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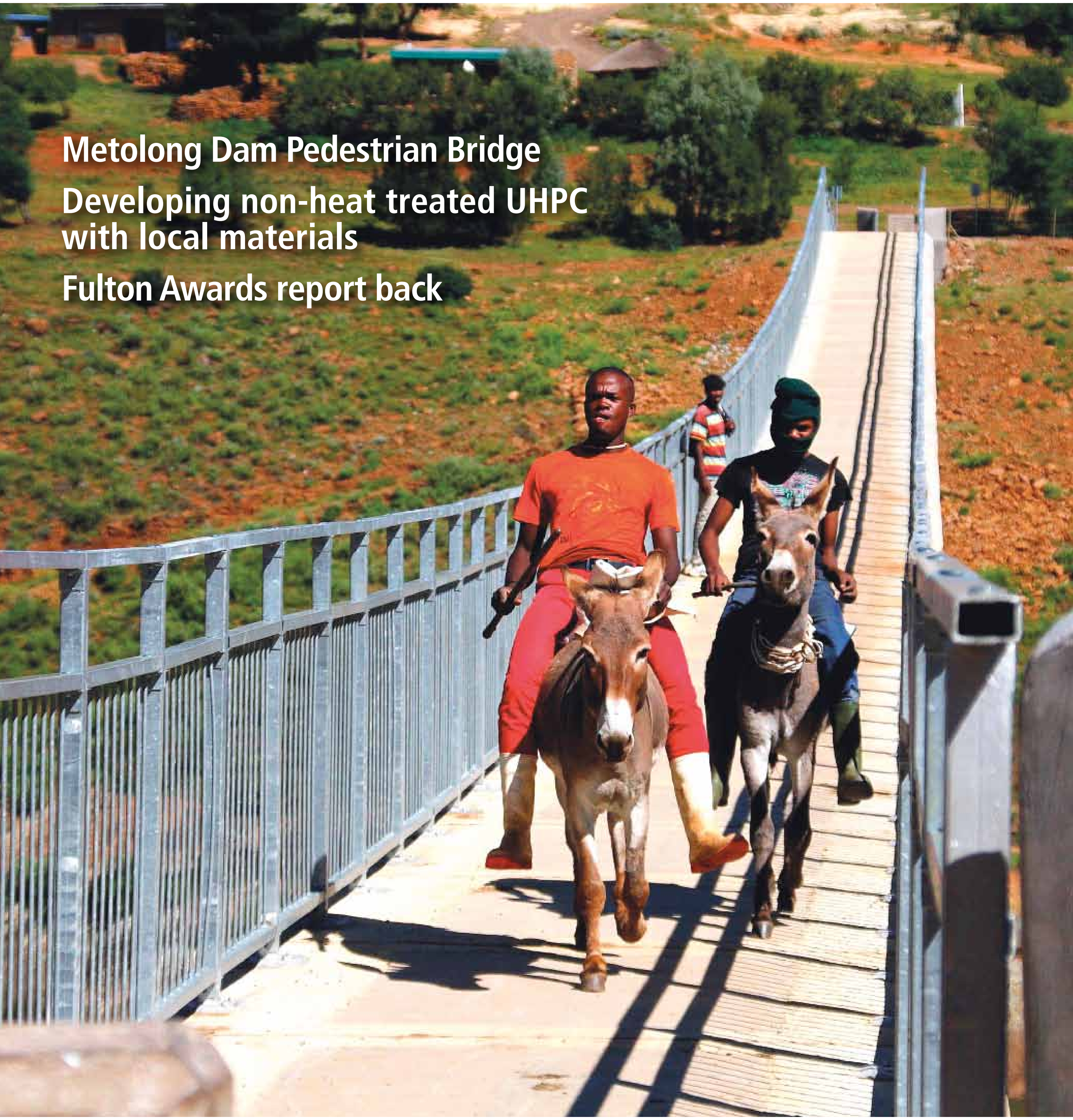
CONCRETE SOCIETY OF SOUTHERN AFRICA

CONCRETE BETON

Metolong Dam Pedestrian Bridge

Developing non-heat treated UHPC with local materials

Fulton Awards report back



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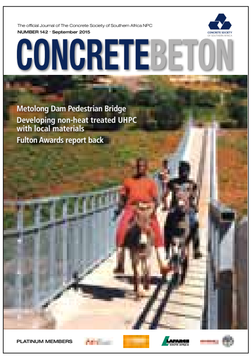

COVER: The Metolong Dam Pedestrian Bridge is an aesthetically pleasing, highly functional and environmentally friendly structure, as it does not have towers or large abutments which would impose on the rural landscape. It is the first multi-span, pre-stressed concrete ribbon bridge in Africa and, with a span of 230 metres, the longest of its type in the world. The judges had no hesitation in proclaiming this project the winner of the Fulton Award in the category Civil Engineering Structure up to R100 million.

Editor's comment

Today's world challenges us all to 'do things differently' and this is no less important than in the concrete industry. 'More of the same' is not an option for moving into the future. For many years now industry leaders and other stakeholders in the concrete sector have questioned the need for so many organisations to represent their interests in the built environment arena.

The roles of the four main concrete industry organizations in South Africa, namely the Concrete Society, The Concrete Institute, the Southern Africa Readymix Association and the Concrete Manufacturers Association, are often blurred in the minds of not only the industry, but also the public, and not surprisingly so. They all have similar names and share the common goal of ensuring the optimum use of concrete in the built environment.

The **Concrete Society of Southern Africa NPC** (CSSA) is a non-profit organisation that promotes excellence and innovation in the use of concrete and related products and services through a concrete 'community'.

CONCRETE SOCIETY OF SOUTHERN AFRICA

The Concrete Institute is a non-profit, technical organisation, funded by three of the country's cement producers to provide technical advice, consulting, education and information services to all interested in concrete.

CONCRETE INSTITUTE

The **Concrete Manufacturers Association** is the primary representative of the precast concrete industry, operating under two pillars, Precast Building and Precast Infrastructure.

The **Southern Africa Readymix Association** (SARMA) represents reputable ready-mix concrete companies.

SARMA

If we really want to promote excellence in concrete in a meaningful and effective way, then surely it would best to drive it through a single organisation, with one congruent voice, driving the promotion, training, innovation, research and quality of concrete whether it be site-mixed, precast or readymix?

What would be better than an all-inclusive, member-based body (company and individual), recognized as truly independent and impartial. It would be built on its technical base to be the leading provider of information serving the

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needs of clients, architects, engineers, specifiers, suppliers, contractors and users of concrete, with emphasis on quality and service.

An independent advisory service would provide prompt, impartial, technical advice on concrete and related matters to subscribing members of any discipline.

The organisation would work through the cooperation of its members to exchange information and experiences and to enhance the performance, productivity and quality of concrete as a construction medium.

At the moment each organization, in relatively small market, is competing for members, sponsorship, publications, support at events, audiences, etc., and this cannot be sustained in the long-term. What is needed is some form of consolidation. Comments and opinions from members and other readers would be most welcome.

John Sheath
Editor

President's message

As anticipated, the first half of 2015 being the "Fulton Awards year", has been very busy in the CSSA and the industry as a whole, and the hive of activity continues for the remainder of 2015.

Having just come out of the 2015 Fulton Awards gala event at the Champagne Sports Resort in the Drakensberg, the feedback received from a survey conducted, is that this was a very successful and well received event. I had the privilege of attending the Regional Fulton Awards events around the country and I was both humbled and motivated by the enthusiasm, high turn out and passion shown in the regions. The bar has been set high and planning has already started for the 2017 Fulton Awards. Thank you to all those who participated in the survey, all suggestions for improvement received will be incorporated in the planning for 2017. I urge you to start thinking about entries for the next "bigger and better" 2017 awards.

Being a Fulton Awards year, two National Roadshow Seminars were organised for this year. The first seminar, RepSem held earlier in 2015, was attended by over 300 delegates in four venues around the country and proved to be a great success. The last National Roadshow Seminar for the year, HybriSem 2015, would have just past when this edition reaches members. Covering progress and the very latest technology in Hybrid concrete construction, delivered by local industry experts including overseas experiences.

I once again urge members to get actively involved in the activities of the Concrete Society to derive maximum benefit from the networking opportunities created and the broad amount of information shared. This, as we continue in our mission to "To promote excellence and innovation in the use of concrete, and to provide a forum for networking and for the sharing of knowledge and information on concrete".

Lastly, enjoy the read and God Bless!

Yours Sincerely
Tseli Maliehe
President – Concrete Society of Southern Africa

Metolong Dam Pedestrian Bridge

The Metolong Dam Pedestrian Bridge in Lesotho is the first multi-span pre-stressed concrete ribbon bridge built in Africa and the longest of its type in the world. The extensive use of concrete elements ensures that this bridge will serve its purpose virtually maintenance-free for many years. The deck spans across the valley supported by a single pier. Once the tail water reaches full capacity the pier will be largely submerged leaving a slender deck draping across the water blending in with the rural landscape in which it was built. This bridge solution is designed to be aesthetically pleasing, eco-friendly and cost effective.

BACKGROUND

The new pedestrian bridge spans across a section of the Metolong Dam where the tail-water on the Phuthiatsana River will be approximately 215 metres wide by 45 metres deep. The design presented a challenge insofar as a cost effective solution had to be found for a fairly long bridge, with a relatively lightweight deck, to span a deep and steep-sided gorge. Of the alternatives considered, a pre-stressed concrete ribbon bridge seemed the most ideally suited for the task, particularly in an area where hard and massive sandstone was available for anchoring the bridge abutments.

The 50 metre high Metolong Dam Pedestrian Bridge provides a vital link between communities divided by the tail-waters of the new Metolong Dam. The walkway chosen for the bridge is a pre-stressed concrete ribbon that is continuous over two spans. Typically, this type of bridge consists of precast concrete elements suspended from cables, pre-tensioned between abutments. These elements are then joined and stressed in the long direction of the bridge by post-tensioning a second set of cables placed in ducts through the elements. Thus, the compression stresses that are induced in the deck elements through post-tensioning, compensate for the tensile stresses that result from subsequent live loads. The obvious benefits of concrete are its durability, its low maintenance, and its low cost, but another significant benefit is that its use in construction is labour-intensive and therefore, provides an opportunity to use local labour in unskilled, semi-skilled and skilled capacities.

The bridge deck is continuous over two spans with respective lengths of 102 metres and 127,5 metres. The total walkway length, including the approaches over the abutments is 249 metres. The central support of the bridge consists of a 35 metre tall reinforced concrete pier, seated on top of a sandstone cliff 15 metres above the river bed.

Central pier under construction

Jeffares & Green (Pty) Ltd, as part of the Lowlands Waterworks Joint Venture, designed the bridge for the Client, Metolong Authority, at a location where the local communities on either side of the Phuthiatsana River needed to have easy access to each other. This location was

identified by the social consultants, in consultation with the local communities, as being a regular crossing point for trade, social interaction and access to other key villages such as Sefikeng and Thaba Bosiu.

The designers considered the use of pre-cast concrete elements advantageous, due to reduced construction time, as several tasks could be overlapped. In particular, the deck panels could be manufactured before the abutments were in place. The use of pre-cast panels also reduced the concrete work required in-situ, and a pre-stressed concrete ribbon type bridge seemed to be the most logical option to choose under difficult circumstances.

View from approach

Other long-span alternatives considered included suspension bridges. These types of bridges are often used for pedestrian bridges, pipe bridges and other light structures in South Africa. A disadvantage associated with these types of bridges is the tendency to resonate under live loads, which deters people from making use of such bridges. Even the introduction of stabilisers to dampen this resonance has proved only moderately successful. From an aesthetic perspective the towers required for these structures also tend to impact negatively on rural landscapes.

A stress ribbon bridge was determined to be a more viable option, in terms of meeting design requirements, cost effectiveness and time constraints.

The following construction sequence is typical (see Figure 1):

- First, the abutments are built and anchored back to rock on either side of the river. Concurrent to the construction of the abutments, the central pier is built (see fig. 1a and b)
- Main bearer cables are then placed over the central pier and stressed between the two abutments (see fig 1c).
- Pre-cast concrete elements are manufactured and suspended from these cables and slid across the river to their respective positions along the length of the bridge (See fig 1d).
- The pre-cast deck elements are then joined by lapping reinforcement and placing in-situ concrete thereby turning the deck into a continuous ribbon (see fig 1e).

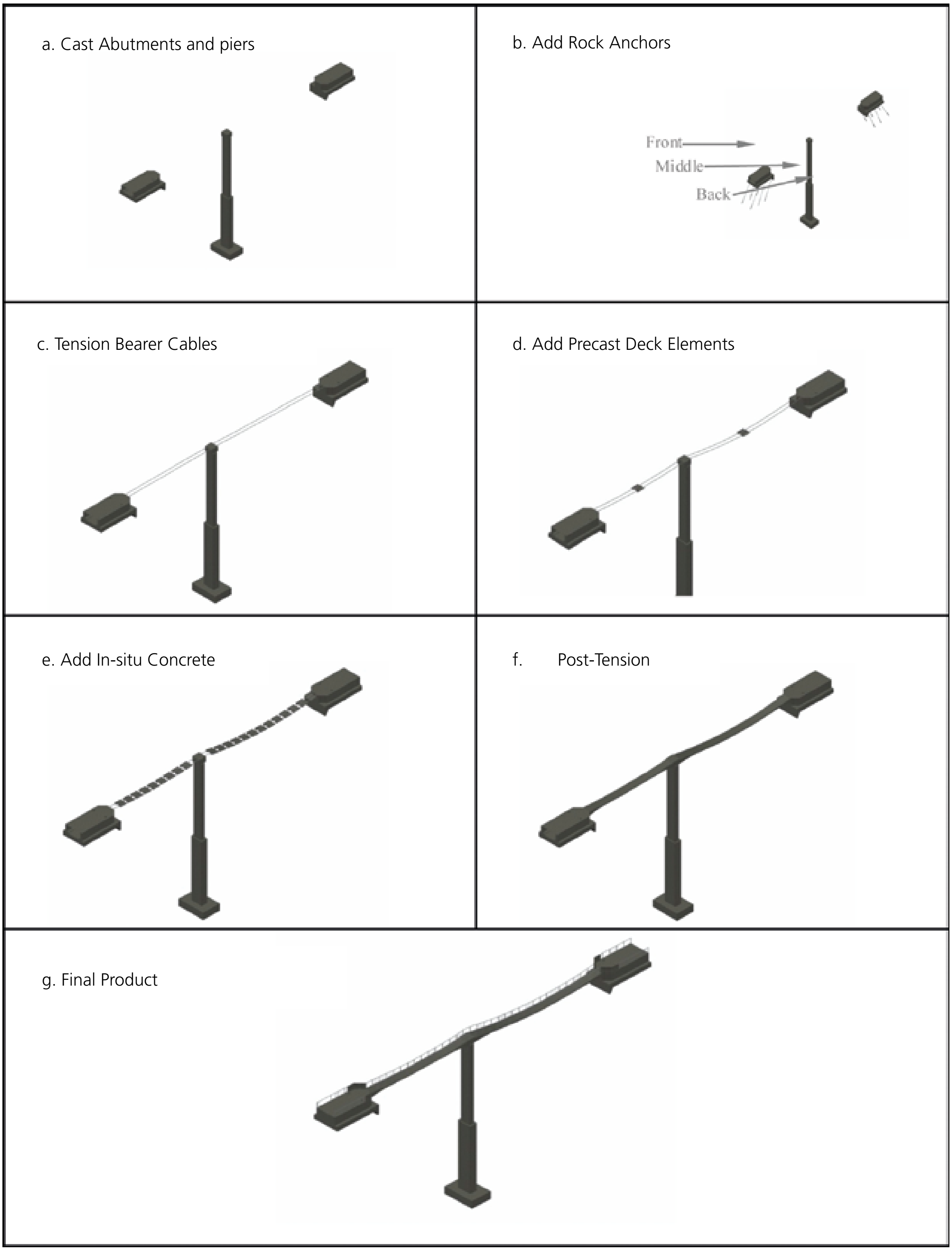

Figure 1: construction sequence of stressed ribbon bridges

- Longitudinal post-tension cables are then placed along the length of the bridge in ducts inside the elements and tensioned, in order to provide sufficient compression stresses to compensate for live load induced tensile stresses (see fig 1f)).
- Handrails and other finishings follow before the bridge is commissioned (see fig 1g).

DESIGN

Conventional software packages are unable to analyse catenary type structures with their large deflections, as these packages are based upon the assumption that plane sections remain plane and deflections are small in relation to actual dimensions. Therefore, the design was based upon first principles done on self-generated spreadsheets.

Rural location of the Metolong Dam Pedestrian Bridge

Deck panels being launched along cables

Skilled launching of deck panels

The self-generated spreadsheets were previously compared with, and confirmed by, results obtained from the Institution of Civil Engineering at the University of Stellenbosch, who were commissioned to conduct finite element analysis on an earlier stress ribbon bridge by using a sophisticated Finite Element Structural Analysis Package.

Also, on the earlier structure, the CSIR's Dr. Adam Goliger, was employed to advise on anticipated wind loadings and the effects thereof. His study was based on a computer-generated model, water tunnel tests and an extensive review of literature pertaining to wind loading on similar bridges. His report concluded that wind is unlikely to play a significant role in the lifespan of the bridge.

The maximum horizontal force that could be applied to each of the abutments under working loads is in the order of 11 MN, which meant that the abutments had to be securely anchored. As competent rock (Dolorite Basalt with a compressive strength of approximately 1000 Kpa) was encountered on site, rock anchors were used.

The design of the rock anchors were undertaken by Clive Wilson, Wilson & Pass Inc.

CONSTRUCTION

The bridge was built by EXR Construction, civil engineering contractors. The bridge was completed in December 2013. Despite the remote location of the bridge very few difficulties were encountered during the construction phase and the work went ahead without major incident.

Deck elements were precast on site. The elements were launched from both abutments to ensure the stresses imposed were balanced. The launching rate of these deck elements met the designers' expectations, as all 84 elements were launched within a week.

Deck panels pre-cast on site.

Most significant quantities for this bridge were 1,166 m^3 of concrete, 82 tons of steel reinforcement, 4,620 MN m pre-stressing tendons and 37.2 MN pre-stressing anchorages.

As far as possible, materials were sourced from local suppliers in Lesotho, but steel needed to be imported from South Africa.

The majority of the workforce consisted of unskilled labour due to the nature of the site and the Works. The main contractor utilised his own skilled personnel to set out and manage the works, while all labour intensive processes were undertaken by the local, unskilled labour force.

Health & Safety issues were managed by the contractor. All OHS requirements were met as part of the stringent Environmental Management Plan and Health & Safety specifications set out in the contract document. No incidents of significance were reported or identified during the construction of the Works.

The tendered price for the Works (including VAT) was R9.5 million.

CONCLUSION

As demonstrated by the Metolong Dam Pedestrian Bridge, prestressed ribbon bridges are ideally suited for providing cost-effective pedestrian access over deep valleys and fairly wide expanses of water. The lightweight bridge is relatively easy to construct and fulfils the criteria for both form and function. Even with its relatively low natural frequency, the speed and magnitude of oscillations produced by live loads remain within acceptable limits and thus meet the requirement of the local inhabitants to feel safe when crossing. ▲

The Metolong Dam Pedestrian Bridge won the 2015 Fulton Award in the Civil Engineering (less than R100 million) Category for its innovative design (in concrete) its cost-effectiveness, and aesthetics. It is a highly functional and environmentally friendly (by virtue of the fact that it does not have towers, stabilisers or large abutments that would impose on the rural landscape) and it provided employment and skills training to people living in the area.

Most importantly, it perfectly meets the needs of both the client and the community.

Developing non-heat treated UHPC with local materials

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ABSTRACT

Non-heat treated ultra-high performance concrete is developed in this contribution, using locally available ingredient material except imported high-strength short steel fibre. While UHPC mix design guidelines have been proposed, ingredient materials available locally but which do not necessarily comply with recommended property ranges, may be compensated for by particular strategies. In this paper, the local ingredient materials are compared based on their mineralogy, specific surface area, particle size and grading. A mix design strategy is proposed and demonstrated, making use of local binder materials and fine aggregate with less than optimal properties. Base paste spread and strength are integral to the design, as is careful consideration of fibre size and dosage to ensure tight packing in the UHPC skeleton. Significant compressive strength enhancement by addition of the fibres is recorded, ascribed to the tight skeleton packing and shrinkage-induced fibre bond enhancement.

Keywords: UHPC, fibre reinforced, non-heat treated, local materials

1. INTRODUCTION

Ultra-high performance concrete (UHPC) without heat treatment has been developed successfully by several researchers. However, under such normal water curing conditions, the ingredient materials should meet tight specifications. When locally available materials are not that ideal, it is challenging to achieve the required performance. For the local materials in South Africa, the optimised mix design for UHPC from other researchers is no longer valid. In order to develop UHPC with the local materials, a good understanding of UHPC is needed and a systematic experimental design approach is required due to lack of corresponding data. This article presents a step by step development of UHPC with maximal use of local materials, i.e. all but the steel fibres. The major philosophy in the mix design is to identify strength potential of paste at early age, i.e. 14 days, and optimal design of fibre reinforcement for bridging of shrinkage-induced micro-cracks whereby fibres are mobilised already in the ascending response to mechanical load such as in the compression test and not only to reduce post-peak brittleness. Using this philosophy, the development of UHPC with 28-day compressive strength of 168 MPa, using local, non-ideal materials and normal water curing is elaborated in this paper.

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2. COMPARING LOCAL MATERIALS WITH TYPICAL MATERIALS USED FOR UHPC

In order to compare the differences in ingredient materials for UHPC, the relevant properties of local materials are introduced and compared with those used by other researchers who successfully develop UHPC under normal curing conditions.

2.1. Cement used in UHPC

Cement is the most important material in UHPC because the hydration of cement provides the fundamental way to achieve concrete strength. It is found that little C_3A content minimizes water demand (de Larrard 1988) which in turn will affect the viscosity of the paste. In addition, the fitness also governs the viscosity of paste (Bonen, Sarkar 1995). Sakai *et al*. (2008) state that the cement with less than 8 weight percentage of the C_3A content according to Bogue analysis does not have a significant influence on the paste viscosity. The above considerations of other researchers could be used as a reference to select cement that is better suitable for UHPC. As shown in Table 1, the cement used for this research is a CEM I 52.5N with 6.8% of C_3A content, which meets this requirement.

The hydration of cement determines the paste strength, which in-turn affects the UHPC strength. The researchers normally choose cement with high C_3S and C_2S contents. The typical C_3A, C_2S and C_3S contents in cement used for UHPC by researchers are listed in Table 1 for comparison.

Each researcher listed in Table 1 optimized their UHPC mix to enable workable fresh UHPC and the highest strength. It can be seen that UHPC strengths over 150 MPa choose cement containing similar percentages of C_3A and C_3S. The UHPC developed by Montreal has similar C_3S and C_2S contents compared with the local CEM I 52.5 N but contains much

Table 1: Cement major chemical contents and corresponding compressive strengths for UHPC.

28 days Strength (MPa)	Cement weight % according to Bogue analysis			Reference
	C_3A	C_3S	C_2S	
165 (water curing)	4.11	67.23	14.5	France (de Larrard, Sedran 1994)
168 (water curing)	4	73.4	10	Lausanne (Habel et al. 2006)
192 (without steel fibre) 201 (2.5 % by volume of steel fibre)	5	74.3	14.1	U.S. (Wille et al. 2011)
121 (water curing)	2	60	16	Montreal (Habel et al. 2008)
128 (water curing)	9	60	10	Toronto (Habel et al. 2008)
126 (water curing)	N/A	N/A	N/A	U.S. (Graybeal 2006)
168 (water curing)	6.8	61.6	17.2	CEM I 52.5 N in 2012; this research
128.6 (without steel fibre)	7.26	59	19	CEM I 42.5 N in 2011; this research

less C_3A content. The cement used in Toronto has similar C_3A and C_3S contents with this research but contains less C_2S content. The UHPC in both Montreal and Toronto achieves the compressive strength of less than 130 MPa, i.e. significantly lower than that achieved by the same lead author Habel *et al*. (2008) of 168 MPa in an earlier work, which emphasizes the importance of cement in UHPC.Habel *et al*. (2008) point out that most cements used in Europe contain approximately 4% of C_3A and 73% C_3S which enable good workability and strength development. The worst workability was found for cement containing 7% C_3A, which was discarded when UHPC was developed in Montreal. This finding differs from that of Sakai *et al*. (2008), who indicate that less than 8% C_3A does not have significant influence on paste workability. The one local cement used in this paper, CEM I 52.5N, contains 6.77% C_3A and was also found to cause a relatively low workability compared with that of Wille *et al*. (2011), which agrees with the finding by Habel *et al*. (2008). The detailed information will be provided in the later section.

Of the two types of cements used in this article, which are CEM I 42.5N and CEM I 52.5N, only the latter leads to sufficient compressive strength to be classified as UHPC. The major Bogue analysis of local cements are listed in Table 1.

2.2. Silica Fume

Silica fume normally has two functions in UHPC. One is its pozzolanic reaction that further enhances the concrete strength. The other is its physical role as a filler between cement particles.

From the physical point of view, the grain size of silica fume influences the packing of the paste. Wille *et al*. (2011) found that medium grain size of silica fume with specific surface area of 12.5 m^2/g has better effect on the workability and compressive strength than the common silica fume with specific surface area of 21.9 m^2/g. Habel *et al*. (2008) confirm that a relatively high specific surface area (15-20 m^2/g) of silica fume they use causes a high water demand and thus does not perform as well as the silica fume used in Europe with specific surface area of 12 m^2/g. Thus it appears that silica fume with specific surface area of approximately 12 m^2/g is the best option to be used in UHPC. However, only one type of grey silica fume with specific surface area of 23 ± 3 m^2/g and silica content over 92 percentage is available in South Africa. This is shown in a later section to have significant influence on UHPC workability.

2.3. Superplasticizer

Very low w/c ratio's make superplasticizer (SP) essential for UHPC to achieve the required good workability and spread. The SP used for UHPC is normally based on polycarboxylate ether containing different lengths of side chains (Schroefl *et al*. 2008). The side chain density is the main mechanism of controlling the workability of the paste (Zingg *et al*. 2009). Due to the chemical reaction between SP and cement/silica fume, different types of SPs are usually compatible with the corresponding cement and silica fume. The SP based on methacrylic acid ester polycarboxylate disperses cement better than silica fume while the allylether based polycarboxylate fluids silica fume well. Therefore, a blend of SPs that could both effectively disperse cement and silica fume are preferred in UHPC mix (Plank *et al*. 2009). In order to achieve a highly flowable paste, effective dispersion of especially silica fume is necessary (Plank *et al*. 2009).

The dosage of SP used for UHPC mix also contributes to the compressive strength. Different amounts of SP were compared and it was found that a lower percentage of SP leads to a reduced shrinkage rate which in turn results in a higher strength (Morin *et al*. 2001). Therefore, if the SP is not efficient in dispersing cement and silica fume, the addition of more SP might cause a higher shrinkage and result in a reduction in UHPC strength.

Although the theoretical role of the types of SP matching the types of cement and silica fume were studied well by researchers as discussed above, the side chain length and density is normally kept secret by chemical companies and no detailed information could be obtained in this research. For this reason, there are no simple chemical balance equations from which to derive the optimal dosage, but a systematic, empirical test program was followed to measure spread values representing the workability of paste, following (Artelt, Garcia 2008).

Four locally available types of SPs were used in this research are marked SP I to SP IV, and were obtained from three local supplier companies. The best performance of SP is determined through slump flow / spread value results for the test mixes reported here.

2.4. Fine Aggregate

2.4.1. Aggregate particle size

Aggregate in concrete mix usually is not involved in chemical reactions. For UHPC, the larger grain size aggregate can influence compressive and tensile strength due to stress concentrations caused by a relatively high shrinkage of paste compared with normal strength concrete. Therefore, most researchers choose fine sand as aggregate in UHPC under normal curing conditions. This is in agreement with de Larrard & Tondat (1993) who indicate that a small size aggregate leads to a higher strength in high strength concrete. The sands used by some researchers who successfully develop UHPC under normal curing conditions are listed in Table 2 below.

particle sizes. However, it contains particles larger than 2.4 mm while all Philippi sand particles pass through the 1.2 mm sieve.

2.4.2. Aggregate grading

Better graded aggregate also helps to reduce the dimensional change due to shrinkage. The aggregate has a positive confinement effect on the cement paste (de Larrard, Sedran 1994) which indicates that the aggregates act as an internal restraint to reduce the shrinkage. Other researchers indicated that better graded aggregate could reduce the volume of cement paste which results in a lower chemical shrinkage (Holt 2001, Esping 2007). Such confinement of aggregate is especially helpful for UHPC because of the relatively high paste shrinkage.

Table 2: Types of sand used by some researchers for water cured UHPC

Reference	Sand types and particle sizes
France (de Larrard, Sedran 1994)	Three type of quartz sand S125, S250 and S400 are used. S125 range between 0.063 mm and 0.125 mm; S250 range between 0.1 mm and 0.25 mm; S400 range between 0.125 mm and 0.4 mm;
Switzerland (Habel et al. 2006)	Quartz sand with the maximum grain size of 0.5 mm.
U.S. (Wille et al. 2011)	Two types of fine silica sand with the maximum grain size of 0.2 mm and 0.8 mm respectively.
Montreal (Habel et al. 2008)	Silica sand with the mean grain size of 0.25 mm.
Toronto (Habel et al. 2008)	Silica sand with the mean grain size of 0.2 mm.
U.S. (Graybeal 2006)	Fine sand with grain size range between 0.15 mm and 0.6 mm.

It can be seen from Table 2 that most of the researchers choose fine sand of grain size approximately between 0.2 and 0.8 mm. The sand from most researchers was supposed to be obtained from their local suppliers but whether the sand is re-graded or not is not reported in their research. This research will only use the local available sand as aggregate instead of sieving and re-grading them.

Two types of natural sands, Philippi and Malmesbury that are commonly used in the Western Cape, South Africa are chosen. The gradings of these sands are shown in Figure 1. Malmesbury sand is generally preferred for normal concrete due to its wider range in

Figure 1: The grading of two types of sands used in this research.

2.4.3. Aggregate particle shape

Besides the grading, the shape of the aggregate also contributes to the workability of concrete. For the similar grain size, well-rounded smooth sands flow much better than the angular sand during the mixing procedure and lead to fewer voids in the UHPC performance. Therefore, well-rounded, smooth sand particles are better suited for UHPC. Enlarged photos of sand particles from the various size ranges are shown in Table 3.

The particle shape for each size is shown in Table 3 with magnification up to a factor of about 200 for better observation. For the very fine size (< 75 µm), the shape of Malmesbury sand appears to be more rounded than that of Philippi sand. However, for the sand size larger than 75µm, the shape of Philippi sand particles is better than that of Malmesbury sand.

2.5. Steel Fibre

Short high strength steel fibres are normally used in UHPC. Since no South African company manufactures high strength steel fibres yet, the steel fibres are imported. Bekaert straight steel fibre of 13 mm in length, 0.16 mm in diameter with a minimum tensile strength of 2600 MPa and brass coating is used in this research. Steel fibres used for UHPC by different researchers are similar and are commonly used to improve the ductility of UHPC.

Table 3: Particle shapes for two South African sand types.

Size (Micron)		Phillipi		Malmesbury	
Between		Photo	Magnification	Photo	Magnification
2360	4750				34
1180	2360		35		55
600	1180		35		42
300	600		173		176
150	300		181		184
75	150		195		195
<75			203		199

2.5.1. The effect of short straight steel fibre content on UHPC performance

Usually, steel fibres mainly improve concrete ductility. This is because only once the concrete cracks, the fibre is significantly stretched to develop resistance in bridging the crack. Therefore, the steel fibre has limited effect on concrete cracking strength, whether in (splitting) tension or compressive splitting.

The effects of steel fibre content on UHPC are different under various curing conditions. Park *et al*. (2008) found that 2% (by volume) of steel fibre results in a 13% improvement in compressive strength under heat curing conditions. For non-heat treated UHPC, an improved compressive strength of 6.7% is achieved with 1.5% (by volume) of steel fibres and an improved compressive strength of 9.8% is obtained with 2.5% steel fibres (Wille *et al*. 2012). It can be seen from work of other researchers that the effect of steel fibres on UHPC compressive strength is less significant under the normal curing conditions as that of the heat curing conditions. In addition, lower steel fibre content results in a lower improvement in compressive strength for UHPC.

2.5.2. The spacing and dispersion of steel fibres in UHPC

The effects of fibre dimension and content on fibre spacing were studied by several researchers, who also proposed formulae for fibre spacing. Among those formulae, the typical expression for continuous fibre is shown as Equation (1) (Romualdi, Mandel 1964); the expression that considers the length of short steel fibres is shown in Equation (2) (Mindess, Young 1981) and the spacing for random oriented steel fibres in Equation (3) (McKee 1969). Equation (3) was also accepted in European standard EN 14487-1 as a requirement for minimum dosage of steel fibres used in fibre reinforced concrete (FRC) to ensure minimum overlap between fibres.

Despite the fact that the fibre spacing expressions were originally used to evaluate the tensile behaviour of FRC, they might also be used as an indication to choose the maximum aggregate size (Markovic 2006). However, the actual dispersion of fibres is more complicated and it is unlikely that fibres arrange in a complete regular grid as assumed by the formulae. The factors that affect fibre dispersion include: the confinement of formwork, fibre size and content, aggregate size, matrix viscosity, vibration, etc. Researchers are developing models that could better simulate the fibre dispersion but there are still quite some limitations. However, it is useful to consider theoretical steel fibre dispersion in the mix design.

$$S = 13.8d\sqrt{\frac{1}{V_f}} \qquad (1)$$

$$S = 13.8d\sqrt{\frac{l_f}{V_f}} \qquad (2)$$

$$S = \sqrt[3]{\frac{\pi d^2 l_f}{4V_f}} \qquad (3)$$

with:
S fibre spacing, d fibre diameter, l_f fibre length and V_f volume content of steel fibres in %.

Figure 2 shows the relationship between the volume percentage of steel fibres and fibre spacing as obtained from the above three expressions. The maximum aggregate size that better fits between steel fibres differs significantly when the steel fibres content is low and such variation narrows when the steel fibre content is high.

It can also be seen from Figure 2 that for Equation (3), the fibre spacing does not change that much with different percentage of steel fibres since the main focus for this expression is to guarantee enough overlap of steel fibres. The fibre spacing for Equation (2) becomes more constant after 3% of steel fibres, while for Equation (1), the fibre spacing reduces with the increased volume percentage of steel fibres and has a high decreasing rate when the steel fibre content is less than 3%.

In order to provide a good dispersion of steel fibres, the fibre length should be typically 2 to 4 times that of the maximum aggregate size (Grünewald 2004). For Malmesbury sand, approximately 98% of the particles are smaller than 2.36 mm according to the sieve test (Figure 1), which complies with the above fibre length requirement. In addition, based on Equation (2), a 1.5% by volume of steel fibre corresponds to approximately 2 mm of maximum sand particle size. Besides the relationship between fibre spacing and maximum aggregate size, the fibre spacing should be lower than 0.45 l_f for a minimum overlap according to EN 14487-1 and Equation (3). With 1.5% of steel fibres, the fibre spacing is approximately 0.56 mm as shown in Figure 2, which is smaller than 0.45 l_f (= 5.85 mm) and meets the requirement.

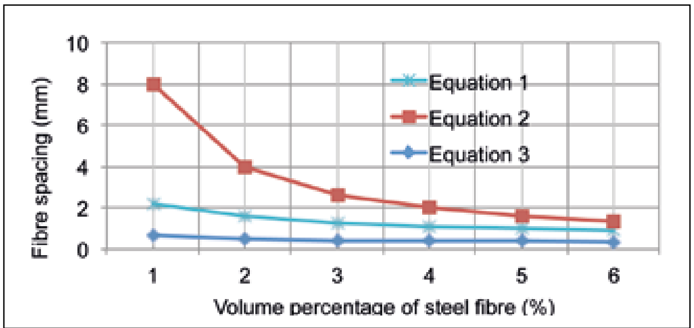


Figure 2: Fibre spacing corresponding to volume percentage of steel fibre.

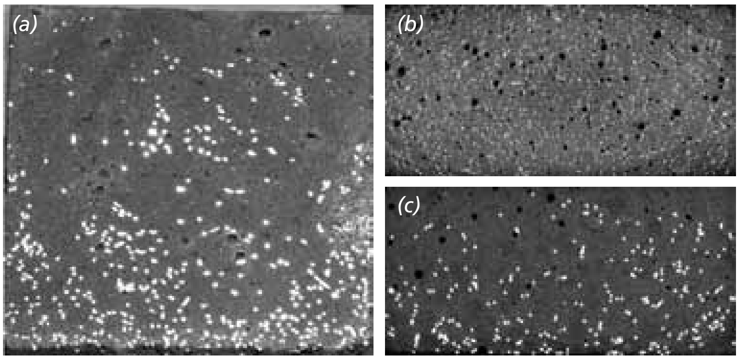


Figure 3: Steel fibre dispersion in (a) fine aggregate concrete (Głodkowska, Kobaka 2013); (b) 40mm thick dumbbell shaped specimen with moderate vibration (this research); (c) 16mm thick dumbbell shaped specimen with excessive vibration (this research).

Based on the above analysis, a 1.5 volume percentage of steel fibre was chosen in this research. In this way, a uniform dispersion of steel fibre is expected. By balancing the particle size and fibre spacing, this research aims to exploit good fibre packing as part of a tight skeleton, whereby paste shrinkage-induced anchorage may lead to significant fibre-enhanced compressive strength.

2.5.3. Steel fibre dispersion in UHPC

As can be seen in Figure 3 (a), the actual dispersion of steel fibres in fine aggregate FRC with 1.5 volume percentage of steel fibres in 150 mm cube specimens may be non-uniform, and thus not ideal as in equations (1-3). The settling of steel fibres is caused by the combined effects of steel fibre gravity, viscosity and vibration time (Głodkowska, Kobaka 2013). The phenomenon of steel fibre settlement was also observed with longer vibration times in this research. Figure 3 (b) shows the steel fibre dispersion in a 40 mm thick dumbbell shaped specimen with the vibration time of one minute, while Figure 3 (c) shows a 16 mm thick dumbbell shaped specimen with the vibration time of two minutes. It can be seen from Figure 3 (c) that with longer vibration time, the steel fibre settlement tends to occur. Moderate vibration may prevent steel fibre settlement as shown in Figure 3 (b), which indicates good dispersion of steel fibres in this research under such considerations.

Besides the fibre dispersion, voids in UHPC can be eliminated with longer vibration time. This can also be observed when comparing Figure 3 (b) and (c). The location of voids close to the top surface of the specimen in Figure 3 (c) indicates that longer vibration time does help to reduce the voids. Settlement of steel fibre should however be avoided in structural application.

3. THE PHILOSOPHY OF UHPC DESIGN IN THIS RESEARCH

Guidelines for developing UHPC have been proposed by several researchers and are not repeated here. However, adaptations to accommodate local ingredient materials are elaborated. The major difference for UHPC developed in this research is to use steel fibre not only to improve ductility, but to also significantly contribute to compressive strength by confinement and internal pre-stressing.

The optimised paste may exhibit suitably high compressive strength at relatively early age, i.e. at 7 or 14 days, but reduced apparent strength at higher age, when testing compressive strength of the paste (UHPP) only. This strength reduction is postulated to be mainly caused by a relatively high shrinkage potential of the paste, internal water consumption by hydration and associated shrinkage strain gradients and internal cracking in the compression test specimen. The added aggregate is usually optimised for a tight packing to form a dense skeleton of the UHPM. This may further restrain shrinkage of the paste and cause apparent strength reduction due to internal cracking. The inclusion of an appropriate size and dosage of fibre contributes to the dense skeleton in the final composite (UHPC). Upon shrinkage of the paste, its tensile strain and associated stress is balanced by compression in the skeleton. By this confining skeleton pressure, anchorage of the fibres is improved. When tensile strength of the restrained shrinking paste is exceeded, tightly embedded fibres may efficiently bridge subsequent micro-cracks. For this mechanism to successfully enhance composite compressive strength, tightly packed, uniformly dispersed fibres with sufficient overlap are required to avoid weak spots that may lead to localized micro-crack coalescence and associated apparent low compressive resistance.

For UHPC, chemical shrinkage dominates at early age, i.e. within 24 hours. After a short period of time, the skeleton of the UHPC is strong enough to resist the shrinkage force, whereby the subsequent autogenous shrinkage strain is reduced (Holt 2001). Normal cured UHPC, such as studied here, shows a continuous shrinkage evolution, while heat-cured UHPC exhibits no evident post-treatment shrinkage (Graybeal 2006). Shrinkage observations in water-cured UHPC reported by Schachinger, *et al*. (2002) indicate autogenous strain in UHPC of approximately 0.14% within the first 24 hours, after which it develops slowly to approximately 0.16% at 7 days. After 7 days, the gradient of autogenous strain is larger, where the micro-cracks may be developed. Especially with low silica fume to cement content ratio of 0.18, a slight drop of autogenous strain occurs in 14 days. This may explain the reduction in UHPP strength at higher age found in this research.

For the paste of w/c ratio of 0.3 and SF/C = 0.10, shrinkage-induced clamping pressure on steel fibre increased significantly with the shrinkage development; the increments in clamping pressure are especially high until 210 hours after casting and continued increase its value until 500 hours when the test is stopped (Stang, 1996). Such improved bond stress induced by improved shrinkage further indicates the higher UHPP strength at 7 or 14 days is quite important to form a strong skeleton.

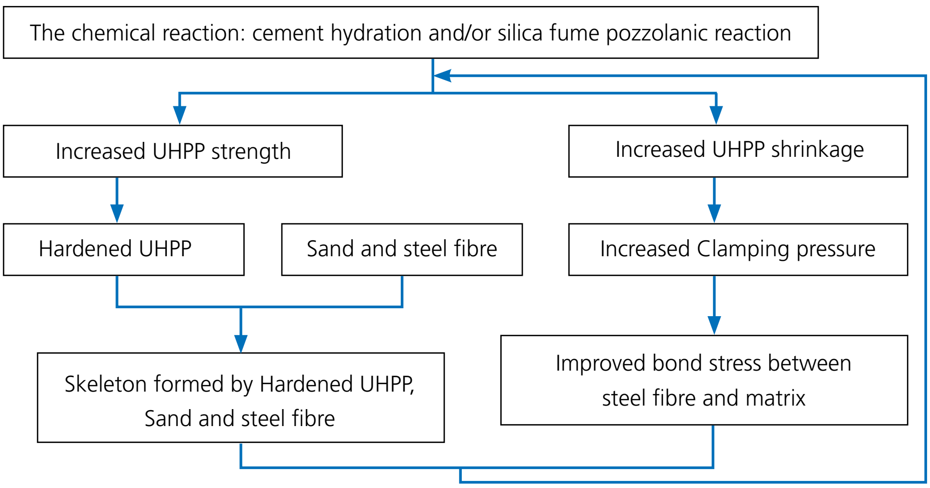


Figure 4: Skeleton formation procedure.

By following the iteration process in Figure 4, the skeleton starts to forms and grows stronger with the increase of UHPP strength. With a quick UHPP strength development up to 14 days, the skeleton becomes stronger and the pre-stressing force in steel fibre becomes larger. After 14 days, the strength of UHPP starts to degrade mainly caused by a relatively higher shrinkage as elaborate above. The formed strong skeleton up to 14 days, enough clamping pressure and lap length, all make steel fibre able to balance differential stress, or micro-cracks may develop in later days.

An advantage of the mix design followed here is that it uses paste shrinkage to its advantage for fibre activation. Other researchers improve strength by adding internal water reserve for continued hydration and

Table 4: UHPC phased design, showing Phase I-UHPP, Phase II-UHPM, Phase III-UHPC

Step	UHPC mix ingredients									Slump (mm)		f_{cu} (MPa)				
	Fibre	S/C		Aggr	SP			SF/C	w/c	CEM I		CEM I				
	V_f (%)	P	M	6mm	%	% s	Type			42.5N	52.5N	42.5N	52.5N	Age	No.	Std
1a. w/c for UHPP strength					2.80	0.84	SP I	0.18	0.30	342.0		109.2		28	3	5.2
					2.80	0.84	SP I	0.20	0.30	326.0		113.0		21	2	1.0
					2.40	0.72	SP I	0.18	0.28	312.0		113.1		28	4	7.6
					2.80	0.84	SP I	0.18	0.28	327.0		118.2		21	2	1.7
					2.80	0.84	SP I	0.25	0.27	229.0		124.0		28	4	4.7
					2.80	0.84	SP I	0.18	0.26	321.0		125.2		28	4	4.4
					3.30	0.99	SP I	0.18	0.24	307.0		138.6		14	4	6.9
					5.50	1.65	SP I	0.18	0.22	320.0		143.9		14	4	2.3
					5.40	1.62	SP I	0.18	0.20	290.0		148.4		14	4	5.9
1c. SP type for UHPP spread					3.20	0.98	SP II	0.18	0.22	278.8						
					5.48	1.67	SP II	0.18	0.22	259.0						
					5.50	1.68	SP II	0.18	0.20	213.3						
					3.42	1.03	SP III	0.18	0.22	315.0						
					5.52	1.66	SP III	0.18	0.22	321.0						
					3.20	1.18	SP IV	0.18	0.22	345.3						
					5.50	2.04	SP IV	0.18	0.22	322.0						
					3.37	1.01	SP I	0.18	0.22	276.0						
					5.50	1.65	SP I	0.18	0.22	260.3						
1d. SF/C					3.20	1.18	SP IV	0.20	0.22		337.8					
					3.20	1.18	SP IV	0.18	0.22		346.3					
					3.20	1.18	SP IV	0.16	0.22		362.5					
					3.20	1.18	SP IV	0.18	0.20		309.3					
					3.20	1.18	SP IV	0.16	0.20		329.0					
1e. SP dosage					1.60	0.59	SP IV	0.16	0.20		278.5					
					2.40	0.89	SP IV	0.16	0.20		327.3					
					2.80	1.04	SP IV	0.16	0.20		336.5					
					3.60	1.33	SP IV	0.16	0.20		329.5					
					4.00	1.48	SP IV	0.16	0.20		323.3					
1b. Sand			0.8		6.80	2.04	SP I	0.18	0.22	225.0		119.5		28	3	3.5
			1.2		6.80	2.04	SP I	0.18	0.22	190.3		117.2		28	3	2.2
		0.2	0.6		6.80	2.04	SP I	0.18	0.22	228.3		122.5		21	1	
		0.8			6.80	2.04	SP I	0.18	0.22	216.0		128.3		21	1	
2: UHPM					2.81	1.04	SP IV	0.16	0.20		336.0		152.8	14	1	
			0.6		2.80	1.04	SP IV	0.16	0.20		294.3		144.3	21	1	
			1.0		2.80	1.04	SP IV	0.16	0.20		247.3		135.3	28	3	4.7
			1.4		2.81	1.04	SP IV	0.16	0.20		203.0		99.3	28	3	6.5
					2.80	0.85	SP II	0.16	0.20		266.5		135.3	28	3	3.1
			1.0		2.80	0.85	SP II	0.16	0.20		163.8		112.5	21	1	
			0.6	12%	2.82	1.04	SP IV	0.16	0.20				131.2	21	1	
3.UHPC	1.5		0.6		2.81	1.04	SP IV	0.16	0.20				168.7	28	3	3.5
	1.5		0.6	12%	2.82	1.04	SP IV	0.16	0.20				161.4	21	3	1.5

reduction in shrinkage of UHPC by addition of superabsorbent polymer (SAP) (Dudziak, Mechtcherine 2008), or a shrinkage reducing admixture (SAR) (Soliman, Nehdi 2014). In this paper, the shrinkage-induced fibre confinement and pre-stressing is exploited to achieve UHPC with modest fibre content, without such SAP or SAR additives.

4. SPECIMEN PREPARATION AND TESTING

The mixing procedure is similar to other researchers. Compressive strength tests were performed on 100×100×100 mm specimens in the first batch only and mixed with a 50L mixer with lid. The remaining batches of specimens were 50×50×50 mm cubes and mixed with a three-speed Hobart 10L bowl mixer. When the mix of UHPC is finished, the fresh UHPC is cast into a mould and vibrated for one minute. The specimens were covered with a plastic sheet and stored in the laboratory at room temperature for 48 hours. Then the specimens were de-moulded and stored in a water tank with the temperature of 23 ± 2°C until the test at an age of 28 days. A total of 8 specimens are cast in the first batch, of which two specimens are tested on the first two weeks and the remaining four specimens are tested on 28 days. The rest of the batches cast a total of 6 specimens, of which 1 specimen is tested for the first three weeks and the rest tested on 28 days. A Contest compressive materials testing machine with the capacity of 2000 kN was used to test the compressive strength.

Besides the compressive test, the workability of UHPP through spread value is also measured. The equipment used to measure the spread value of UHPP is a cone according to ASTM C230/C230M without compacting.

The measurement of UHPP is different from that of UHPM. As for the UHPP, the cone was located on a flat steel plate and filled with fresh UHPP. The top surface of the cone was levelled after filling the UHPP and no leakage was allowed between the cone and the plate. Upon removing the cone, the UHPP flowed under the gravity. Measurement of the flow diameter was taken after 1 minute. In order to minimize the error, four measurements were taken. The UHPM flow test followed ASTM C1437 procedures for layered filling of the cone and tamping, levelling the upper surface, removing the cone, dropping the table 25 times within 15 seconds and subsequently measuring the spread value.

5. STEP BY STEP DEVELOPING UHPC IN THIS RESEARCH

The design method entails three phases, namely

Phase 1: Design of high strength, yet sufficiently flowable UHPP;

Phase 2: Addition of fine aggregate which to form sufficiently strong, flowable UHPM;

Phase 3: Addition of suitable fibre and fibre volume to complement the skeleton in UHPC.

An iterative process may be required. This may be to redefine the flowability and/or strength threshold for the preliminary optimized UHPP composition if incompatibility between the paste and fine aggregate leads to UHPM of insufficient flowability or compressive strength.

In addition to compressive strength, the spread value of UHPP was evaluated through flow table tests, due to its efficiency in indicating optimised paste packing density (Wille *et al*. 2011). A threshold value of 300 mm was used while varying other paste ingredients of cement (C), silica fume (SF) and superplasticiser (SP) type and dosage for optimised strength.

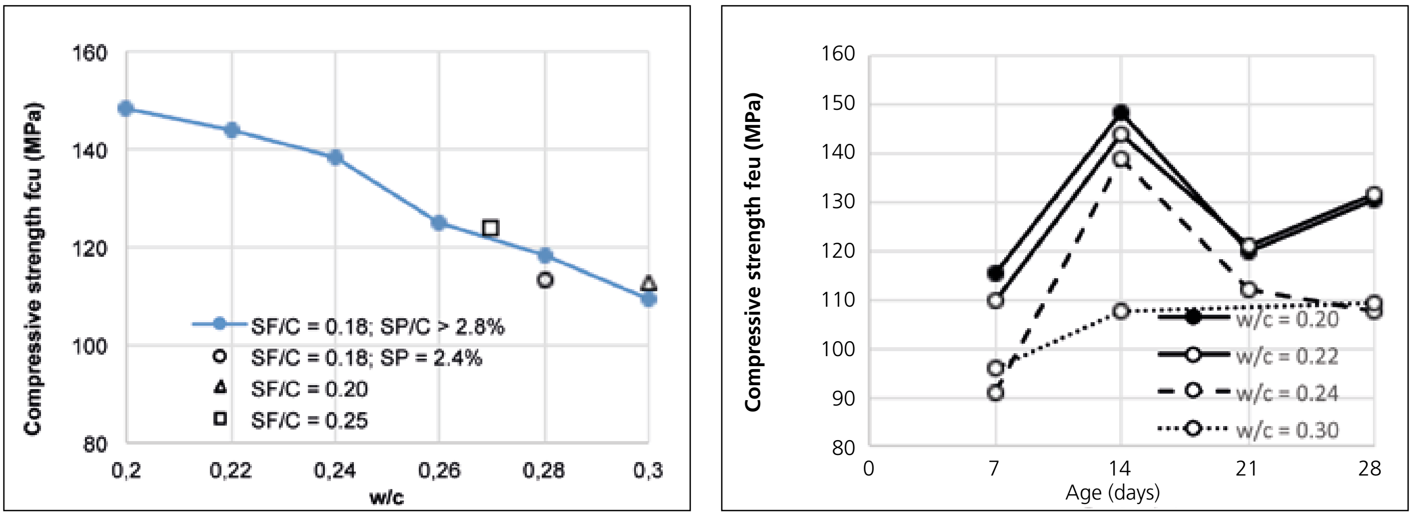
The phases of design, together with detailed mix proportions, spread and compressive strength results, are summarized in Table 4. In the following sections, the steps towards deriving an UHPC mix using local materials but no heat curing, are elaborated.

5.1. Phase 1 - Optimization of the UHPP

Since the UHPP provides the chemical reaction that governs the compressive strength of UHPC, the mix design starts with the UHPP mix design, based on the established design guidelines of ingredient materials with desired physical and chemical characteristics and proportions elaborated in section 2 of this paper. Two types of local cement (denoted by C), a CEM I 42.5N and a CEM I 52.5N were considered. Local availability dominated this decision, with the preferred CEM I 52.5N becoming available only after Phase I in this research. The only type of local Silica fume (SF) was used.

5.1.1. Phase 1a: Role of w/c ratio

The role of w/c in UHPP compressive strength is shown in Figure 5a, for phase 1a. Increased strength is observed for reduced w/c values, while keeping the SF/C ratio constant at 0.18. Also shown is the increased



(a) Stage 1a max. strength vs w/c results

(b) Stage 1a: compressive strength development

Figure 5: UHPP compressive strength vs (a) w/c ratio and (b) test age up to 28 days.

strength for higher SF/C ratios of 0.20 and 0.25 at w/c ratios of 0.30 and 0.27 respectively. However, of importance is sufficient UHPP spread, as indication of good lubrication once fine aggregate and fibres are added. While slump flow of more than 300 mm could be obtained with reasonable amounts of SP for SF/C = 0.18, the flow values dropped significantly for increased SF/C values, with the extreme drop to 229 mm for SF/C = 0.25.

For the fixed SF/C = 0.18, when w/c ratio is under 0.24, the slump flow is much lower than 300 mm by direct addition of the full SP dosage. Step addition of SP, i.e. applying for instance half dosage at a time with continued mixing of several minutes in-between, can improve the slump flow compared with direct addition of SP (Tue *et al*. 2008). In order to achieve better slump flow, step addition of SP was used, but still the slump flow only reached 290 mm when w/c ratio is 0.2, indicating more efficient SP is needed. For the UHPP mixes with SF/C = 0.18 and w/c ratios of 0.24 and below, step addition of SP was followed in this work.

The strength evolution with curing time is shown in Figure 5b. When w/c = 0.30, the UHPP strength increases with time until 28 days. When the w/c ratio is below 0.24, it shows a drop in UHPP strength after 14 days. The slump flow is over 300 mm indicating that enough packing density is achieved with this UHPP. The reason for the drop in UHPP strength after 12 days is believed to be the high autogenous shrinkage, which by skeleton restraint causes internal tension and cracking.

The w/c ratio of below 0.24 is chosen for two reasons: The cement and SF are not as ideal as those researchers who successfully develop UHPC with w/c ratio of about 0.2. Secondly, the UHPP strength is too low for w/c = 0.3, with only 109 MPa in 28 days.

Therefore, the UHPP maximum compressive strength approaches 150 MPa for the base mix of w/c = 0.20, SF/C = 0.18 and sufficient amount of SP to achieve at least 300 mm slump flow. Improved slump flow may enable increased SF/C ratio, which was shown to hold potential for strength increase. Also, CEM I 52.5N should be used instead of the CEM I 42.5N to improve strength.

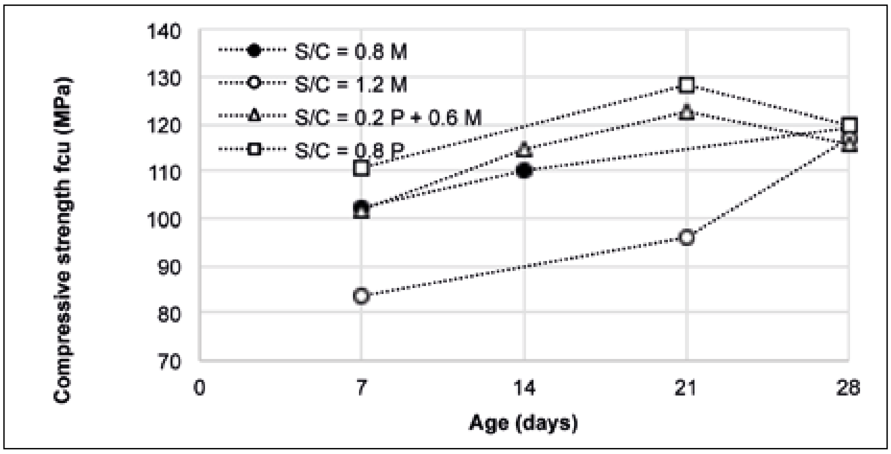


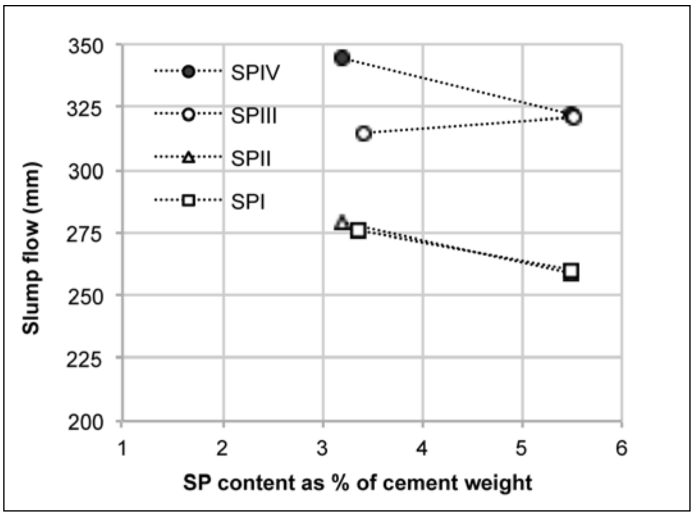
Figure 6: UHPM compressive strength for Phase 1b.

5.1.2. Phase 1b: UHPP base mix performance combined with locally available fine aggregate

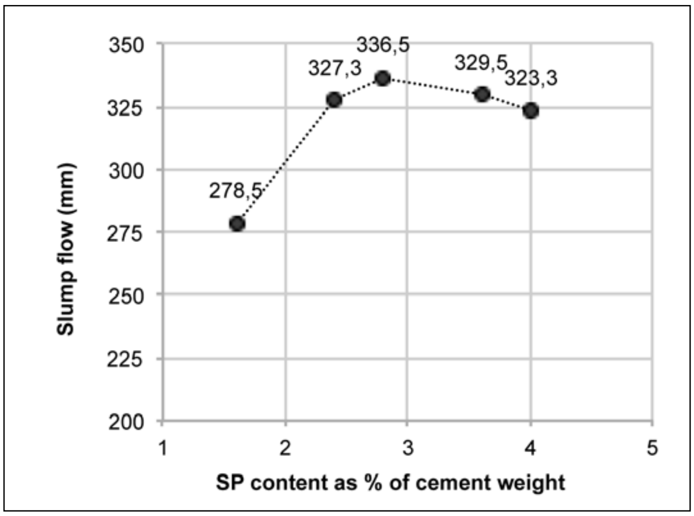
The compatibility of the base mix (w/c = 0.22, SF/C = 0.18) with local fine sands is checked in this step by slump flow and compressive strength tests. The sand content was varied in the range 0.8 ≤ S/C = 0.8 and 1.2, and for the case S/C = 0.8, only Phillipi sand (P), only Malmesbury sand (M) and a 1:3 blend were tested. The compressive strength evolution results are shown in Figure 6.

Figure 6 shows a significant reduction in maximum compressive strength from the UHPP base mix strength of more than 140 MPa in Figure 5. It also appears that the fine Phillipi sand leads to an increased maximum strength (5%) above the blended sand. However, the strengths are considered to be insufficient, to an extent indicated by strongly reduced slump flow values from 320 mm for the UHPP base mix, to the range 190 – 228 mm as shown in Table 4.

This indicates that further optimisation is required, to maximize UHPP strength and slump flow, to compensate for less than ideal local sand, as described in section 2.4. For this purpose, the best performing SP is selected next (Phase 1c) according to highest UHPP slump flow, and that SP dosage is optimised in Stage 1e. The interim Phase 1d introduces further strength enhancement by replacing CEM I 42.5N cement with newly available local CEM I 52.5N, and finally reducing the w/c of the base mix from 0.22 to 0.20.



(a)



(b)

Figure 7: UHPP slump flow (a) for different SP types and (b) optimisation with SPIV.

5.1.3. Phase 1c – 1e: UHPP improved spread by optimizing SF/C and SP type and dosage

From Phase 1a an indication of higher strength for a higher spread value is seen, for instance for the case of w/c = 0.28 containing a higher SP content, leading to a higher spread value and higher compressive strength. In Phase 1c, the most suited SP type from four available local types is examined in this research, based on slump flow tests for the selected base mix from Phase 1a. See Table 4 for the mix detail for Phase 1c. The results are shown in Figure 7a, where it is apparent that SPIV achieves the highest slump flow for this particular base mix. This SP is selected for further mix optimization in subsequent steps. Cross checks with other SP types are performed from time to time to confirm that SPIV is the most suitable for the UHPC developed here – see Table 4.

As the requirement of higher strength was apparent after Stages 1a and 1b, the newly available CEM I 52.5N was used from here onward as replacement of the CEM I 42.5N cement. In Phases 1d and 1e the option was taken to minimize the w/c ratio and maximize the spread, at the cost of SF, by reducing the SF/C further to 0.16. This was due to the lessons from Stage 1b, which showed significant reduction in slump flow once fine aggregate is added. This is believed not to be a unique option for UHPM and UHPC, which will be investigated further in future, due to the potential strength gain by higher SF/C values seen in Phase 1a, albeit at the cost of reduced slump flow. An acceptable slump flow value of 329 mm is finally found for the Phase 1d optimized UHPP mix, containing CEM I 52.5N at w/c = 0.2, SF/C = 0.16 and SPIV at 3.2% of the cement weight – see Table 4.

From Figure 7a it is not clear what the optimum dosage of SP is, justifying a systematic study. The results are shown in Figure 7b, which confirms an optimum dosage of this type of SP for the UHPP base mix of about 2.8%.

5.2. Phase 2 - Optimization of the UHPM

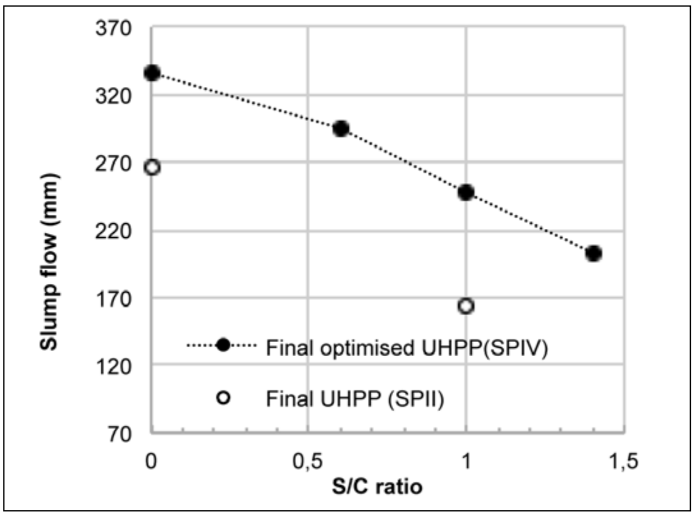
A slight benefit could be seen in Phase 1b of this research in using the finer Phillipi sand rather than Malmesbury sand. Nevertheless, only Malmesbury sand was used in Phase 2. Optimisation of UHPC containing these local sands is a current, ongoing research focus. An objective of this paper is to illustrate exploitation of non-perfect local ingredient materials for UHPC, which is served well with this choice. This fact becomes clear in Phase 3, when fibre is added to the composite and UHPC which exceeds the strength requirements, is achieved, without heat curing.

From Phase 1b no clear indication of the optimum fine aggregate content could be found. Clearly the maximum amount of sand will be beneficial from a cost point of view. For this reason three contents were tested, ranging from a relatively low value of S/C = 0.6, through a typical value of S/C = 1 to a high value of S/C = 1.4 – see the UHPM descriptions in Table 4. In Figure 8a the slump flow results for these UHPM mixes are shown, decreasing from 336 mm for the optimized UHPP to 294 mm, 247 mm and 203 mm once Malmesbury sand is added in the mentioned respective increasing S/C ratios. Also shown in the graph are results of final slump flow checks that another SP is not as effective as the selected SPIV for the specific mix and dosage. The spread value of UHPM with S/C = 1.4 developed by Wille, *et al*. (2012) is approximately 300 mm, stressing the importance of optimized fine aggregate and UHPP to achieve this.

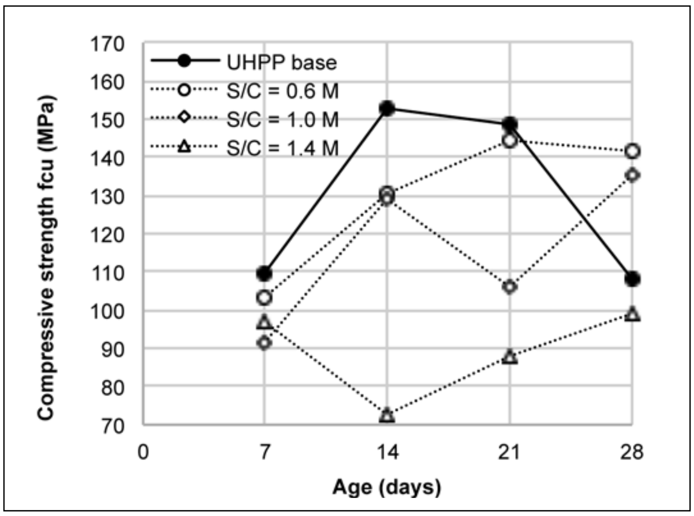
The compressive strength results are shown in Table 4, and graphically in Figure 8b. From the graph it is apparent that sand content S/C = 0.6 leads to a reduction in compressive strength from 153 MPa of the optimized UHPP base mix also shown in the graph, to 144 MPa of UHPM. Beyond this sand content, its inclusion in UHPM leads to erratic strength evolution, possibly also due to poor dispersion and sensitivity to test cube geometrical imperfection.

5.3. Phase 3 - UHPC

In the final stage, short steel fibres at 1.5% by total volume is added to the optimised UHPM. The resulting compressive strength development up to 28 days in Figure 9a. As comparison, the strength evolution of the finally optimised UHPP and UHPM are shown in the figure as well. The steadily increasing strength development in time is evident of a sound skeleton and bridging of micro-cracks induced by shrinkage of the UHPP. An ultimate strength of 168.7 MPa is achieved at the age of 28 days, succeeding in developing UHPC without heat curing.

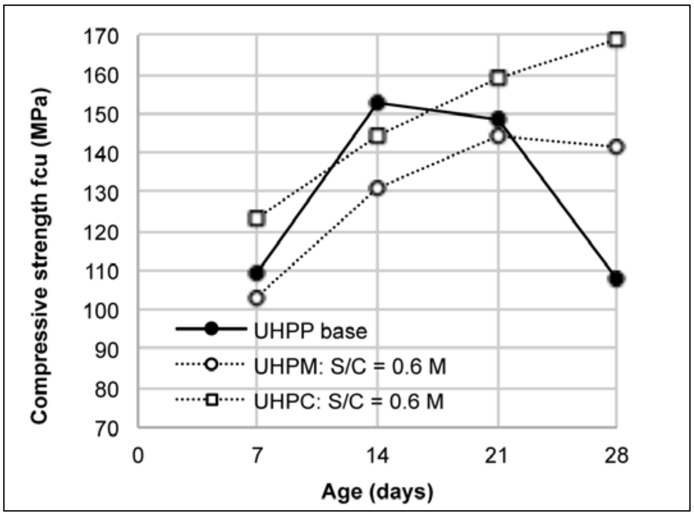


(a) Phase 2 – UHPM Slump flow

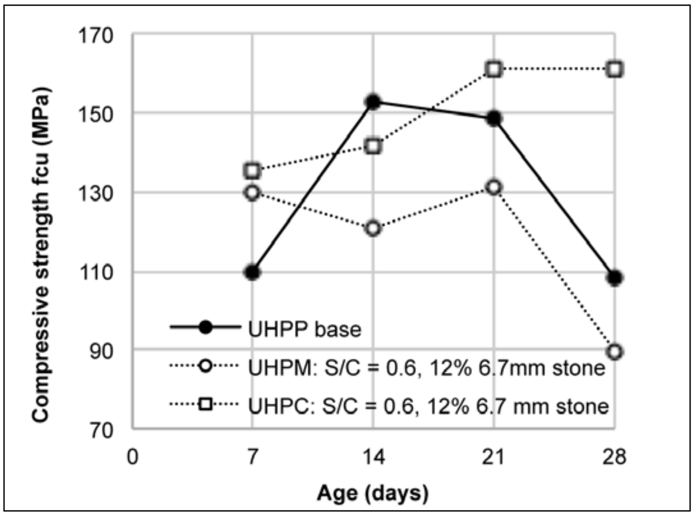


(b) Phase 2 – UHPM strength

Figure 8: UHPM (a) slump flow and (b) compressive strength development.



(a) Phase 3 – UHPC, only fine aggregate



(b) Phase 3 – UHPC, fine & coarse aggregate

Figure 9: Compressive strength development of UHPM containing (a) fine sand only, and (b) fine and coarse aggregate.

Figure 9b shows the results when, in addition to fine aggregate (Malmesbury sand at S/C = 0.6), 12% by volume of small particle stone (6.7 mm) is added to both the mortar (UHPM) and composite (UHPC). Clearly, the UHPM strength evolution is erratic, but that of the UHPC demonstrates that the shortcomings are overcome once the 1.5% steel fibres are added. An ultimate strength of 161 MPa is achieved in this case. This successful achievement of UHPC may be ascribed to the optimised UHPP. Also, the large aggregate particle size of 6.7 mm approaches the requirement that the fibre length is at least 2 to 3 times the aggregate particle size.

The final strength of UHPC is 19% higher than the UHPM strength, by the addition of only 1.5% by volume of short steel fibre. This is a significantly higher increase than reported by Wille *et al*. (2012) of 6.7% increase achieved with 1.5% steel fibres and 9.8% with 2.5% steel fibres, and indicates the effective use of fibres in this research.

6. CONCLUSION

The research reported here produced UHPC without heat treatment, using locally available binder materials, fine aggregate and super-plasticisers, together with imported short steel fibres. Due to chemical and geometrical properties not falling within optimal ranges according to reported guidelines, an alternative strategy is followed here. Instead of avoiding relatively larger UHPC shrinkage, the shrinkage is used to improve the bond stress between steel fibre and the matrix. The following conclusions are drawn:

- It is possible to design UHPC with relatively low C_3S content (61.6% of cement weight), and relatively high C_2S content (17.2%) cement.
- Local available silica fume with specific surface area of 23 ± 3 m^2/g was used successfully in UHPC reported here, while literature reports indicate a preferred value of near half this value (12 m^2/g).
- Probing tests in this research showed that higher paste strength could be achieved with silica fume to cement ratios in the range 0.2-0.25. However, due to the high water demand of the fine local silica fume, a low ratio of 0.16 was successfully used to produce UHPC.
- Fine aggregate from a natural local source and maximum particle size more than 2.4 mm can be successfully used in UHPC, by optimising the UHPP to have the most compatible superplasticiser, cement and silica fume mix. A lower sand content (S/C = 0.6) was used, due to the slump flow reduction to significantly below the preferred threshold of 300 mm.
- The maximum compressive strength of the UHPC achieved in this work (168 MPa) is 19% higher than that of the UHPM, which is a significantly higher contribution by the fibres than values reported in the literature. It is ascribed to the well dispersed, overlapping fibre and the tight skeleton formed of fibre and fine aggregate, whereby fibre bond is enhanced. Paste shrinkage further enhances bond.
- High early age compressive strength at the age of 7 – 14 days, of the water-cured paste is a good indicator of UHPC potential. By introducing a mechanism of shrinkage induced clamping pressure, a bridging effect of steel fibre with adequate lap length and uniform dispersion is achieved. In this way, high compressive strength development is achieved.

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Sika products play vital role in major Durban Interchange upgrade

The massive R352-million Umgeni Interchange upgrade currently in progress along one of Durban's arterial routes will be a feat of engineering skill when completed. Sika was proud to supply a varied selection of their internationally renowned products for this multi-bridge construction project.

SIKA AG CORPORATE PROFILE

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. Worldwide local presence in 80 countries and some 15 200 employees link customers directly to Sika and guarantee the success of all partners. Sika generated annual sales of CHF 5.14 billion in 2013.

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

Having successfully designed the bridges for the Gillooly's Interchange in Gauteng, one of the busiest interchanges in the southern hemisphere, Consulting Engineers, Hatch Goba were commissioned by SANRAL in 2009 to design an upgrade for the old split-diamond, signalised intersection between the N2 (National Road) and the M19. The new design was for a free-flow directional four-level systems interchange; involving the construction of five new bridges and two pedestrian bridges, with two incremental launch bridges as prominent features. The project was awarded to main contractors Rumdel Cape and Mascon.

As both highways comprise major traffic routes, the emphasis on this project was to keep traffic disruption to an absolute minimum. Additional challenges were space constraints caused by the nearby Umngeni River and the adjacent residential and commercial developments. The standard segmental method of bridge building for two directional ramps at the intersection was therefore scrapped in favour of the innovative method known as incremental launch. This method entails building the entire bridge deck from one end of the structure and eliminating the need for formwork, thereby allowing traffic flow to continue uninterrupted.

The incremental launch technology involves sliding sections of bridge deck over special bearings, which are concrete blocks covered with stainless steel and reinforced elastomeric pads. The first such bridge constructed was 232 metres long, from Umgeni Road onto the N2 Northbound while the second one measured 205 metres long from the N2 Northbound onto Umgeni Road.

Metier Mixed Concrete supplied shotcrete for rock stabilisation of the Umgeni on-ramp to the N2 Southbound. Two Sika products were added to the shotcrete: an aqueous polymer solution that is a multi-purpose water reducer and superplasticiser,

and a retarding concrete admixture developed for the control of cement hydration. It can be used in wet or dry spray shotcrete where cement hydration of the concrete mix is prevented (for up to three days, if required). Many more Sika construction chemical products were also supplied.

When construction on the R352 million project commenced in March 2011, three of the neighbouring communities benefitted greatly as local labour was used to fill 150 newly created jobs. The Umgeni Interchange upgrade, which is nearing completion, will significantly alleviate traffic congestion by allowing the free flow of approximately 14 000 vehicles during morning peak hour and approximately 16 000 vehicles during afternoon peak hour.

By supplying numerous dependable, innovative products, Sika has played a vital role in this project. As one of the largest undertakings of its kind in South Africa, Hatch Goba believes it will set an international benchmark for any similar projects in the future. ▲

AfriSam unlocks concrete possibilities with the launch of its dry mortar product

Leading concrete materials company, AfriSam, has responded to demands for increased convenience by introducing its premium quality Dry Mortar product to the market. With a track record of producing high quality readymix concrete, cement and aggregates for more than 80 years, AfriSam has extended its range by producing its Dry Mortar product.

Amit Dawneerangen, sales manager for AfriSam's Gauteng region, says that immediate access to an already blended dry mortar solution is very attractive to South Africa's time-pressed and cost-conscious contractors.

This product adds to AfriSam's extensive range of concrete solutions and ensures that contractors have a one-stop solution for all their wet trades, ranging from readymix concrete of varying strengths and specifications to cement, aggregates and Dry Mortar. Through its affiliation with Concrete Laser Flooring, AfriSam also offers contractors peace of mind flooring solutions.

"The AfriSam Dry Mortar mix offers contractors a number of benefits in addition to time and cost savings. Using a pre-blended mortar mix will enable optimum product integrity and subsequently quality construction on a project," he says.

"Manual blending of mortar or plaster requires careful attention to ensure that the correct ratios of sand and cement are used and incorrect blending or mixing will affect the quality of the final product and may result in cracking of plaster. Our Dry Mortar solution alleviates human error and goes a long way to ensuring quality workmanship – something contractors have identified as one of their greatest concerns these days," Dawneerangen says.

As a Class II mortar, AfriSam's Dry Mortar product has been specially engineered as a dual purpose mix that can be used for both mortar and plaster applications.

Ideal for both mortar and plaster applications

This Class II mortar has been specially engineered as a dual purpose mix that can be used for both mortar and plaster. It will meet the minimum strength requirement of 5 MPa at 28 days with ease, whilst its well graded, smooth texture requires minimal water addition and it facilitates an extremely smooth and crack-free surface.

Value-adding benefits

The product is supplied in 10 or 20 ton silos. This is a space saving advantage on a construction or building site as it effectively eliminates the need to accommodate large stockpiles of sand and frees up the area normally used to store bagged cement.

Supplying the product in either 10 ton or 20 ton silos offers optimum flexibility for all customers who can then decide on the size required based on individual project requirements.

The 10 ton silo is delivered fully loaded from the AfriSam facility, while the 20 ton silo is delivered to site empty and filled via bulk tanker. Discharge into the silo is conducted using a closed conveyance system which ensures product integrity and the elimination of dust during the process. Not only does this guarantee optimum quality of the product, but the process also complies with all the requisite environmental regulations, a factor that underlines AfriSam's long-term commitment to environmental stewardship.

To add to this, stockpiled building materials are often pilfered on site and by using the AfriSam Dry Mortar silos, theft is virtually eradicated and there is a similar significant reduction in wastage.

There are also other environmental and convenience benefits such as fewer vehicles on the road delivering raw materials to site. Instead of having separate deliveries for sand and cement, these now arrive in one vehicle. Procurement is simplified with the number of suppliers reduced, as is the amount of raw materials on site.

By attaching a mixer and water connection to the silo, a ready-to-use product is discharged when the dry mortar comes into contact with the water.

Discharge mechanism

On smaller contracts that do not make use of automated systems, the dry mortar can be discharged from the silo directly into wheelbarrows or other mixing vessels. Other options include attaching a mixer and a water connection to the silo so that when dry mortar is discharged, it comes into contact with the water and delivers a product that is ready to use.

This wet product is then discharged into a utility unit such as a dumper or concrete hopper. Where high-rise construction is taking place and there is a need to convey the mixed mortar upwards, a mortar pumping system may be connected to the silo to facilitate the easy transfer of the product.

Production process

Dawneerangen says that the most critical aspect of a ready-to-use dry mortar product is that the sand must be completely dry prior to the blending process to prevent any possibility of the cement reacting to any moisture.

AfriSam has responded to demands for increased convenience by introducing its premium quality Dry Mortar product to the market.

Special care is taken to ensure that the sand is completely dry and free of excessive clay and other deleterious material ensuring that a product of only the highest quality is produced.

The sand is then blended with AfriSam's All Purpose Cement in a controlled environment at a bespoke plant to produce a mix that is underpinned by high levels of quality. AfriSam's All Purpose Cement is an advanced composite cement containing milled clinker as well as advanced mineral components and additives. "These improve the product's workability and durability and it has the lowest carbon footprint in the 42.5N strength class. This ensures that the AfriSam Dry Mortar is a more environmentally responsible choice for contractors," he says

The fully automated plant has a 400 ton per day capacity, with plans in place to expand the capacity in response to market demand. The plant also offers the opportunity to produce coloured mortars and plasters, which AfriSam is currently in the process of developing. This will eliminate the need for paint and other expensive decorative coatings.

Quality assurance

Batch printouts are produced to verify consistency and ensure optimum quality. In addition, samples of the dry mortar product are taken at regular intervals and tested at AfriSam's Centre of Product Excellence to ensure compliance with the required specifications. In addition, the Centre of Product Excellence will assist customers with queries and will provide product technical support to assist contractors in achieving a quality build.

Product availability

AfriSam Dry Mortar has already been introduced to customers in Gauteng with much success and will be rolled out to the other provinces shortly. Customers can obtain more information about AfriSam's Dry Mortar as well as place orders through the company's customer contact centre by dialling 0860 110 010.

"We are excited about the addition of Dry Mortar to our existing product range. We believe it demonstrates our commitment to delivering superior concrete solutions to our customers through continuous product innovation", concludes Dawneerangen. ▲

ABOUT AFRISAM (PTY) LTD

AfriSam is a leading construction materials group in Africa, with operations in South Africa, Lesotho, Swaziland and Tanzania. The company supplies superior cement, readymix and aggregate products and technical solutions to its customers from its seven cement production facilities, 17 quarries and 42 readymix operations. Founded in 1934, the company employees over 2 000 staff and is a proud Level 2 Broad Based Black Economic Empowerment (BBBEE) contributor.

LafargeHolcim

A new leader for a new world: LafargeHolcim officially launched around the globe

LafargeHolcim has officially launched the new Group around the world and announces key elements of its ambitions for the future. Following the successful completion of the merger between Lafarge and Holcim and the listing of the new LafargeHolcim shares in Zurich and Paris, the new Group will now work towards creating the highest performing company in the building materials industry.

LafargeHolcim CEO Eric Olsen says: "Now as LafargeHolcim, we will step into the next phase of our transformation to become the leader in every respect – a company that has a positive impact on the world and can make a real difference for its customers, its employees, its shareholders and society."

New ambition supported by five key focus areas

The company is initiating a strategic transformation by building on the best of both Lafarge and Holcim. The Group will now focus on five areas in the first integration phase:

- Synergies: delivering on EUR 1.4 billion synergy target within three years
- Capital allocation: rigorous approach to capital allocation and overall reduction of capital spending
- Commercial transformation: creating differentiation through innovative products and solutions
- Integration: creating one new group and culture
- Health and Safety: putting Health and Safety at the centre of the organization.

LafargeHolcim will be organized along a new operating model oriented to serve the local customers, while leveraging the Group's size, footprint, and capabilities at global scale. It combines empowered countries, regional management platforms and expertise-driven group functions.

In South Africa, the company will be known as Lafarge – a member of the LafargeHolcim Group. South African operations will not be affected. Lafarge's focus on customer service and providing innovative products and services will continue unabated. The reason for the minimal impact of the merger on Lafarge South Africa is the absence of a Holcim presence in the country. There is no overlapping of interests requiring restructuring to avoid duplication of resources.

However, the changes that will emanate from the successful joining of two giants in the building materials industry bring wide-ranging benefits directly and indirectly to all stakeholders and certainly to its customers.

More information is available on www.lafargeholcim.com ▲

Safer system for cleaning readymix trucks

The konkrete BLASTER is a safe, quick, cost effective and environmentally friendly solution to cleaning the insides of concrete drums, without the need for human entry and confined space work procedures.

Making use of the Ready Jet (USA) patented technology, konkrete BLASTER provides a robotic, non-human entry concrete removal system for the safe, quick and efficient removal of hardened concrete from concrete drums at the producer's premises with video ('go-pro' style) recording of work done for the maintenance department's reference and asset files. The system keeps the fleet's mixer drums clean, allowing trucks to run with less unnecessary weight and with a larger storage capacity, which in turn allows for fewer journeys to achieve the same goal.

- Enhanced safety and reduced health risks – employees are no longer exposed to the dangers of Silica dust, which can become airborne during jack hammering. Employees control the konkrete BLASTER from outside the mixer drum, meaning safety risks coupled with entering the mixer drum can be completely avoided.
- Reduced transport costs and increase fuel efficiency – Traditional concrete drum cleaning retains 'dead/hardened concrete' in the mixer drum which translates to higher transportation costs due to surplus weight being carried.
- Increased mixer drum capacity – Retaining more 'dead/hardened concrete' greatly reduces the available capacity within the mixer drum, meaning less ready-mix concrete can be transported and the risk of concrete spillage significantly increased.
- Improved company image – Creates a better company image with no unsightly jack-hammer marks on mixer drums and no need for costly drum repairs due to jack hammer holes and marks and associated re-painting and sign-writing.
- Reduced drum maintenance cost – All cleaning is done with ultra-high pressured water (no chemicals) therefore no damage to drum or blades.
- Reduced truck-mixer down time due to drum cleaning – Our system is universal and can be used on all mixer drum types with minimal down time of your mixer drums (cleans can be scheduled after normal working hours).
- Pioneering water blasting technology

konkrete GLOBAL is the authorized and registered agent and distributor for Blaster Ready –Jet in Southern Africa. ▲

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Major infrastructure projects benefit from integrated materials supply solutions

The development of fully integrated building materials supply and management solutions by Lafarge South Africa focuses strongly on the needs of its construction contractor customers and their projects. The approach is proving to be highly effective, offering customers both peace of mind and better value in a competitive marketplace.

The company is in a unique position to meet the needs of the construction industry through having a strong presence in all of its construction related business lines of cement, aggregates, ready-mixed concrete and fly ash. Lafarge South Africa is a member of the LafargeHolcim group, the world leader in the building materials industry. With its commitment to drive sustainable solutions for better building and infrastructure, and to contribute to a higher quality of life, the Group is best positioned to meet the challenges of increasing urbanisation. In South Africa, the emphasis is on building better communities by contributing to solutions for decent housing, hospitals, schools and offices, together with the associated infrastructure to connect and service cities, such as roads, airports, as well as water and power utilities.

Key supplier for Eteza interchange

An efficient integrated service package is being supplied by Lafarge South Africa for the SANRAL contract to construct an overload control facility and full diamond interchange at Eteza on the N2 in KwaZulu-Natal. Construction began in October 2014 and is scheduled for completion in January 2017.

The motivation for the project, which is approximately 20 km from Richards Bay, was to provide a vehicle management facility that would take overloaded vehicles off the road and create a safer environment for all road users. The normal lifespan of a freeway is 30 years but overloaded heavy vehicles travelling to and from the local port can reduce the usable life by over a third because of accelerated deterioration of the pavement.

The project raised two main concrete issues: the first being to place the Continuous Reinforced Concrete Pavement (CRCP) on time and within specification when the closest commercial ready-mixed concrete plant was 45 km from the project site. The second concern was ameliorating the Heat of Hydration (HOH) in the extremely hot, humid conditions.

Lafarge South Africa's successful offer to supply all main building materials, concrete, cement, fly ash, and 165 000 tons of road aggregates, as well as 4 500 tons of the company's specialised cementitious roadbinder, made it viable to provide a Lafarge mobile concrete batching plant on site. This will enable the required combined total of 13 000 m³ of CRCP mix and other Conventionally Vibrated Concrete (CVC) to be supplied without compromising the quality or integrity of the concrete.

The solution for assisting with the control of HOH is the supply of 6 500 tons of Lafarge's CEM II 42,5 R type premium technical cement. This unique product is not only a Low Heat Cement with a typical HOH value of 227 J/g (compared with the EN 197-1 criterion of < 270 J/g at 41h), but it can also be extended further on site with fly ash to meet the various mix requirements.

Taking responsibility for durability

Lafarge South Africa is providing similar support for the ongoing SANRAL contract to upgrade Section 14 of the N1 freeway between the Trompsburg Interchange and Fonteintjie, a distance of 20,8 km. The existing pavement had deteriorated badly and, instead of a normal pavement upgrade, it was decided to build a greenfield carriageway. However, it is an extremely busy section of freeway, involving bridges and many other structures. Another challenge was the fact that the site is some 120 km from the nearest fixed commercial ready-mixed concrete plant and this represented a potentially significant risk in terms of compliance with the tight durability specification.

The solution from Lafarge South Africa was to position a mobile concrete batching plant optimally on site to service the major concrete pours and take on the durability risk. This was conditional on being awarded the full supply package of building materials. The successful outcome was the contract to supply of 10 000 m³ CVC concrete, on-specification and on-time. This involves supplying 3 500 tons of Lafarge 42,5R type cement, 7 000 tons of aggregates, 1 000 tons of fly ash, as well as 8 000 tons of the cementitious roadbinder. The project started in October 2014 and has a scheduled duration of 24 months.

Better value

"Our construction contractor customers are appreciating the benefits of having their building materials supplied and managed from a single reliable source," comments Unathi Batyashe-Fillis, Lafarge South Africa's Country Communications Manager. "By matching the extensive capabilities of Lafarge South Africa with the needs of the specific construction project and the individual construction company, we achieve consistent quality and better value all round for the stakeholders." ▲

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BASF presents industry solutions at Totally Concrete Expo 2015

BASF's Master Builders Solutions® brand showcased innovative products aimed at the construction industry, with interactive demonstrations that focused on customer solutions.

After the successful launch of its global Master Builders Solutions® brand in South Africa at the 2014 Totally Concrete Expo, BASF once again demonstrated its latest innovative products at the 2015 event held at the Sandton Convention Centre earlier this year.

The portfolio of products and services marketed under the Master Builders Solutions® brand embraces chemical solutions for new construction, maintenance, repair and renovation of buildings as well as infrastructure: concrete admixtures, cement additives, solutions for mining and tunneling, waterproofing, sealants, concrete repair & protection, performance grouts, and high-performance flooring products.

According to Managing Director of BASF South Africa's Construction Chemicals Division, Morgan Govender, the Master Builders Solutions® brand strengthens BASF's industry orientation: "It stands for BASF's commitment to provide the whole construction industry with tailored products and solutions allowing us to concentrate our ability to collaborate across technologies and functions on a global scale," he said. "That way, we create solutions geared to meet the individual construction challenges of our customers and meet our corporate purpose of making our customers more successful."

Totally Concrete 2015 saw BASF showcasing a variety of its products during interactive demonstrations. The focus was on industry challenges and BASF's product solution range.

BASF is celebrating its 150 anniversary during 2015. According to Vice-President and Head of Business Center South Africa and Sub-Sahara, Joan-Maria Garcia-Girona, the Totally Concrete Expo provides the ideal opportunity to showcase BASF's innovative solutions that it has developed over years of intense collaboration between researchers and industry partners. "Our core purpose of 'We create chemistry for a sustainable future' underpins BASF's commitment to creating collaborative partnerships with all industry role-players in order that we can strive to make our customers more successful," he said.

BASF, through its Construction Chemicals division, has played a significant role in many of the recent milestone achievements in infrastructural development projects in Southern Africa. The construction of the stadia for the 2010 FIFA World Cup, the Gautrain rapid rail system, the De Hoop Dam in Limpopo Province, the Ingula hydro-electric water scheme in the KwaZulu-Natal midlands and the construction of wind turbine farms, are but a few of the projects that BASF has been involved in by supplying specialist solutions to a variety of construction industry partners. "We are proud to be part of this progress by offering solutions which are based on our global know-how and provided by our local experts," said Garcia-Girona.

The Totally Concrete Expo is an educational and networking platform for insights on the latest developments and technologies associated with the concrete and construction industry aimed at ready mix and pre-cast concrete producers, specifiers, specialist contractors, engineers and architects. ▲

Concrete in water infrastructure: keeping the lifeblood of society flowing

By Claire Cole

"Leading water scientists say it is no longer debatable that South Africa is experiencing a water crisis given that there are already serious problems in supplying enough water of sufficient quality to meet the country's social and economic needs. "

Predictions are that continued population and economic growth, combined with climate change, could result in serious water shortages in some parts of the country by 2025.

Concrete has played a role in the provision of water and sanitation for centuries. The ability to supply clean drinking water and remove waste in a controlled fashion from towns arguably played a role in the ability of those areas to develop into sizeable urban settlements – and consequently in the development of civilisation as we know it.

Today, water and sanitation are critical components of cities, and their adequate provision to both urban and rural areas of South Africa is a cornerstone of our developing democracy. Access to clean drinking water is, in fact, enshrined in the Constitution as a basic human right. "The development of our society, our growing population, and the legitimate demands of the disadvantaged majority for access to that most crucial natural resource - water - have placed new demands on what is, although renewable, a limited resource that can easily become polluted or over-used," states the National Water Policy .

Concrete: a remarkable material

The uses of concrete in this field are many and varied, ranging from the construction of massive dams, tunnels, reservoirs and water supply lines to storm water drainage, sewer lines and works, and smaller (even domestic) scale elements such as gullies, tanks, pipes, troughs and farm reservoirs.

Water infrastructure vital to SA's prosperity

Modern water infrastructure plays a vital role in South Africa – a country with scarce water resources and a growing population. According to the Department of Water Affairs and Sanitation, South Africa is the 30th driest country in the world. According to the department, "Water is a critical element to sustainable socio-economic development and the eradication of poverty and is at the core of the green economy in the context of sustainable development and eradicating poverty". Ensuring the availability and supply of clean, potable water is just as important as ever – but it needs to be done on an increasingly large scale as different areas of the country develop.

Delivering adequate water supply – particularly to remote and rural communities – has never been easy. The cost of infrastructure and the associated maintenance are, without doubt, a challenge. There could, however, be an even more serious problem looming which will pose an even bigger challenge – that of drought. According to a recent article published in Infrastructure News , the world could be heading for a severe drought due to climate change before 2050.

A wealth of applications – and the importance of standards to regulate them

Recently many big dam projects have been completed in southern Africa e.g. the Spring Grove Dam in KwaZulu-Natal, the De Hoop Dam in Mpumalanga and the Metolong Dam in Lesotho.

Not all concrete installations are as pioneering or impressive as that of large dams, but concrete nevertheless plays an important role in other aspects of water infrastructure. As Concrete Manufacturers Association's Concrete Pipe and Portal Culvert Handbook puts it, "Concrete is possibly the most widely accepted material for stormwater pipes, culverts, sewer lines and many other applications. This acceptance stems from concrete's ability to be moulded into almost any shape and to satisfy a broad range of performance requirements in terms of strength and durability.

To meet these needs, the concrete pipe industry in South Africa has grown tremendously in the past sixty years. The use of precast culverts has, in recent years, become popular as they offer many advantages over cast-in-place culverts. Modern technology and the acceptance of SABS standards ensure that products of uniformly high quality are produced. Provided sound design and installation methods are followed, the concrete pipe and portal culvert will give satisfactory hydraulic and structural performance for many years."

The use of pervious concrete readily allows water to percolate into the ground. Used for parking lots, sidewalks, and other pavements, pervious concrete can help to retain stormwater run-off and replenish local water supplies. Concrete cisterns capture rainwater and store it for non-potable uses such as flushing and irrigation, or - after suitable treatment - bathing and drinking.

Is it too late to think ahead?

Infrastructure provision is at a challenging time in South Africa as a whole. The country has already seen the effects that a lack of adequate planning and maintenance on the electricity grid have resulted in, with regular electricity cuts having become part of our daily lives. Recent media reports have picked up on comments that the country was witnessing the same kind of failures that crippled its electricity grid in the management of its water infrastructure.

The National Water Policy puts it well when it says: "The use to which we, as a society, put our water will come under increasing scrutiny and intensifying management as we move into the 21st century. We will have to stretch our understanding, and apply our wisdom ever more creatively if our aspirations for the growth and development of our society are not to be constrained as a result of limited water resources.

"This is a significant challenge for a country where rain falls unevenly in space and time; where the areas of highest rainfall are far from the industrial and urban heartland and from areas of rural poverty; where crippling droughts or devastating floods repeatedly wreak their vengeance on our land and our people; and where available water resources are inequitably distributed and sometimes inappropriately used.

"South Africa has shown the world that peace can be created out of conflict. This new water policy for South Africa is yet another demonstration of this unique ability. The new water policy embodies our national values of reconciliation, reconstruction and development so that water is shared on an equitable basis, so that the needs of those without access to water in their daily lives are met, so that the productive use of water in our economy is encouraged, and so that the environment which provides us with water and which sustains our life and economy is protected."

The Council for Scientific and Industrial Research (CSIR) researchers have warned that continued population and economic growth, combined with climate change, could result in serious water shortages in some parts of the country by 2025.

PPC's role in resource efficiency and sustainability

Conserving water resources, by incorporating admixtures and/or using recycled water in concrete mixes, reduces the freshwater requirement. Certain admixtures reduce the amount of cement required, which, in turn, reduces the carbon footprint. When it comes to designing green buildings, concrete is ideal, as it can be designed to incorporate supplementary cement materials (SCMs), such as fly ash or slag, resulting in a reduction of the carbon footprint.

PPC is also incorporating these SCMs in the production of cement, making extended Portland cements with slag, fly ash, and/or limestone. Their premium, general purpose cement is ideal for general building operations, structural concrete, and the manufacture of cement-based products. PPC also manufactures a Portland cement (which some may say adds to the carbon footprint); how ever, this CEM I 52,5N allows it to be blended with locally available SCMs or by-products that would otherwise end up in landfills.

PPC has responded to the threat of global climate change by reducing the effective footprint of cement manufacturing. Significant progress has been made through various initiatives. One of the main focal areas to improve the eco-impact of cement production is the reduction of resource and energy requirements for the production of Portland cement.

While PPC has the product to support water-infrastructure development, it serves the construction fraternity and the community in many other ways. PPC's mobile app and the Cement and Concrete Cube (C3), an online information portal, facilitate the skills transfer process through knowledge and information sharing. The provision of these services ensures that the development of the local industry keeps up with latest global trends and standards.

Supporting and uplifting communities takes PPC a few steps closer to sustainability. ▲

Retaining walls stabilise building platforms at Mpumalanga shopping centre

Five geosynthetic reinforced retaining walls using precast concrete retaining blocks manufactured by Aveng Infraset have played a crucial role in creating stable terraces for the construction of Emoyeni Mall, a recently completed shopping centre situated between Nelspruit and Hazyview in Mpumalanga.

The mall was built by one of the country's leading rural retail centre development specialists, McCormick Property Development, a company with a strong focus on the emerging markets of South Africa. Engineered Interlock Solutions (EIS) in conjunction with TMV Consulting Engineers designed the geosynthetic reinforced concrete block retaining walls. The walls were built by EIS in close collaboration with the main earthworks contractor, Joubert en Seuns.

EIS owner, Manie Troskie, says that EIS won the retaining wall tender on the basis of an alternative and more cost-effective design which also offered better functionality.

One of the closed-face walls.

"There are substantial quantities of sub-surface water on this site and our design had to make provision for extensive drainage. In fact there were some embankment sections where one could actually see water oozing from the ground.

"Three walls were open-face designs and were built with Aveng Infraset's retaining wall blocks. The other two walls were closed-face.

The largest wall, some 200 metres long, was built in an open-face configuration at an angle of 70˚. It was constructed on the perimeter of the property to reinforce an embankment which rose to 12 metres at its highest point from a service road below.

"We only had five to six metres to work with on this wall and the installation of extensive sub-surface drainage was required before construction of the wall could begin. Sub-soil drains were installed on top of the foundations three-to-four blocks below kerb level. Fin drains, wrapped in with non-woven needle-punched geotextile which go right back to the cut face, were laid to trap water at the top, sides and bottom of the embankment.

"We also installed 250 mm wick drains which were wrapped with non-woven needle-punched geotextile. In areas with the heaviest water flows we positioned 100 mm slotted pipes covered with stone and PVC coated, multi-filament woven polyester to trap the water at the cut face. All ground water drains into a pipe at the bottom of the wall which runs parallel to the foundation and feeds into the storm water drainage system.

"The foundation of the perimeter wall was steel reinforced. One metre wide, it varied between 450 mm and 300 mm in depth depending on the height of the wall. TB 490 retaining blocks were used to erect the lower section of the perimeter wall and the upper section was laid with lighter TB 300s," said Troskie.

High tenacity planar structures consisting of a biaxial array of composite geosynthetic strips were used to reinforce the wall. The material was specified due to its very low elongation properties. It also attains its tensile strength very quickly and has a stretch factor of less than 5%. This product reaches back to the cut face and was laid at a spacing of every second block on the lower half of the wall. A geogrid, made from high molecular weight, high tenacity polyester multifilament yarns, was installed at every third block on the top half and extends nine metres into the fill.

The parking basement wall was also built as a geosynthetic reinforced wall. Rising to 5.5 metre it takes a heavier loading than the perimeter wall as it has to support a portion of the weight of the building which was built on a jockey slab, concrete columns and normal foundations. Because of the heavier loading, the wall was built using the TB 490 block only.

"Basement walls are normally built with solid concrete retaining walling, however, retaining block walls are more cost-effective," advised Troskie.

Two closed-face walls were built using Aveng Infraset attractive Infrablok™ 350 at an angle of 85˚ due to limited space. The one wall which varies in height between one metre and 3.4 metres was built adjacent to a car-park feeder road and supports a building platform on which a Cashbuild store was built. The walls were built around the concrete support columns and reinforced soil, and the retaining wall supports a portion of the building's loading. The planar structure geogrid was used to reinforce this wall to prevent any soil movement under the building's foundations.

The second closed-face wall was built around a water reservoir situated on ground above the centre. This wall was constructed with Infrablok™ 350's at a face angle of 75˚ and the geogrid was used for geosynthetic reinforcing. A combination of the geogrid and cement-stabilised backfill was deployed in areas where the space between the reservoir and the concrete block retaining wall was limited.

Other members of the professional team included the main consultant, Endacon Consulting Engineers, and the main building contractor, Ikotwe Construction. ▲

Established in 1994, Concrete 4 U is a leading producer of quality readymix concrete in the Eastern Cape.

AfriSam acquires equity stake in Eastern Cape readymix concrete supplier

AfriSam, the largest producer of concrete materials in southern Africa, has acquired an equity stake in Port Elizabeth based Concrete 4 U, expanding its footprint in the Eastern Cape.

AfriSam has an existing well established cement presence in the Eastern Cape through its depots in East London, Queenstown and Port Elizabeth, which are supplied from its highly efficient integrated cement plant in Ulco, in the Northern Cape. This acquisition augments and strengthens AfriSam's ability to provide superior quality concrete solutions to its customers in this region.

"The equity acquisition in Concrete 4 U expands AfriSam's readymix footprint in the Eastern Cape region and fully aligns with our growth strategy", says AfriSam CEO, Stephan Olivier. "We are making good progress with our growth plans and this transition will also be further strengthened by our planned grinding plant at the Coega Industrial Development Zone (IDZ). Our intention is to begin construction as soon as we have received a positive environmental authorisation," he adds.

Established in 1994 Concrete 4 U is, in its own right, a leading producer of quality readymix concrete in the region. With distribution plants in Port Elizabeth, East London, Mthatha and Port St Johns, Concrete 4 U prides itself in the production and distribution of quality concrete.

With its sound infrastructure, technological prowess and committed people, Concrete 4 U is well positioned to expand its customer base, offering quality products and support services throughout the region.

"The relationship with AfriSam is in line with our progressive strategies, allowing us and our customers to benefit not only from the production and supply of quality products, but also with the integration of technologically advanced systems" said Deon Fourie, managing director of Concrete 4 U. `

The AfriSam and Concrete 4 U affiliation forms a strong foundation for continued future expansion within the construction industry as a whole, creating job opportunities and security in tandem with future economic developments. ▲

CMA announces Awards for Excellence 2016

The Concrete Manufacturers Association NPC (CMA) has announced that its Awards for Excellence competition will be run during 2015/16. PPC, the leading supplier of cement in southern Africa, is the anchor sponsor of the competition.

According to Echo Group managing director, Monique Eggebeen, who chairs the CMA's Awards committee, the essential purpose of the awards is to recognise excellence in the use of precast concrete and to honour those professionally associated with its diverse applications.

"This is the pinnacle event in the precast concrete construction calendar and it presents an outstanding opportunity for CMA members, both large and small, to showcase their products and to establish themselves as trendsetters in the use of precast concrete," says Eggebeen.

The competition is open to all provided that the precast products entered for the competition were made by a CMA member. Entries must be submitted by no later than October 16, 2015.

There are six award categories in this year's competition:

- Aesthetics Commercial
- Aesthetics Residential (Private Single Dwellings)
- Community Upliftment
- Technical Excellence
- Innovation
- Precast for Life

Winners of the last CMA Awards for Excellence in 2012

Entries will be judged on the contribution precast concrete elements make in one or more of the competition categories, i.e. the same project could be entered into more than one category. For example, a township paving project could contest several, if not all six, categories.

Six floating trophies will be presented to the manufacturers of the precast concrete elements in the nominated categories. In addition, commendation awards will be made to three runners-up per category providing these entries meet the standards of the judges.

Entry leaflets, which cover the rules of the competition, and entry forms can be downloaded off www.cma.org.za. Any queries regarding the competition should be referred to the competition organiser, John Cairns. He can be contacted on 011 431 0727 or 079 884 7986 or via jcpaving@gmail.com.

Trophies and commendation awards will be presented at a gala dinner ceremony which will take place at Summer Place in Hyde Park, Johannesburg, on 23rd April 2016. ▲

Concrete masonry housing is the sustainable choice, says The Concrete Institute

Concrete masonry housing offers substantial environmental benefits, says Bryan Perrie, managing director of The Concrete Institute.

The increasing focus on environmentally-friendly practices and energy-efficiency has resulted in the emergence of global 'green washing' with its inherent unsubstantiated, or misleading, claims about the environmental benefits of products or materials. As a result, it has become necessary to delve deeper into the manufacturing processes of materials to distinguish the truth from fiction in this regard," Perrie asserts.

"The ability to incorporate recycled and industrial by-products into the concrete masonry manufacturing process not only reduces the embodied energy of the units significantly, but also has immense environmental benefits. It decreases the demand for non-renewable resources by reducing the amount of virgin aggregates to be sourced.

"Secondary energy consumption generated by long-distance transport of aggregates from quarries to manufacturing plants can be reduced by using locally available building rubble. At the same time, it eases the pressure on landfill sites by decreasing the amount of rubble and waste material to be transported to, and dumped at, landfill sites. Concrete masonry manufacturing plants also have the unique ability to become zero-waste manufacturing sites by recycling their own manufacturing waste back into the process.

"Further to that, any so-called 'green' material should be evaluated against its ability to contribute towards the overall sustainable future of South Africa. In order to do that, one needs to consider that true sustainability is the result of a balance between environmental, economic and social factors.

"The inherent cost-effective, durable and low-maintenance qualities of concrete masonry have for long made it the material of choice for the South African context. The labour-intensive nature of concrete block-laying provides the opportunity to create numerous jobs in the unskilled labour market – all of which contribute immensely towards social and economic sustainability.

"Furthermore, the thermal mass quality of concrete provides it with the ability to improve environmental sustainability by aiding passive climate control design. From this perspective, it is clear that concrete masonry is an inherently 'green' material ideally suited to improve sustainability in South Africa," Perrie adds. ▲

Precast concrete cover slab to circular shaft

In this regular section of Concrete Beton, we feature concrete-related, confidential reports emanating from the Structural Safety organisation* in the UK, represented in South Africa by the joint Structural Division of SAICE.

An incident recently occurred on a project involving the construction of a 12.5 m internal diameter x 12.5 m deep storage shaft. The reporter says that the cover slab for the storage shaft was designed as an interlocking arrangement of seven precast concrete slabs with half joints between the individual units. Once the precast concrete slabs had been lifted into position above the shaft a layer of in-situ concrete was to be placed over them to form the finished composite cover slab. The cover slab was a bespoke design prepared by a specialist supplier who also manufactured the precast concrete slabs off site at their production facility. When the precast concrete slabs arrived on site they were lifted into place but approximately 10 minutes after the last slab had been placed, five of the seven slabs collapsed into the shaft. Fortunately no one was on the cover slab at the time of the collapse so no one was injured as a result of the incident. The investigation into the incident looked at a number of possible causes including design errors and low concrete strength but it very quickly became clear from discussions with the specialist supplier and destructive examination of the failed precast concrete slabs on site, that the reinforcement in the half joints between the slabs had not been installed as per the design. Reinforcement had the correct cover but the bars were not the correct shape, diameter or spacing. The reasons for this were attributed to the fact that the units were manufactured over a holiday period when the usual steel fixers were unavailable. When bespoke concrete elements are constructed on site it is standard practice for the principal contractor to carry out a pre-pour inspection to check that the subcontractor has fixed the reinforcement in accordance with the drawings, cover is correct etc. prior to placing concrete.

It is the reporter's opinion that when procuring bespoke precast concrete units manufactured off-site by a specialist supplier a risk assessment should be carried out to determine what level of inspection of the manufacturing process should be carried out by the purchaser. The reporter continues that third party accreditation and certification of the suppliers QA procedures should not be relied on as giving sufficient confidence that the manufacture of individual units has been carried out correctly. The reporter's firm has subsequently carried out a thorough review of in-house processes covering testing and inspection and the way in which these deal with off-site manufacture.

Comments

Reputable precast-concrete suppliers will have recognised QA processes to avoid such occurrences. Good practice may suggest that precast units should be checked on delivery although in this case the problems of incorrect shape, diameter or spacing might well not have been detected. Treatment of off-site manufactured bespoke products is somewhere between that for on-site construction and that for off-site manufacture of mass produced products. For construction on site a contractor would probably check everything, and for mass produced products a contractor would probably check little or nothing - relying on third party product certification. The level of checking for bespoke items made off-site should be determined from a risk assessment process which evaluates likelihood and consequences of a non-compliant product. This might include the contractor making checks at the pre-cast works.

Clearly whatever procedures should have been in place did not operate on this occasion, with potentially fatal consequences. It is reassuring that a thorough in-house review by the contractor took place to avoid a recurrence. A key question in any safety assessment is: "Do you know that what you thought was being constructed was actually constructed?" Another point is that half joints have a long history of problems partly because they are shallow and the numerical capacity tends to be sensitive to small errors in cover and the positioning of reinforcement. One of the most costly forms of failure is when a mass produced element has been wrongly designed or manufactured so that the defect is repeated multiple times. Car manufacturers sometimes have this problem resulting in mass recalls of vehicles. ▲

** If you found value in this material, please consider submitting issues that you have come across, such that others may, in turn, benefit from your experience. This is done through Confidential Reporting on Safety (CROSS) at www.structural-safety.co.za*

FULTON AWARDS 2015

The 2015 Fulton Awards was a resounding success and the celebratory weekend, in the words of many people, was the "best ever".

Sponsorship

PPC was the Anchor Sponsor for the 2015 Fulton Awards, and we are very grateful to them for the generosity given to the Society in support of rewarding excellence in concrete. Several other industry companies also sponsored various aspects of the Fulton Awards Gala Weekend, and we thank the following organisations for their loyal support:

AfriSam	NPC
Ash Resources	SARMA
BASF	Sephaku Cement
Chryso-abe	Sika
Lafarge	

Judging

All went well with the on-site adjudication of all the projects and a huge thank you to Bryan Perrie, Managing Director of The Concrete Institute and a Director of the Concrete Society, and Sindile Ngonyama, President of the South African Institute of Architects for their diligence, professionalism and time spent, on this very challenging exercise. It was unfortunate that this year, due to last-minute cancellations we were unable to retain the support of SAICE for the judging, as we had every intention to have three professionals adjudicating the awards. We will ensure that we are not faced with this situation again in future events.

Entries

We started off with 36 nominations but, as has become the norm, we lost 12 of these once the formal entry submission packs were sent out. A survey is to be carried out to ascertain why there is such a large drop-out at this stage.

With the introduction of new categories this time around, there was a different spread of projects. Disappointing though, that two of the categories had no entries (Architectural <R100 m and Building Structure <R100 m). This meant that we received no residential projects which have traditionally portrayed concrete at its very best.

The winners

Projects that won a Fulton Award this year were as follows:

INNOVATION IN CONCRETE
Gouda Wind Farm Precast Concrete Towers, Western Cape

ARCHITECTURAL CONCRETE >R100 MILLION
Chevron Project Core, Western Cape

BUILDING STRUCTURE >R100 MILLION
Fairscape Precinct, Botswana

CIVIL ENGINEERING STRUCTURE <R100 MILLION
Metolong Dam Pedestrian Bridge, Lesotho

CIVIL ENGINEERING STRUCTURE >R100 MILLION
Umgeni Road Interchange, KwaZulu-Natal

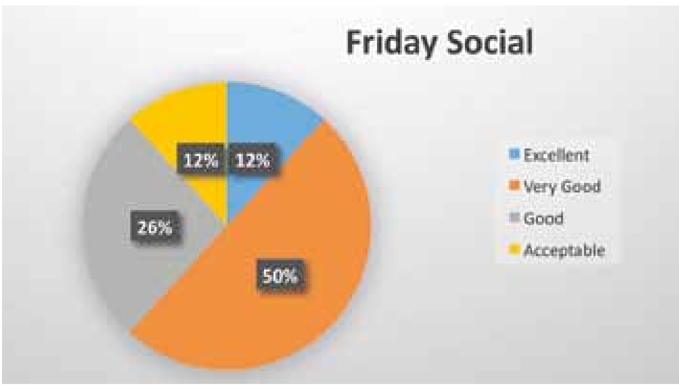
Commendations were also awarded by the judges to several projects in the various categories mentioned above:

- Precast Coal Bunkers and Overland Conveyor at SASOL Shondoni Colliery (2)
- Fairscape Precinct
- Stafford's Post Interchange on N2, Section 21
- Gouda Wind Farm Precast Concrete Towers
- PPC's Cement & Concrete Cube (Special Commendation)

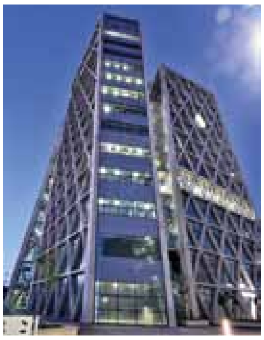
Gala Weekend

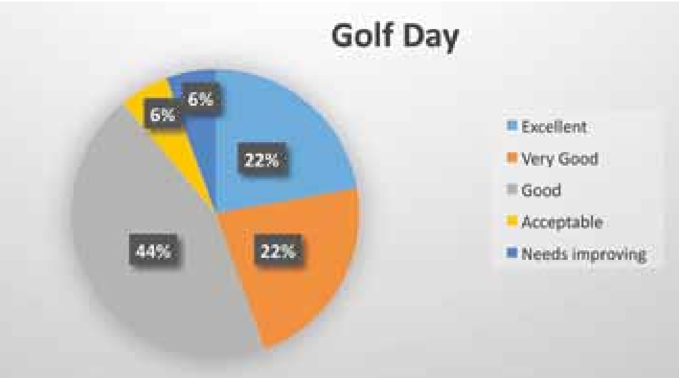
A survey was carried out amongst the delegates attending the gala week-end in the Drakensberg and it was very pleasing to see a majority of positive responses. Here are some of the results:

This clearly illustrated to us that, despite the fact it was the fifth time we had held the week-end at Champagne Sports Resort, it is still a 'winning formula'.



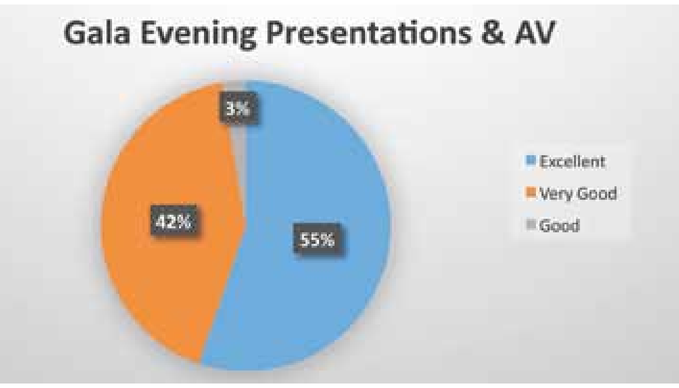
Generally, the Friday evening social (designed for family gatherings) received positive responses. There were however, a few who, for various reasons, did not rate it very high.



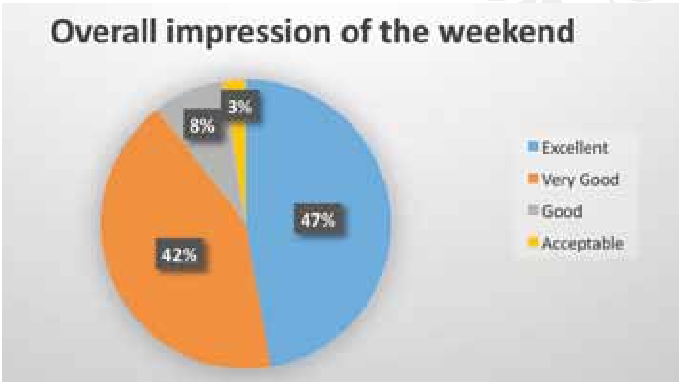


The Golf Day ran very well, but a few respondents felt that the format used for this year's tournament should be reconsidered. This will be taken into consideration when planning for the 2017 awards. Many thanks to Armand van Vuuren, from Chryso SA for organising the event in his own inimitable style.

The theme and décor for the gala evening were impressive, and the delegates thought so too!



Similarly, the presentations and audio visuals were of a very high standard



So, as can be seen in the above chart, 97% of delegates were happy with the overall weekend. Congratulations to Natasja Pols and Marike van Wyk for organising such a memorable occasion and making us very proud of the Concrete Society.

Branch Review Events

The branches also did us proud with each event being run very well, with their own format and style. The President and CEO of the Concrete Society, who attended each event, were very well received and thoroughly enjoyed the opportunity to interface with regional members on their home ground. Bookings at the various Fulton Awards events, including the gala weekend were excellent, exceeding 700 people overall.

Conclusion

Fulton's 2015 was a great success, and the 'bar' has certainly been set very high for the next Awards. The judging process will be revisited again for the 2017 awards and various stakeholders in the industry will be canvassed for input on this very critical aspect of the awards. ▲

Pro-concrete, Past-President, now Professor

"The key for (sustainable concrete) in the near future lies in using supplementary cementitious materials, optimising mix designs, improving durability and, lastly, using advanced/unconventional applications of concrete."

This was one of the viewpoints of Prof Billy Boshoff of the Department of Civil Engineering at Stellenbosch University (SU) in his inaugural lecture on 14 April 2015.

Billy, Immediate Past President of the CSSA, said that although concrete seems like the perfect construction material for modern society, it has a significant negative effect on the environment both directly and indirectly.

Referring to the impact of cement, Billy said "it is estimated that cement manufacturing alone contributes to more than 5% of world CO2e emissions and it is estimated that this will increase to 10 % by 2050 if current trends are sustained".

Prof Hansie Knoetze, Dean of the Faculty of Engineering, Billy Boshoff and Eugene Cloete, Vice-Rector: Research and Innovation, at the inaugural lecture.

Professor Billy Boshoff with his wife Huba at the inauguration.

Unfortunately, modern society cannot function without concrete, Billy said. "The world simply cannot do without concrete, it is entrenched in almost every sphere of human settlement and industry."

He added that there is no current technology that offers a solution to replace concrete in a sustainable manner with a new material that is so-called carbon neutral (or even carbon negative), durable, robust and easy to use.

Billy said advanced and high-level research should continue and even be accelerated, as this could produce long-term solutions to the environmental impact of concrete. "Universities should also expose future engineers to new technology", he added.

Billy has been a staunch CSSA supporter and has served on the Board (previously the National Council) for a number of years. As President of the CSSA, he said: "I am proud to be a member of the Concrete Society of Southern Africa, even more so, to be President of this Society. The reason is quite simple: it is a society that opens doors for its members, as it has for me. For me these doors have included meeting interesting people, gaining their knowledge of the broader concrete industry, and also giving perspective, to ensure that I always see the bigger picture."

Billy's vision for his personal and academic growth has positively impacted all those who interact with him, including the CSSA. His contribution to the body of knowledge in concrete technology is immense and the Society is truly proud to have him as a part of their 'concrete community'. ▲

Loyal Concrete Society member reveals some valuable history

Gordon Forrester, now Technical Director of Basalt Technology (Pty) Ltd, sent the editor a priceless piece of Society history recently, in the form of a copy of his original membership certificate which was handed to him on the 11th October 1978. His name was applied using Letraset (for those who can remember this unique 'embossing' method), and it is signed by the then President, C W Wolhurter.

Interesting to note that the certificate indicates that Gordon's membership number was 2. Could this mean he was the second member of the Society? There are records showing Presidents going back to 1969, so it seems doubtful. If any member reading this knows more of the old history of the Concrete Society, the Editor would be very interested to hear about it.

Thank you Gordon for sharing this with us. ▲

Inland Branch technical site visit: University of Pretoria Centrifuge Laboratory

More than 20 Inland Branch members attended a special technical site visit recently at the University of Pretoria's Centrifuge Laboratory, located at its Hatfield campus.

Professor SW Jacobsz

Professor Elsabé Kearsley (Head of Civil Engineering) and Professor SW Jacobsz were both on hand to welcome the visitors, after which Prof Jacobsz proceeded to describe to the audience the background to the introduction of a Geotechnical Centrifuge Laboratory at the University and the current research work that is being carried out using this unique facility.

The centrifuge is used to subject small scale models to high accelerations, thereby creating the correct stress distribution in the model. This is necessary to ensure realistic behaviour. The centrifuge enables geotechnical and concrete problems to be studied by means of physical modelling.

The 150 G-ton Actidyn C67-4 centrifuge is capable of accelerating a payload of up to one ton to 150G. The effective centrifuge radius is 3 metres, and an automatic balancing system keeps the machine in perfect balance during tests.

The centrifuge is fitted with a Digidaq system for data acquisition and complemented by an HBM Quantum systems (24 channels). This sufficient for all data acquisitioning, including several cameras on the centrifuge.

The control system is entirely computer-based and the control room is located adjacent to the centrifuge enclosure. This houses the control computer, two high-end personal computers used for data acquisitioning and processing, a large monitor and a small discussion area.

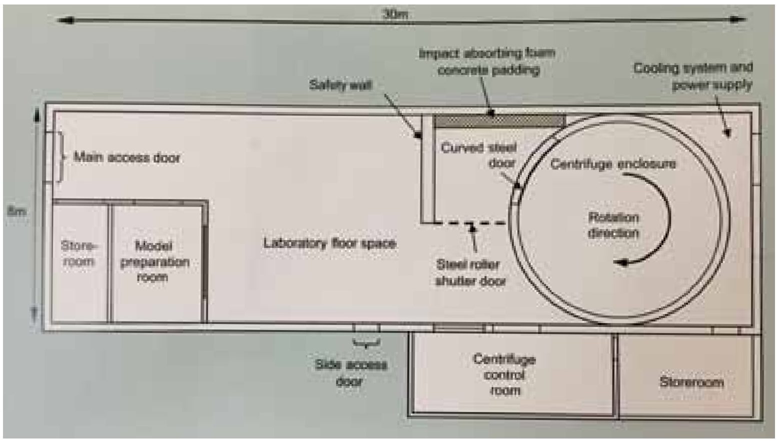
From a safety point of view, extensive measures have been taken. The machine is housed in a heavily reinforced concrete chamber. The walls have been designed to absorb an impact resulting from the release of a model package of one ton at 150G. The chamber is fitted with a light stainless steel door which is shielded from the Centrifuge Laboratory and adjacent laboratories with another reinforced safety wall, padded with impact absorbing foam concrete.

Professor Jacobsz then moved on to describe some of the research work, much of it concrete-based, that is currently being carried out using the facilities of the centrifuge. This included:

- Dolomitic sink holes
- Ultra-thin continuously reinforced concrete pavements (UTCRCP)
- Settlement of opencast mining backfill
- Segmental concrete block retaining walls
- Modelling of cave mining
- Soil structure interaction of strip footings
- Soil Culvert Interaction.

The Department of Civil Engineering at the University is fortunate to employ a team of highly skilled technicians to provide the necessary technical support with the development, construction and testing of centrifuge models.

In conclusion, Professor Jacobsz indicated that there were numerous research possibilities with physical modelling and the University would welcome any industry collaboration in reaping the benefits of this technology. ▲



Plan of the Centrifuge laboratory

KZN Branch

The committee for 2015/2016 is:

Chairman .... Theresa du Plessis
Vice Chairman ...... Nithia Pillay
Secretary............... Graham Smith
Treasurer............... Werner Hefer
Committee .... Andries Van Rensburg
Bruce Ivins
Gary Hooper
Giselle Dawson
Ken Brown
Mark Duckham
Phil Everitt
Rod Raw
Samuel Govender

Corrie Meintjies from Jeffares and Green was presented with the Branch Chairman's Award in March 2015 for his contribution to the industry. The special evening event was well attended and the overview of Corrie's career was both amazing and moving. The presentation was followed by a speech by Corrie which captured the very essence of this worthy receiver of this award.

In June 2015 the KZN Branch hosted the Fulton Awards for its members. It was well attended and was a very enjoyable evening. Tseli Maliehe – the President of CSSA, and CEO, John Sheath and his wife Mollie attended the event. BASF kindly sponsored the welcome drinks and Structural Maintenance sponsored wine for the tables. Grateful thanks go to PPC for being the anchor sponsor for the Fulton Awards 2015.

In beginning of August 2015 we had an interesting technical meeting (MTM) on Non-Destructive Testing presented by Graham Smith from Conchem.

The remainder of 2015 is about the EPD and Cube Competition in August 2015, The Garth Gamble Golf Day in September 2015 and, to finish the year, with a MTM and a site visit.

Eastern Cape Members visit the new Bay West Mall

The Eastern Cape Branch held a site visit recently at the Bay West Mall on the western side of Port Elizabeth. The Bay West Mall comprise 87 500 m^2 of lettable area and construction value of approximately R1.7 billion with a further R250 million being spent on developing the road.

The development is a joint initiative between the Billion Group and Abacus Asset Management, with Murray & Roberts the primary contractor.

The layout of the mall takes the typical cross mall shape, featuring a large central food court in the middle of the shopping hub with a secondary "ring-mall" linking the anchor tenants situated on the four corners of the building. Mall entrances are provided at each quadrant with an inter-connecting parking podium on two levels.

The energy requirements of this scale of development are significant thus considerable emphasis has been placed on the incorporation of been considered and "green design principles" to achieve natural lighting, cooling, ventilation and recycling, thus reducing the building's energy demand, improving efficiencies and minimising any negative impact on the environment.

A dedicated concrete readymix batch plant was erected on site to supply the 57 000 m^3 of concrete required in the construction of phase 1 of this 2-phase mixed development.

The event was well attended by contractors, suppliers, engineers and architects. The visit commenced with Fanie Smith the local Concrete Society Branch Chairman welcoming everybody and explaining procedures. This was followed by Pieter Stander from Murray and Roberts giving a presentation explaining the workings, challenges and achievements of the project.

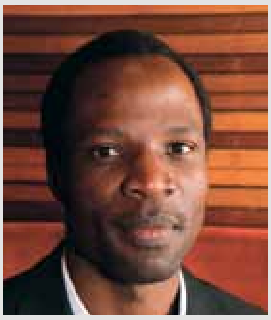
The visitors were then given a tour of the site, followed by refreshments sponsored by Concrete 4 U. ▲

Inland Branch committee member's profiles

Debbie Harvey Born and bred in the city, Debbie Harvey has always been a Jo'burg Girl. Here, she completed her schooling and went on to study towards a diploma in Contact Centre Management and another in Event Management.

Debbie joined AfriSam in 1989 when it operated under the name of Pioneer Readymix Concrete and has been with the company ever since. Over the years, she has fulfilled many roles starting as Salaries clerk and then moving on to Human Resources, Engineering and Sales and Marketing divisions. Debbie currently manages events for the company.

Her view *"The world is moving so fast these days that the man who says it can't be done is generally interrupted by someone doing it."*



Mike Otieno (New member) received his PhD and MSc (Eng) degrees from the University of Cape Town, and his First Class Honours BSc (Civil Eng) degree from the University of Nairobi in Kenya – his native country. He has worked as an engineer for a number consulting engineering firms in Kenya and Australia. He is currently a lecturer in the School of Civil and Environmental Engineering at the University of the Witwatersrand, Johannesburg, and continues to provide specialized consultancy support to the concrete industry. His research interests include concrete durability, service life prediction, steel corrosion in reinforced concrete structures and repair and rehabilitation of concrete structures.

His view: *"Concrete is the one construction material that continues to amaze me… By careful design and application, coupled with the ongoing novel research undertakings in South Africa and around the world, it can be tailored to meet virtually any desired fresh and hardened properties. There seems to be no boundaries to the use of concrete!"*

Michelle Fick grew up in Cape Town, before moving Johannesburg. With a background in the modelling, beauty and motor industry, Michelle has dedicated a decade towards making concrete beautiful by promoting CHRYSO's admixtures and additives to the construction industry. Michelle is a social butterfly at heart, and never misses a concrete and construction industry event.

Her view: *"Concrete is anything but 50 Shades of Grey. It is a multifaceted, dynamic material that never ceases to surprise and excite me with its many capabilities and possibilities."*

Inland Branch

DATE	MEETING/EVENT	VENUE	CONVENOR
16 September 2015	Committee/Planning Meeting	AfriSam, Constantia Park	Roelof Jacobs
14 October 2015	Committee Meeting	AfriSam, Constantia Park	Roelof Jacobs
11 November 2015	Committee Meeting	UJ, Auckland Park Campus	Roelof Jacobs
13 November 2015	Chairman's Breakfast	Blue Valley Golf Estate	Roelof Jacobs/Natalie Johnson

**Excludes Site Visits – to be announced later*

KwaZulu-Natal Branch

DATE	MEETING/EVENT	VENUE	CONVENOR
17 September 2015	Event: Golf Day	Mt Edgecomber Country Club	Andries Van Rensburg
20 October 2015	Committee Meeting	UKZN	Theresa du Plessis
20 October 2015	Site Visit: Transnet Pavements	TBC	Mark Duckham
17 November 2015	Committee Meeting	UKZN	Theresa du Plessis
17 November 2015	MTM: Bridge Launching	UKZN	Bruce Ivins / Gary Hooper

International

DATE	MEETING/EVENT	VENUE	CONVENOR
15 – 18 September 2015	International Conference on Sustainable Structural Concrete	La Plata, Argentina	Luis Lima
05 – 07 October 2015	4th International Conference on Concrete Repairs, Rehabilitation and Retrofitting (ICCRRR)	Leipzig, Germany	F. Dehn, M.G. Alexander, H. BEushausen & P. Moyo
15 – 17 October 2015	International Congress on Polymers in Concrete	Singapore	Lu Jin Ping

National Office

DATE	MEETING/EVENT	VENUE	CONVENOR
22 October 2015	Board Meeting	Premier Hotel O.R. Tambo, Rhodesfield, Kempton Park	CSSA President
31 October 2015	2016 Membership Renewals Notices	E-Mailed to All CSSA Members	CSSA Administration
November 2015	Concrete Beton	Posted to All CSSA Members	CSSA Administration

Eastern Cape

DATE	MEETING/EVENT	VENUE	CONVENOR
08 October 2015	Committee Meeting	109 Cape Road, Mill Park	Fanie Smith
October 2015	EPP Cube Test Competition	NMMU	Patrick Flannigan
October 2015	Site Visit: Gilwell Mall	East London	Fanie Smith / Patrick Flannigan
05 November 2015	Committee Meeting	109 Cape Road, Mill Park	Fanie Smith

Western Cape

DATE	MEETING/EVENT	VENUE	CONVENOR
17 September 2015	MTM – Proposed PhD Presentations by UCT/Stellenbosch Students	TBC	Adrienne Taylor
October 2015	Cube Crushing Competition Awards Ceremony and Prize Giving	TBC	Riaan Combrinck
November 2015	Cocktail Function	TBC	Adrienne Taylor

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