2017.

SKATEISTAN is an award-winning international non-profit organisation that empowers youth through skateboarding and education. Over 1500 at-risk youth attend Skateistan's programmes every week in Afghanistan, Cambodia and South Africa. Through innovative programmes such as Skate and Create, Back-to-School and Youth Leadership, Skateistan aims to give youth the opportunity to become leaders for a better world. skateistan.org // @skateistan

Commenting on the company's sponsorship, Victor Bouguenon, marketing manager at AfriSam says, "We are proud that our contribution to the Skateistan Skate School will facilitate learning possibilities for the youth of Johannesburg."

Bouguenon says that AfriSam is not about what its concrete makes, but all about what its concrete makes possible. "Making a difference extends far beyond AfriSam's products and what these products can create. We are the brand that helps create spaces that foster life, relationships, stories and growth. At AfriSam, we are about creating concrete possibilities."

The Skate School is also a good fit with AfriSam's corporate social responsibility (CSR) focus on education. The company is involved in various educational projects nationwide, with the aim of empowering and equipping communities with the necessary knowledge and skills, as well as providing them with the tools and facilities to become self-reliant by facilitating sustainable initiatives.

Bouguenon says. "The ethos of creating concrete possibilities is deeply entrenched in the company's philosophy and values, and this is underpinned by many of the company's business practices which clearly demonstrate its commitment to a lasting legacy." ▲

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Lafarge South Africa leads by achieving Global GreenTag® certification



Lafarge South Africa recently became the only building materials company in the country to provide the construction industry with environmentally-friendly level C Global GreenTag® certified products.

Three of the company's value-added global brands, Agilia™, Artevia™ and Hydromedia™, were all successfully certified by the internationally-recognised Global GreenTag® ecolabel at the end of June. This achievement places Lafarge South Africa at the forefront of green building in the local industry, thus contributing to sustainable development through energy conservation and protecting natural resources.

The global brands were scored against the six main sustainability assessment criteria (and another twenty plus life cycle and social criteria), namely; greenhouse gas emissions, biodiversity, health and ecotoxicity, life cycle analysis, synergy (product efficiency) and social responsibility and labour conditions.

The Global GreenTag® certification standards are recognised in Australia, New Zealand, Malaysia, South Africa, Africa and SE Asia and in over 70 other countries.

The company's global brand products will boast the Global GreenTag® ecolabel and QR code for the next year until the time comes for a reassessment.

"The effectiveness of our company's green solutions is not only reflected in our rapidly growing track record of involvement in building projects with highly-ranked Green Star ratings registered by the Green Building Council of South Africa (GBCSA), but now also in our newly Global GreenTag® certified global brands", says Alta Theron, General Manager: Readymix at Lafarge South Africa.

Lafarge South Africa's highly-experienced team, led by Building Marketing Head, Herbert Groenewald, was instrumental in seeing the intense Global GreenTag® certification process to successful fruition.

Designers who specify the global brands as finished surfaces, walls and floors will be able to do so easily and confidently as research, analysis and reviewing of the product's standards has already been done.

"We are able to provide architects and engineers with a wide range of well-integrated efficient building systems that not only contribute to energy conservation and lowering the carbon footprint of their designs, but also contribute to credit towards their Green Star interior rating", added Theron.

Green Star buildings have reduced operating costs, achieve 5% higher rental income and the overall asset value increases by 12%. ▲



Lafarge South Africa launches another industry first

Lafarge South Africa have launched another industry first, this time, offering the EkhayaBag, an innovative ready-mix solution of smaller quantities of mortar, concrete or Artevia™ Colour delivered to site in bags and ready to use.

The EkhayaBag simplifies building as customers don't always require big amounts of concrete for their projects. Using this product, customers don't need to purchase cement, sand or stone separately, as the EkhayaBag is delivered ready to use. No additional water or mixing is required, resulting in cleaner job sites.

"We are the first building materials company in the country to provide this unique value proposition, once again proving that we put innovation at the forefront of our business, and that we are always aim to provide solutions to our customers' needs," said Alta Theron, General Manager for Readymix at Lafarge South Africa.

The EkhayaBag's name is derived from the isiZulu term 'Ekhaya' which means "At home".

"Homes are a pivotal part of communities and at the heart of our company's ambition of Building better communities through our range of innovative products and solutions," added Theron.

One EkhayaBag contains 0.5 m³ (500 litres) or approximately 1 200 kg of material. The EkhayaBag product range includes:

- EkhayaBag concrete: available in two grades and can be used for domestic foundations, garage and house floors to light commercial floors, concrete walls and columns.
- EkhayaBag mortar: available in a 12, 24 and 48 hours' workable mix and can be used for laying masonry units such as bricks, blocks and stone.
- EkhayaBag Artevia™ Colour: a range of pigmented concretes in sandstone, mahogany and charcoal colour tones and can be used for floors, driveways, braai areas, swimming pool surrounds and patios. ▲

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Prestressed slabs specified for naval security wall

Some 3 400 pre-stressed hollow-core concrete slabs are being used to construct a five kilometre security wall for the Department of Public Works at South Africa's naval base in Saldanha.

Designed by Delta Built Environment Consultants in close collaboration with leading prestressed hollow-core concrete slab manufacturer, Topfloor, the wall is being erected by KP Construction, the project's main contractor.



Topfloor contracts manager, Norlando Nomdoe, stands on one of the concrete foundations.



A Topfloor wall slab is offloaded prior to installation between the steel H sections.



An inner section of the Saldanha wall in which the attractive V-shaped indentations between the slabs are clearly visible.

According to Topfloor director, Wessel Prinsloo, the slabs are being precast at Topfloor's Cape Town factory where they are prestressed with steel reinforcement before being delivered on flatbed trucks to Saldanha.

"Prestressing provides hollow-core slabs with additional strength and the slabs being used for the Saldanha wall boast a strength rating of 50 MPa plus. As a result, nothing short of mechanised demolition equipment or high explosives would make any sort of destructive impression on the wall. This is why prestressed slabs are being used on an increasing basis to safeguard property of strategic importance or high value in other parts of the country," advises Prinsloo.

The wall is being built to a simple yet effective design which uses galvanised steel H sections to support the six-metre-long slabs. The H sections are bolted onto six threaded bars cast into the reinforced concrete foundations. These extra heavy duty foundations were specified by Delta to ensure that the wall can withstand the frequent and sometimes gale-force winds prevalent on this stretch of coastline.

The wall follows the natural contours of the undulating fynbos-strewn land and rises 3.2 and 4.2 m above ground level; a section of approximately 400 mm is buried below ground.

Construction, which began in December 2015 and is due for completion by the end of 2016, is effected by hoisting the slabs using a truck-mounted crane. A special grab mechanism had to be designed by Topfloor to lift and install the slabs. The crane has sufficient reach to service three wall bays from one location. Once installed, the slabs are caulked into the H sections with a plaster sand and cement mix.

Part of the contract involves the planting of a line of various types of trees on the outer perimeter of the wall to add a green and aesthetic element to what would otherwise have been a stark monolith.

Additional aesthetic appeal is achieved by mounting the panels so that the slabs' smooth soffit sides are positioned on the outer (public) side of the wall. Moreover, the slabs have been cast with bevelled edges which form V-shaped channels where the slabs meet to further enhance the appearance of the walls.

Prinsloo says there are several advantages to this type of walling, speed of construction and the superior strength of the wall being major considerations.

"Eight to 10 bays or 48 to 60 linear metres are completed daily (eight hours). A conventional masonry wall, which is not nearly as strong or durable, would have taken two to three times as long to build.

"The cost of constructing a security wall using prestressed hollow-core slabs is considerably less than an in-situ wall offering the same properties. Moreover, precast walling requires no shuttering or propping, onsite curing, formwork or grouting.

"As with other walls built with prestressed hollow-core panelling, the Saldanha wall will have a very long life span. It is maintenance free, and other than occasional cleaning, no other servicing is required. The slabs can also be dismantled and re-used elsewhere," adds Prinsloo. ▲

Contact: Wessel Prinsloo, Topfloor, Tel: 021 951 7700, David Beer Tel: 011 478 0239 / 082 880 6726



Figure 1: Attendees at the 'Workshop on Research Priorities in Cement & Concrete in South Africa', University of Johannesburg.

Workshop on research priorities in cement and concrete in South Africa

Information for benefit of members of CSSA, *by Mark Alexander (University of Cape Town)*

1. INTRODUCTION AND BACKGROUND

A Workshop on Research Priorities in Cement and Concrete was held at the University of Johannesburg, and sponsored by The Concrete Institute and the Concrete Society of Southern Africa. It was convened based on a perception that it was important for active researchers in cement and concrete in South Africa to communicate their work to the broader cement and concrete industry, and for the industry to indicate their research concerns to researchers. Similar workshops had been held at regular intervals up to the early 2000's, but had fallen into abeyance.

The workshop was preceded by a call to active researchers and to representative industry members to support and attend the workshop. Selected industry representatives were asked to present their view on research priorities, while researchers were asked to present their current research areas and topics.

The presentations at the workshop were followed by an open forum discussion chaired by Dr Hylton Macdonald, in which common understandings were sought and from which a matrix of research needs and research activities was identified to inform future research directions.

This short report is intended to inform Concrete Society members on the main outcomes of the Workshop and to give them an opportunity to comment on needed research going forward.

2. LIST OF PARTICIPANTS

Invitations were sent to a broad range of industry, including the major companies involved in cement manufacture and concrete construction. In total, the workshop was attended by 31 people. A photograph of the attendees is given in Figure 1.

3. PROGRAMME AND SPEAKERS

Presentations on research were made by representatives from the research-active universities, viz. (in alphabetical order) the Universities of Cape Town, Johannesburg, Pretoria, Stellenbosch, and Witwatersrand. (The Council for Scientific and Industrial Research (CSIR) had been invited to the workshop but did not make a presentation). Product-specific research is carried out by various companies in the Cement and Concrete Industry, but otherwise there are no other active research entities in South Africa in this field, to the knowledge of the workshop organisers.

Industry speakers were drawn from AfriSam (cement producer); Jones & Wagener (consultant) Murray & Roberts (Contractors), PPC Cement (cement producer), StefStocks (contractor), Transnet Freight Rail (national infrastructure agency), and Ulula Ash (cement extender company). SANRAL (national infrastructure agency) made input by being included on the forum during the afternoon session.

The full programme and speakers can be found on the TCI website – see footnote 1.

4. WORKSHOP OUTPUTS

As mentioned, the workshop consisted of presentations from industries and active researchers, and an interactive discussion session. Using these inputs, the main output of the workshop was the compilation of a Topic Matrix of research needs and activities, shown in Figure 2, described and summarised briefly below.

- The topic matrix comprises a series of columns (I-VII), giving the research activities of the different universities, and a series of rows (A-H) representing the research needs of the industries. The particular universities involved in a given area of research are also given in the matrix in the respective columns.
- The needs or interests of the various industries are represented by the rows, with a particular company being identified by an acronym in the relevant cells of the matrix. Summarised details of the industry and university topics are given below the matrix.

The topics and research needs were gleaned from the workshop presentations and discussions.

- The matrix matches research activities with industry needs. Thus, for example, the industry need of "Durability and reinforced concrete corrosion" is linked with the university topic "Concrete deterioration and durability". Shown in the relevant block in the matrix are the specific companies that indicated the particular research need; in the case given here, they are Transnet FR, Murray and Roberts, StefStocks, and SANRAL. Other matching topics are given in the relevant blocks in the matrix.

4.1 Evaluation of the Topic Matrix

It is immediately apparent from the matrix that the needs of industry are in large measure being addressed by the university researchers, at least in broad outline. It may well be that specific research concerns in these

1 A copy of the report, together with copies of the presentations, are available on the TCI Website: <http://www.theconcreteinstitute.org.za/#research-priorities-workshop/bn7u9>

UNIVERSITY TOPICS		Concrete deterioration and durability	Cements, new and blended; hardened properties of concrete	Fibre reinforced concrete, HP & HS concretes	Sustainability and environmental impacts	Structural integrity and health monitoring	Cracking potential and thermally induced cracking	Standardising new construction materials	Concrete pavement overlays (UTCRCP)
		I	II	III	IV	V	VI	VII	VIII
UNIVERSITIES INVOLVED		UCT, US, Wits, UJ, UP	UCT, UP, Wits, UJ	UP, US, UJ	UCT, US, Wits, UJ, UP	UCT, UJ	Wits	US, UP	UP
A	Durability and reinforced concrete corrosion	TN, MR, SS, SR							–
B	Field testing & behaviour of cements & concrete		PPC, AS, TN, UA, SS, SR						–
C	High performance concrete			AS, TN					–
D	Sustainability, community involvement, environment				PPC, MR, JW, SS, SR				–
E	Repair methodologies and materials					TN, MR, JW, SS, SR			–
F	Heat of hydration, temperature effects on concrete development						TN, JW, SS		–
G	Code related work, translation of research into local codes, performance parameters and testing regimes							PPC, UA, JW, SS, SR	–
H	Slabs & pavements	–	–	–	–	–	–	–	JW, SR

Industry topics

- A Concrete deterioration and durability**, including AAR, sulphate attack and sulphate resistant concrete; developing and refining specifications for durability
- B Field testing of concrete. Behaviour of cements outside of the lab and in the field:** Portland cement systems, FA and Slag concretes and their limits, understanding new cements, fibre reinforcing and polymer concretes
- C High performance (HP) concrete**
- D Sustainability: community involvement, environment**
- E Repair methodologies and materials:** Viability of repair costs and maintenance of existing structures eg. Tunnels, bridges, buildings. Concrete crack repair and bonding old and new concrete.
- F Heat of hydration and temperature effects on concrete development:** thermal expansion, delivery temperatures of fresh concrete and their effects on curing time and strength development.
- G Code related work**, translation of guidelines/research into local codes, performance parameters and testing regimes
- H Slabs & pavements**

AS AfriSam
PPC PPC Cement
TN Transnet FR
MR Murray & Roberts
UA Ulula Ash
JW Jones & Wagener
SS StefStocks
SR SANRAL

University topics

- I Concrete deterioration and durability:** developing and refining specifications for durability, carbonation and chloride induced corrosion models for cracked and uncracked reinforced concretes
- II Cements, new and blended:** use of pozzolanic materials, geopolymer concrete, FA and Slag substitutions. Hardened properties of concrete, cement chemistry.
- III Fibre reinforced concrete, high performance and high strength concretes**
- IV Sustainability and environmental impacts**
- V Structural integrity and health monitoring. Structural effects of deterioration.** Dynamic assessments, repair and strengthening, vibration serviceability and non destructive testing of concrete using various electronic sensors. Repair methods, patch repair, mortar design and bonding old to new concrete.
- VI Cracking potential of concretes and thermally induced cracking;** heat of hydration effects
- VII Standardising new construction materials;** including code development
- VII Concrete pavement overlays (UTCRCP)**

Figure 2: Topic Matrix, showing research needs of industry, and research activities of universities

different topic areas are not being addressed, but it is noteworthy that industry's needs are being covered to a large extent. This indicates that the researchers have a good sense of what the industry needs are, and are alert to the requirements of industry.

4.2 Open Panel Forum

A summary of the open panel forum and the points discussed therein are given in Appendix 5 of the full Workshop Report available on the TCI website (see footnote 1). The details noted in abbreviated form therein are very useful, and can be taken as further elaboration of the research needs of industry, for the information of researchers and of Concrete Society members.

5. CLOSURE AND WAY FORWARD

The Workshop on Research Priorities in Cement and Concrete succeeded in its aim to bring together representatives of the relevant industries and active researchers, to discuss common concerns for concrete research. A noteworthy alignment between industry's needs and current research topics was apparent from the workshop, taken in broad outline. However, it is also apparent that not all specific industry topics within the broad alignment areas are covered by the researchers. These aspects can be addressed by the relevant industry representatives with the universities concerned, while the workshop outputs give details for the researchers in this regard.

The outputs of this workshop are commended to all relevant and interested parties for on-going discussion between industry and researchers. The workshop also served to sketch the broad scope of

current research (2015) in the relevant South African universities, and indicates a sensitivity on the part of the researchers to the needs of industry, whether explicit or implicit. The outcomes of the workshop will be carried forward as follows:

- The Workshop Report has been distributed to all attendees and sponsors; as mentioned, it is also openly available via the TCI website.
- This brief report for CSSA is being published in Concrete Beton for information of CSSA members in particular. It also serves as a more general invitation for further comment – see below.

In the medium to longer-term, it is intended to follow up this workshop with further workshops, probably on a biennial or triennial basis. This will allow for feedback on the topics and thrusts identified in the earlier workshop(s), and allow research needs and activities to be reported and discussed regularly. This is intended to keep a sharp focus on research needs and ensure that the sponsors of research in the universities are getting value for their research investments.

5.1 Comments invited

This report invites comments on the outcomes of the workshop and any other relevant matters that members think need consideration in respect of research needs and productivity in the South African Concrete Industry. Please send these comments timeously to Mark Alexander, mark.alexander@uct.ac.za, in order for them to be analysed and collated for dissemination, and also included in future workshops.▲

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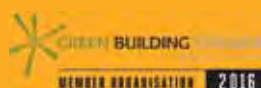
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Inland Branch Annual Golf Day 2016

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Welcome to
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Community

The Inland Branch held its second annual golf day recently at the RandPark Golf Club, RandPark, Johannesburg. More than 60 players teed off at this pristine 70-year old course, in perfect golfing weather.

The day was designed to be a fun occasion, and to help it along, there were special features and prizes available for the players to enjoy.

There were 16 teams representing various companies in the industry competing for prizes on the day. Chryso-abe provided some refreshment on the course with a wet hole, and at the Marshmallow Game. BASF and AfriSam branded two of the dry holes.

Feedback after the event reported that everybody had a great time and good networking was the order of the day. Hanlie Turner, National President of the Society managed to hit the marshmallow the closest to the flower, but only on her second try, and thus was not awarded the first prize.

The Inland Branch Committee proved once again that they can present great networking opportunities to the industry, intermingled with a lot of fun. The donation of dinner for the students and team from Home-Base, was a good way to end the day. This organisation currently has eight residential students, of whom seven are from children's homes. They are given the opportunity to study further after school and having a safe family home environment, which makes all the difference to them.



Students and the team from Home-Base

The golf was followed by a short interlude of networking and liquid refreshment, and then the players assembled for dinner and the prize-giving. Vice-Chair, Johan van Wyk

announced the prize winners, whilst Hanlie Turner the national president of the Society presented them to the winners.

The final results were as below:

RESULT	PRIZE SPONSOR	WINNING TEAM
1st Place	PPC	Dom dos Santos, Ajesh Sooklall, Deon Jansen, Riaan Petzer
Runners Up	Chryso-abe	R Harriparsadh, H Meijer, A Hoffman, A Combrink
3rd Place	SIKA	Marius Joubert, Graig Macleod, Peter Cloete, Marlene Corrie
Longest day	AfriSam	E Massyn, M Barker, A van Vuuren, H Engelbrecht
Longest Drive – 4th hole	AfriSam	M Joubert
Longest Drive – 14th hole	AfriSam	William Moriarty
Closest to the Pin – 5th hole	AfriSam	Trevor Smith
Closest to the Pin – 15th hole	AfriSam	Andre Combrink
Marshmallow Game	Chryso-abe	Henk Meijer



Winning Team (part)



2nd Place Team (part)



3rd Place



Longest Day' prize winners



Longest Drive 4th



Longest Drive 14th Hole



Closest to the Pin



Closest to the Pin 15th Hole



Winner – Marshmallow

The Inland Branch would like to thank the sponsors of this event for their generous support. These were (in alphabetical order):



The Vice-Chair thanks players, organisers and sponsors



Concrete Society members visit the site of the iconic PwC tower block

Members of the Inland Branch of the Concrete Society were treated to a site visit recently to view the construction of the PwC office tower in Waterfall City.

The new R1.5 billion high-rise head office for PwC comprises 40 000 m² of modern offices, designed to house 3 500 PwC employees in an efficient and optimally designed workplace. It will also have 6 levels of basement parking, and will be the first high-rise within Waterfall City.

Following a presentation by Kobus Prinsloo, Contracts Manager with the main contractor WBHO, the visitors were given an extensive tour of the structure including a 10-storey climb inside the building.

The completed 'core' of the building, which utilised 3,500 m³ of concrete, and was constructed using a 172-ton sliding shutter, will house 9 lift shafts.

The office structure around this is at the 15th floor level out of 26 floors in total. At the time of visiting, 40 000 m³ of concrete had been used out of the estimated total of 79 000 m³. The 36-month project is scheduled for completion early in 2018.

The building is designed to conform to the internationally recognised LEED (Leadership in Energy and Environmental Design) silver standard. LEED is a set of rating systems for the design, construction, operation, and maintenance of green buildings, homes and neighbourhoods.

The height of the new PwC Tower and the fact that it is situated on a high point in Waterfall City will make it the tallest structure on the corridor between the Sandton and Pretoria/Tshwane CBDs. The PwC Tower will be visible from almost anywhere within a 30km radius.

At the end of the tour, Vice-Chairman of the Inland Branch and organiser of the visit, Johan van Wyk, on behalf of all those present, expressed sincere thanks to WBHO for allowing the tour to take place and to view some excellent concrete construction and finish. ▲



View of Mall of Africa from the 10th floor



Visitors receive safety instructions



Not easy to photograph such a tall structure



Excellent concrete finishes exhibited



Steel tubing (from 8 m to 21 m) acts as ties to the adjacent crane



Inland Branch committee, President and CEO attended the site visit



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Guide to the safe use of portland cements & concrete

As with most materials, there are potential risks involved in handling or working with portland cement or mixes made using portland cement.

1. The chemical composition of portland cements

The composition of portland cement is such that when dry cement is exposed to water a chemical reaction called hydration takes place releasing a very strongly alkaline (and caustic) fluid with a pH greater than 13. This can cause alkali burns and safety measures should be observed.

Portland cement is a complex combination of compounds that includes minute quantities of trace elements. Although South African cements typically contain less than two parts per million of Hexavalent Chrome (widely regarded as a safe level), it may serve as an aggravating factor in cases of exposure to alkaline fluids. There have been some reports of allergic dermatitis after exposure to these fluids.

Human skin is a vital organ composed of a complex structure containing fats and oils that make it supple and waterproof. In its natural state, skin is slightly acidic with a pH of about 5. When fresh concrete or its bleed water comes into contact with human skin, the alkalis react with the oils and fats in the skin as well as the proteins in the skin itself causing tissue damage.

Other organic tissue (e.g. mucous membrane) can also be attacked by strong alkalis leading to burns that can sometimes be severe, and users should try to avoid all unnecessary contact with these fluids. Where such contact is unavoidable, suitable precautions should be taken.

2. Recommended precautionary measures

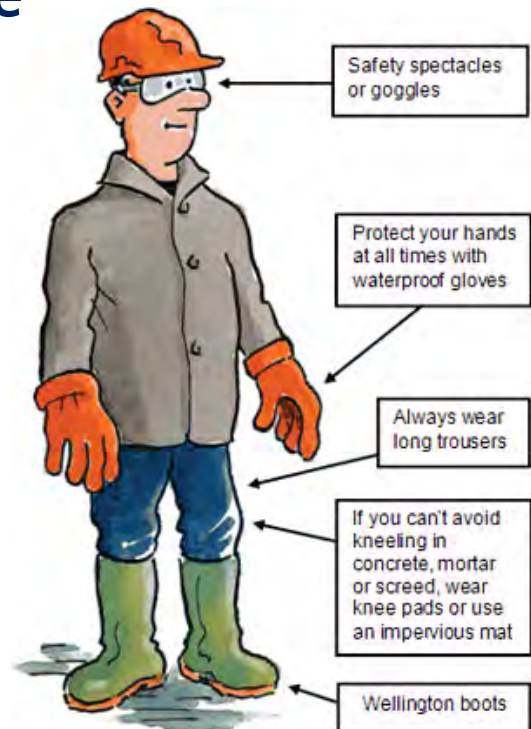
2.1 Physical hazards

Working with cement and concrete usually involves manual labour and lifting heavy loads. Care must be taken to avoid back and other kinds of strain due to unaccustomed physical labour. Bagged cement is usually packaged in 50 kg units. Handling and moving cement bags should be undertaken with due regard for the possibility of these strains.

Similar caution should be exercised when mixing, transporting, placing and finishing concrete as many of these operations may involve unaccustomed physical effort or working in awkward or uncomfortable positions for long periods.

2.2 Exposure to cement and other dust

- **Cement** – Cement dust, dusts from handling aggregates and from cutting concrete are easily inhaled. Prolonged or regular exposure to these dusts should be avoided.
Cement is a fine, abrasive powder, and when handled, some dust may become suspended in the air in the working area. Users should avoid inhaling cement dust as this may cause irritation of the nose and throat. Cement dust may also cause irritation of the eyes. This will occur as a result of the chemical reaction of the suspended dust with the moist mucous membranes.
Every attempt should be made to keep airborne cement dust to a minimum to avoid these problems. Should this be impractical, then the use of goggles and dust masks is strongly recommended.



- **Silica dust** – Many of the aggregates used in concrete have high silica contents. The fine silica dusts created when crushing or handling these aggregates could cause lung problems, and precautions should be observed to avoid breathing in such dusts.
- **Dust from demolishing or cutting hardened concrete** – This may contain unhydrated cement and could cause respiratory problems similar to those outlined above. In addition, if the coarse or fine aggregate used in making the concrete contains crystalline silica, then inhalation of these fine silica particles could expose workers to the risk of developing silicosis.
A concerted effort should be made to avoid generating such dusts. If this is not possible, the use of suitable respiratory protective equipment is recommended.

2.3 Exposure to fresh concrete or mortar

As mentioned earlier, the product of the hydration reaction between portland cement and water is a very alkaline fluid which has the potential to attack exposed organic tissue. When fresh concrete or its fluid comes into contact with human tissue, the alkalis react with the oils, fats and proteins in this tissue causing damage.

Roughness and dryness of the hands after working with concrete is a typical consequence of loss of these oils and fats. More prolonged exposure could result in irritant dermatitis. It is possible that the effects of trace elements may aggravate the condition and lead to an allergic dermatitis.

To safeguard against accidental exposure, appropriate protective equipment is strongly recommended:

- Regularly wash (at least daily) protective clothing and keep it clean and free of concrete.

- Wash any areas that have been accidentally splashed with wet concrete as soon as possible with large quantities of clean water.

Particular care should be taken to ensure that:

- Normal and protective clothing does not become soaked with wet concrete or concrete fluids as this could result in exposure over an extended period, resulting in tissue damage that can be particularly severe and even disfiguring.
- Workers do not kneel on fresh concrete during placing, compacting and finishing operations. If kneeling is unavoidable, thick waterproof kneepads should be worn and a kneeling board used to prevent the pads sinking into the fresh concrete. In severe cases of alkali burns, consult a medical practitioner as soon as possible.

3. First aid and remedial treatment

- Carefully remove wet concrete-soiled clothing. Although some first aid books state that clothing should not be removed from a burn wound, concrete burns are chemical burns – not heat burns – and clothing will not normally adhere to the wound.
- Rinse the affected skin as soon as possible with cool clean water. If the skin is treated soon enough (before ulceration), vinegar can be added to the rinse water to neutralise the alkalis (half a bottle of vinegar to a bucket of water). Milk

(which is a good natural buffer) can thereafter be applied to the skin with a pad to neutralise any further traces of alkalis without risk of acid-burning the skin. The skin should then be dried by gently dabbing with a towel, and lanolin may be applied to replace lost fats and oils and to restore suppleness.

- If ulceration has already set in, do not attempt to treat the wound with anything other than clean water without first seeking expert medical advice. The risk of spreading infection to the wound at this stage is severe.
- A sterile burn dressing can be applied over the wound and bandaged. An ice pack can be applied afterwards above the dressing but not directly to the skin.
- Do not delay getting medical treatment as the alkalis will continue to destroy tissue.


Important: It is advisable to notify any medical authorities that the victim should be treated for “alkali burns” as many medical practitioners may be unaware that concrete is a highly alkaline material that can cause third degree burns.

Acknowledgement – The Concrete Society of Southern Africa is grateful to The Concrete Institute as the source of this information. ▲



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INLAND BRANCH

DATE	MEETING/EVENT	VENUE	CONVENOR
01 October	Annual Concrete Boat Race Day	Benoni Sailing Club, Homestead Lake, Benoni	Johan van Wyk/Michelle Fick/Committee
03 November	Undergrad Research Achiever's Award	University of Johannesburg	Roelof Jacobs/Martin Dube/ Kim Twiname
18 November	Chairman's Breakfast and Annual Golf Day	Fabz Garden Hotel & Conference Centre, Lonehill, Johannesburg	Natalie/Johnson/Debbie Harvey/Committee

NATIONAL OFFICE

DATE	MEETING/EVENT	VENUE	CONVENOR
03 - 06 October	Technical Meeting: The New South African Concrete Code: An Introduction to SANS 51992-1-1	Cape Town, Port Elizabeth, Durban, Johannesburg	Organising Committee
20 October	3rd Board Meeting	Venue to be Confirmed	CSSA President
31 October	2017 Membership Renewals Notices	E-Mailed to All CSSA Members	CSSA Administration
November	Concrete Beton	Posted to All CSSA Members	CSSA Administration
30 November	2017 Fulton Awards: Entries Closing Date		Fulton Awards Committee

INTERNATIONAL

DATE	MEETING/EVENT	VENUE	CONVENOR
12 – 14 September	ConSec 2016 – 8th International Conference on Concrete Under Severe Conditions – Environment & Loading	Lecco, Italy	Laura Losapio
21 – 23 November	Fib 2016 Symposium	Cape Town, South Africa	A/Prof. Hans Beushausen
06 – 08 March 2017	11th High Performance Concrete & 2nd Concrete Innovation Conference	Tromsv, Norway	Braarud Henny Cathrine
12 – 14 June 2017	Fib 2017 Symposium	Maastricht, Europe	Marjolein Humme
20 -22 November 2017	ICT's First International Conference Military Technological College	Muscat, Oman	Michael Grantham

PICTURE: GOTTHARD BASE TUNNEL

DATA: The world's longest and deepest railway tunnel, currently under construction LOCATION: Switzerland, Europe
FEATURED: Keynote lectures, *fib* Symposium 2016

fib Symposium 2016

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VENUE

The *fib* Symposium 2016 will be held at the University of Cape Town's Graduate School of Business (GSB). The GSB is situated in close proximity of the Victoria & Alfred Waterfront and offers panoramic views of the city's iconic Table Mountain. A travel agent has been appointed to assist with hotel bookings, car rentals and tourist activities. To find out more, visit our website www.fibcapetown2016.com

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membership details




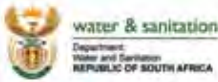








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2017 Fulton Awards



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- * ARCHITECTURAL CONCRETE
- * MINING
- * INNOVATION IN CONCRETE

Nomination Forms:

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