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Platinum members:
AfriSam, PPC and Lafarge

Accredited Technical Paper:
Controlling properties of concrete through nanotechnology

Fulton Award Winners:
Moses Mabhida Stadium
Van der Kloof Dam

President's Message

Just four months have passed, since I was elected president of the Society and it has been hectic. With the aid of our National Council we have finalised a business plan for 2010/11, and revisited our articles of association, which needed updating, to bring them in line with new legislation. In addition, Council has decided to proceed with the recruitment of a full-time Director for the Society and a job description and personal profile have been drawn up for recruitment agencies. If any readers are interested, or know of any person that may be interested in applying, for this position, please contact Natasja Pols at the CSSA Head Office in Pretoria. Applications will be kept confidential.

My thanks go to Natasja Pols and Jeanine Steenkamp, at Head Office, for making my first four months as President totally seamless and professional. Without their assistance and efficiency, my time would have been far more difficult, especially as I came into the presidency virtually overnight.

By the time you read this message the Soccer World Cup will be an event of the past and business will hopefully be getting back to normal. This momentous event has focused the world on South Africa over the past few months and many mindsets about our country have been changed dramatically (for the good).

Part of the build up to the World Cup has been the construction of many magnificent stadiums and the first phase of Gautrain from Sandton to OR Tambo Airport. Concrete has played its part in creating these new structures and shows that this unique building material does not have to be square, dull and cold. The prestigious 2011 Fulton Awards will celebrate the use of concrete. I urge the engineers, designers, architects, contractors and/or clients to consider submitting some, or all of these projects for awards, as they truly honour concrete in the best possible way and are worthy of recognition.

In August the Society will host a two-day symposium on concrete themed: 'Concrete for a Sustainable Environment' (CSE 2010), at the Emperor's Palace in Kempton Park. Topics to be presented will centre on durability, carbon footprint, recycling, efficient use of materials, life cycle costing and new technologies. We have secured six guest speakers, including one from the USA and a further 16 technical papers to complete the programme. Sponsorship support has been fantastic and my personal thanks go to those companies for their continuing faith in the relevance and work of the Concrete Society.

The symposium features a comprehensive exhibition alongside the technical programme and this premier event, in our calendar, promises to be one not to be missed. Please visit the dedicated website at www.concretesociety.co.za/cse-2010 for more information. I look forward to meeting many more members and their guests on the 2^{nd} and 3^{rd} of August.

In the meantime, enjoy this issue of Concrete Beton and I would welcome comments at any time from readers regarding its content, design and usefulness.

Yours in concrete,
John Sheath
President

Cover:
Moses Mabhida Stadium

Moses Mabhida Stadium

The iconic, 70 000 seater, Moses Mabhida Stadium in KZN has given FIFA 2010 World Cup followers a magnificent view of the eThekwini Municipality venue. The spectacular stadium is a worthy winner of the Fulton Awards for the 'Unique Design Aspects' category for 2009.

The impressive stadium was constructed for the eThekwini Municipality, the principal agent BKS together with contractors Group Five/WBHO/Pandev and subcontractors BKS, Goba, PD Naidoo & Associates, Structural Diagnostics, Lafarge, Wiehahn Formwork, Doka and Form-scaff, made it a worthy World Cup venue.

The Moses Mabhida Stadium won the coveted Fulton Awards 'Unique Design Aspects' and the project was commended in the 'Construction Techniques' category.

As Durban had been selected to host a semi-final, in addition to many of the playoffs, the eThekwini Municipality committed to the redevelopment of the Kings Park Sporting Precinct that could not only accommodate the World Cup event, but also be capable of hosting Commonwealth and Olympic Games.

The Municipality stipulated that the new stadium was to be an iconic representation of the size and importance of the city, as well as being a symbol of the city's renaissance and of its aspirations for the future.

In response to a design competition called for by the municipality, the Ibhola Lethu Consortium led by BKS Engineering and Management submitted a design incorporating the stadium's iconic arch symbolising both the curved entrance to a traditional African house as well as the distinctive 'Y' pattern in the South African flag.

The main concrete structure comprises an oval bowl of tiered seating with six access levels, shear cores, stairwells and a surrounding podium. The roof is supported by steel-cables suspended from the arch. The impressive 104 m high arch spans 380 m onto massive concrete foundations.

The principal building contract was awarded to Group5/WBHO/Pandev JV in January 2007. Concrete was the

construction material of choice to achieve the highest quality of finish; while the versatility of concrete allowed for the complex design shapes and forms; the products high durability and the speed of construction proved beneficial. A designed slump >200 mm enabled concrete to be tremmied to depths >20 m in CFA piles. Self-compacting concrete with its high-early strength (27 MPa/24 hrs) was used in critical and heavily reinforced structural junctions between 9 m in situ columns and 55-60 t precast columns over. This detail was repeated 102 times involving raked-columns up to 62,5°. Stringent durability indices were achieved using GGBS and continuous wet curing. Pre-cast manufacture, which included triple tiered seating panels, columns, staircases, illumination beams and architectural cladding panels enabled massive time saving. Admixtures were used to enhance waterproof characteristics in exposed slabs, thereby eliminating membranes. Power trowelled surfaces (54 680 m^2) were transformed by grinding/polishing to produce a highly durable and attractive finish.

From the outset of this project, the requirement for 'the highest achievable quality of concrete' has been paramount. The resurgence of old crafts and skills coupled with state of the art equipment and materials has enabled an off-shutter concrete product of exceptional excellence.

The planning and execution of the work, the attention to detail and the meeting of all stringent design criteria on this project has exemplified the pride in our building heritage.

The Moses Mabhida stadium may be described as a concrete showcase and must rate as one of the finest examples of concrete construction in the city of Durban's history, of which all Durbanites may be truly proud.

Judges' Citation

The judges were particularly impressed by the varied and very often integral technical design issues that were well addressed and resolved as part of this project.

Economic excellence was achieved by choosing the correct structural materials for the different elements, resulting in a well conceived structural system with phenomenal complementary aesthetic attributes.

It is of special note that concrete was chosen as the structural material of choice for a vast majority of applications.

The ingenious large concrete foundations, situated at great depths and which support the feature arch are an outstanding feature of the project.

Also impressive are the well conceived design details such as the saw toothed raking beams with their hidden rainwater leakage channel feature as well as the high quality precast seating panels and their joint details, which after construction provides a flawless and visually pleasing end product.

The Adjudication Panel included: Al Stratford, president of the South African Institute of Architects; Professor Elsabe Kearsley, President of the South African Institution of Civil Engineering (SAICE) for 2009; and Francois Bain, President of the Concrete Society of Southern Africa for 2009.

The judges were impressed by the precast concrete facade columns, which act as both significant structural members and architecturally defining elements.

The choice of constructing these out of precast concrete is commendable since this has led to an enhanced appearance and facilitated a faster construction speed.

The stitching of upper precast concrete to lower cast in situ concrete portions of these columns, using self compacting concrete, is also regarded as a noteworthy technical aspect.

The decision to optimise the use of precast elements served the designers well, in that it allowed for high quality finishes to be accomplished, with significant gains in construction speed, which is commendable.

It impressed the judges that the professional team opted for polished concrete floor finishes to large portions of public areas, showcasing concrete as a high quality floor finish in itself.

This phenomenal project bears witness to the inventiveness of South African built environment professionals, and their ability to work together to achieve a common, highly technical goal, within strict time parameters.

The Moses Mabhida stadium, Durban, Kwazulu-Natal, is a worthy recipient of the Fulton Awards 'Unique Design Aspects' category for 2009.

FULTON Awards 2011

Call for Nominations

2011 Fulton Awards promises to, yet again, attract significant entries due to the timing thereof being towards the culmination of a particularly active period in the local construction industry with some very large capital expenditure projects taking place.

The Concrete Society of Southern Africa (CSSA) is calling for nominations of projects for the prestigious Fulton Awards, presented by the Society every two years to honour excellence and innovation in construction utilizing concrete.

Awards will be made in the following 6 categories:

- OVERALL CIVIL ENGINEERING PROJECT
- OVERALL BUILDING PROJECT
- CONCRETE IN ARCHITECTURE
- UNIQUE DESIGN ASPECTS
- CONSTRUCTION TECHNIQUES
- INNOVATIVE TECHNOLOGIES

Any project completed during 2009 or substantially completed during 2010 is eligible for entry, and projects may be entered in more than one category. Closing date for nominations is 15 October 2010.

Francois Bain, Chairman of the Fulton Awards 2011 organizing committee, says: "The 2011 Fulton Awards promises to, yet again, attract significant entries due to the timing thereof being towards the culmination of a particularly active period in the local construction industry with some very large capital expenditure projects taking place".

The occasion will be celebrated over the weekend of the 3rd to the 5th of June 2011 at the beautiful Champagne Sports Resort in the Drakensburg with the actual awards taking place at the exquisite gala event on the Saturday evening.

EXPOSURE FOR ALL 2011 SUBMISSIONS

The Society aims to provide increased exposure for all entrants and project submissions. As in 2009, emphasis is placed on the entries for the Fulton Awards with a special exhibition created for the nominated projects.

PUBLICATION OF ALL 2011 SUBMISSIONS

Each submission will be published in a special 2011 Fulton Awards Edition of the Concrete Beton.

CONCRETE SOCIETY OF SOUTHERN AFRICA

For nomination forms and entry packs, contact The CSSA Administrator on Tel: 012 348 5305 or admin@concretesociety.co.za

Van der Kloof Dam Spillway Bridge

concrete retrofitment solutions

The Van der Kloof Dam Spillage Bridge provides a vital link over the Orange River for tourism, the surrounding rural communities and in particular for the agriculture-originated heavy vehicles. The Department of Water Affairs and Forestry's initiated the retrofitment of the dam spillage bridge, which scooped top honours in the Fulton Awards 'Special Category: Repair & Maintenance Project'.

The 2009 Fulton Awards introduced a 'Special Category: Repair & Maintenance Project' as it became evident to the judges that repair and maintenance projects, which are generally smaller in size and can easily be overshadowed by the larger projects. These special category projects represent excellence in their own right.

The Fulton Awards honours the unique concrete solutions employed to retrofit the Van der Kloof Dam Spillway Bridge.

The Department of Water Affairs and Forestry's project was undertaken by BKS, the principal agent, contractor Ibhayi Contracting and subcontractors included Sika and MBR was BKS, the Department of Civil Engineering, University of Cape Town was retained as a specialist subcontractor.

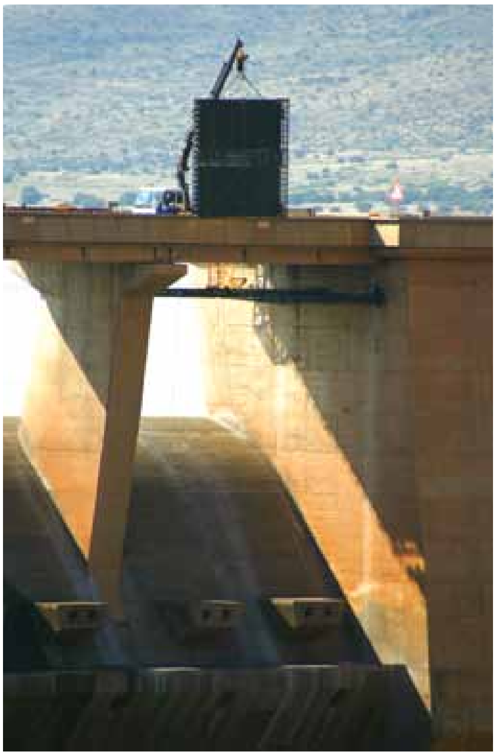
The Van der Kloof Dam is South Africa's highest concrete double curvature arch dam wall and South Africa's second largest dam by storage volume. Comprising 15 spans with an overall length of 204 m, this bridge structure is classified as a major bridge and is positioned at significant height above natural ground level. These physical constraints further complicated the nature and scope of the rehabilitation work.

A forensic engineering approach, comprising a comprehensive suite of concrete material tests, visual inspection by experts, thorough review of record drawings and advanced structural modelling, was utilised to determine the characteristics and extent of the defects. Significant longitudinally-oriented cracking was observed in the deck slab, midway between adjacent longitudinal beams. The detailed structural assessment indicated that the existing superstructure configuration utilised two end transverse beams in each span and relied on the deck slab to provide transverse stiffness to the structural system. This resulted in the commissioning of specialised vibration-based dynamic testing of the superstructure, conducted by the University of Cape Town.

The design utilised a systems approach that integrated the retrofitment activities, rehabilitation works, routine maintenance, access, legislative safety and environmental requirements. Technically challenging retrofitment activities performed at the Van der Kloof bridge superstructure included the installation of new reinforced concrete transverse beams and the construction of a fully-bonded concrete pavement (or roadway); while routine rehabilitation activities included concrete repairs, replacement of bridge bearings, replacement of expansion joints and other ancillary works. The new transverse beams were constructed by introducing viscosity-controlled self-compacting concrete through holes cored through the existing deck slab into suspended steel shutters housing a reinforcement cage dowelled, through the existing longitudinal beams. The physical constraints posed by the double curvature arch dam wall and the envisaged scope of work at the spillway bridge resulted in the development of innovative temporary access systems.

The success of the retrofitment actions was quantified by repeating the specialised vibration-based evaluation post-retrofitment. Quantifiable improvements in the transverse stiffness, as much as 25 times, were achieved for the retrofitted structure.

Judges' Citation



The judges were impressed by the design engineers' insightfulness in suggesting an alternative of retrofitting and refurbishing this existing bridging structure over the Van der Kloof Dam spillway, as opposed to merely demolishing and rebuilding.

Of particular interest was the fact that the bridge span structures were modelled to assess the dynamic behaviour thereof and that further on site vibration-based dynamic tests were done to support these findings and from these results ingenious retrofitment details and techniques were proposed in order to strengthen the bridging structure adequately.

Of special note on this site was the temporary access systems utilised, the use of site batched self compacting concrete in the newly introduced transverse beams as well as the new fully bonded reinforced concrete pavement introduced on top of the deck.

The judges were also impressed by the thoroughness of the design team in that they opted to perform post-retrofitting dynamic assessments of the structures. The degree of structural enhancement that has actually been obtained is impressive.

The quality of the work observed on site by the judges is exemplary.

Concrete retrofitment solutions utilised at the Van der Kloof Dam spillway bridge is a worthy recipient of the Special Fulton Award for the Repair and maintenance project category for 2009.

Controlling properties of concrete through nanotechnology

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ABSTRACT: This article is a summation of recent work at the Centre for Advanced Cement-Based Materials (ACBM) at Northwestern University. ACBM's areas of focus currently include self-consolidating concrete (SCC) and nano-modification of paste matrices with carbon nanotubes. Concerning SCC, three projects discussed here include reducing formwork pressure through use of nanoclays, quality control of fibre-reinforced SCC using an AC-IS method, and development of an improved slipform paving concrete. All of these topics share innovative processing techniques to ensure superior concretes that can further today's growing need for reliable high performance concretes.

1 INTRODUCTION

The future of today's high strength and high performance concrete relies on both new processing techniques as well as new types of admixtures specifically geared towards the nanostructure of cement paste. This article is a summation of recent work at the Centre for Advanced Cement-Based Materials (ACBM) at Northwestern University.

ACBM's areas of focus currently include self-consolidating concrete (SCC) and nano-modification of paste matrices with carbon nanotubes. SCC has seen a growing share in the concrete industry, and at ACBM, research has focused on formwork pressure, fibre reinforcement and modification for slipform applications. Both of these topics share innovative processing techniques to ensure superior concretes that can meet today's growing need for reliable high performance concretes.

2 REDUCED FORMWORK PRESSURE OF SCC

A key advantage of SCC is accelerated casting and placing since vibration is not required for consolidation. However, faster casting rates may lead to higher lateral pressure on formwork; this is a major concern for cast-in-place applications, especially when casting tall elements, and has raised questions about the adequacy of using current formwork design practices for SCC. Since the development of formwork pressure is not fully understood in SCC, construction codes in the USA require design of formwork withstand full hydrostatic pressure due to the fluidity of the concrete. However, it has been demonstrated that the formwork pressure of SCC can be less than hydrostatic (Fedroff & Frosch 2004) due to the rebuilding of a three-dimensional structure when the concrete is left at rest (Sun et al. 2007). The mechanisms behind this stiffening phenomenon are of particular interest to users of SCC. Ideally, SCC should be flowable enough to self-consolidate, then immediately stiffen to gain green strength (or strength right after casting) once at rest. This will prevent formwork pressures from reaching hydrostatic pressures during the casting process and allow a more efficient design of formwork. Underestimating the pressure may cause deformed structural elements or even formwork collapse, while overestimating the pressure leads to unnecessary costs due to over-built formwork.

Formwork pressure and structural rebuilding of SCC is highly influenced by the mixture proportioning of the paste matrix. With proper design, it may be possible to achieve significant reductions in lateral pressure development. In order to test formwork pressure for different mixes, a pressure device was developed that subjects a sample of plastic concrete to a vertical load using a universal testing machine. Lateral pressure and pore water-pressure transducers are used to determine the total lateral pressure and pore-water pressure, respectively, generated by the vertical loading. This pressurised cylinder setup, referred to as the piston method, consists of a cylinder 300 mm in height that enables it to measure lateral pressure variations over time in the laboratory for concrete subjected to various vertical loads that correspond to different casting heights, and is shown in Figure 1.

Figure 1. Formwork pressure device.

Using this device, two SCC mixtures were tested; both were proportioned using a fine-to-coarse aggregate ratio of

0.47, w/b ratio of 0.35, and paste volume of 36%. A constant VMA dosage of 400 ml/100 kg of binder was used in all of the mixtures, and the superplasticiser content was adjusted to an initial slump flow of 670 ± 12.5 mm. The formwork pressure results are shown in Figure 2 (Ferron et al. 2007).

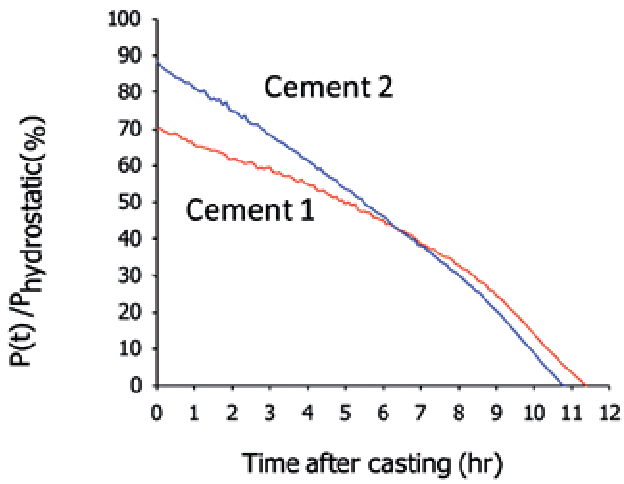

Figure 2. Evolution of pressure decay, where P(t) is the formwork pressure of the concrete at a specific time; $P_{hydrostatic}$ is constant and corresponds to the total vertical pressure applied at the end of casting (approximately 240 kPa). The casting height was 10 m (33 ft), and the casting rate was 7 m/hr (23ft/hr).

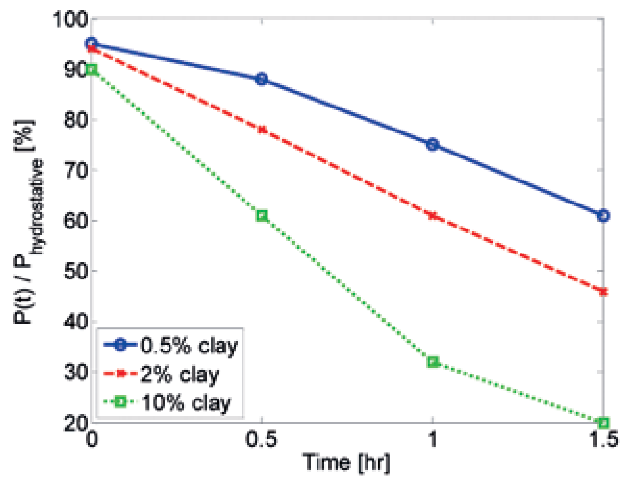

Figure 3. Influence of a metakaolin clay on formwork pressure.

The main difference between the mixtures was the composition of the paste matrix, specifically the type of cement used in the concrete. Although both cements were ASTM Type 1 cements, the alkali and C3A content of the mixtures was significantly different

(Cement 1 had a lower alkali/C3A content). As seen in Figure 2, a 30% reduction in formwork pressure (with respect to the hydrostatic pressure) was produced by altering the paste matrix. In this case, Cement 1, with a lower alkali/C3A content, required less superplasticiser in order to maintain the same slump flow diameter as Cement 2 (Ferron 2008).

ACBM is currently investigating how the addition of small amounts of processed clays can increase the reduction of formwork pressure. Previously, clay particles have been shown to enhance green strength and allow a stiffer structure in concrete to develop (Curcio & DeAngelis 1998). Figure 3 shows the fraction of vertical pressure of SCC transferred as lateral pressure for 0.5, 2.0, and 10.0% replacement of cement with a metakaolin clay.

3 FRESH STATE MICROSTRUCTURE OF SCC

To understand why changes in alkali/C3A or clay amounts affect the structural rebuilding, research has focused on the microstructure, and more recently, the nanostructure, of fresh state concrete. Characterising the structure of cement suspensions is difficult due to the polydisperse, high solids concentration and hydration characteristics. Thus, there is a lack of knowledge about the fresh state structure of cementitious materials, which is especially important during the processing of concrete. Furthermore, the initial fresh state microstructure affects the final microstructure, thereby influencing mechanical properties of hydrated paste or concrete (Struble 1991). Rheology of concrete is related to the degree of flocculation/ coagulation of the paste matrix, which in turn is a function of the interparticle forces. Thus, perhaps the most representative parameter for studying the flocculation process (and indirectly the interparticle forces) is to monitor the change in size of the particle flocs.

A novel experimental method using a focused beam reflectance measurement (FBRM) probe was recently used by researchers at ACBM to examine the floc size evolution of concentrated cement paste suspensions subjected to shear (Ferron 2008). This is one of the first experiments for in-situ investigations of the microstructural response of concentrated cement paste suspensions subjected to shear-induced stresses. Results of compositions shown in Table 1 are presented in Figure 4.

Table 1. Mix compositions for FBRM pastes.

Mix	w/b	SP/b [%]	VMA dosage
P1	0.4	–	–
P1-SP	0.4	0.8	–
P1-VMA_H	0.4	–	high
P1-SP-VMA_H	0.4	0.8	high
P1-SP-VMA_M	0.4	–	medium

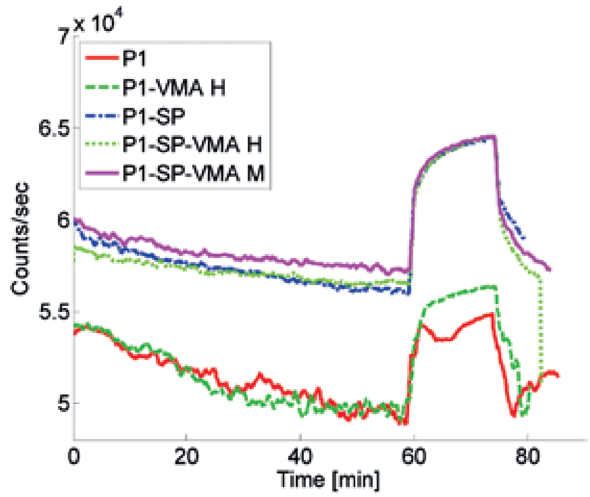

Figure 4. Influence of chemical admixtures on floc evolution

The FBRM floc size measurements were conducted while subjecting the sample to a 40 rpm mixing intensity followed by a 400 rpm mixing intensity. Generally, higher count numbers indicate mixtures with fresh state microstructures that are less agglomerated.

As seen in Figure 4, no substantial changes in the number of chords counted were seen when VMA was added (compare P1 and P1-VMA_H), which is an indication that additional flocculation of the cement particles was not due to the incorporation of this VMA. Rather, the superplasticiser was shown to be the dominating factor affecting the chord length measurements – a significant increase in the number of counts occurred when superplasticiser was used (compare P1 with P1-SP). This shows that the superplasticiser molecules directly interact with the cement particles such that the cement particles are deflocculated, which increases the number of particles in the system. When both VMA and superplasticiser are used in a paste, the flocculation behaviour is more similar to that of a paste with just superplasticiser. This behaviour is seen regardless of the VMA dosage (compare P1-SP, P1- SP-VMA_M, and P1- SP-VMA_H). It can be concluded that the VMA did not interact with the cement particles, or if it did, it did not have any influence on the flocculation properties.

Thus, it is likely that the increase in cohesiveness when this particular VMA is used is garnered from the polymers binding to the water phase.

Developing a quantitative relationship between paste, mortar, and concrete rheology is perhaps the most fundamental issue concerning concrete rheology. The relationship among paste, mortar, and concrete rheology is complex, but the ability to link these three behaviours is beneficial because this would allow for the prediction of concrete rheology solely from the characterisation of the paste or mortar phase.

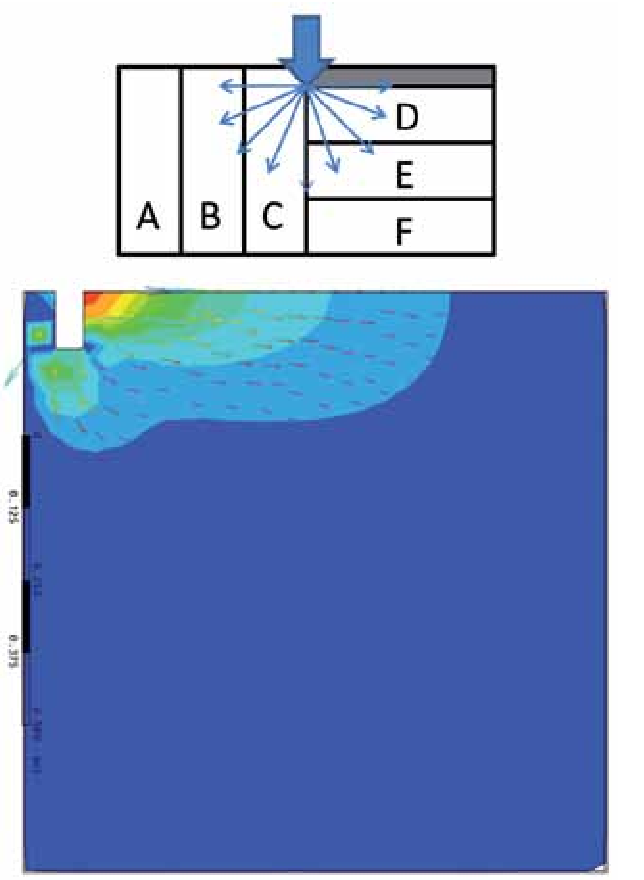

Figure 5. Schematic of the casting of the test-slab and results of CFD modelling (shear rate vectors highlighted).

4 FIBRE-REINFORCED SCC

Currently, the concrete industry is interested in the possible use of steel fibres as a partial or even total replacement of secondary reinforcement in concrete. The negative effects of fibres on concrete workability as well as improper placement and compaction may cause poor fibre distribution (Ferrara & Meda 2006). Regions with reduced amounts of fibres act as flaws, triggering early failure and activating unforeseen mechanisms. This leads to compromised structural performance, e.g. in terms of deflection stiffness, crack opening toughness, and load-bearing capacity. The advantage of adding steel fibres to SCC lies in the self compactability of SCC as well as the rheological stability of SCC in the fresh state (Ferrara et al. 2008a). It has been shown that with an adequate mix design (Ferrara et al. 2007) fibres can be oriented along the flow direction. By suitably tailoring the casting process to the foreseen application, fibre orientation can be designed to match the anticipated stress pattern (direction of the principal tensile stresses) within the structural element during service(Ferrara et al. 2008b, Stahili et al. 2008). The possibility of modelling the casting of fresh concrete, e.g. through Computational Fluid Dynamics (CFD) (Roussel et al. 2007), can help predict the direction of flow lines along which fibres may orient and optimise the whole process. Monitoring fibre dispersion related issues through suitable non destructive methods, such as the Alternating Current Impedance Spectroscopy (Ozyurt et al. 2006) would also be crucial for reliable quality control.

Thorough investigation on these subjects has been performed jointly by Politecnico di Milano and ACBM. Four 1m×0.5m×0.1m slabs were cast with a self-consolidating steel fibre reinforced concrete (SCSFRC) containing 50 kg/m^3 of steel fibres. The fibres were 60 mm long with a 0.8 mm diameter. The slump flow diameter of each slab was 600 mm. Each slab was cut into beams and the fibres were counted on the beam side faces to determine fibre orientation factor, $\alpha = n_{fibers} V_{fiber}/A_{fiber}$, where nfibre is the specific number of fibres on the examined surface, Vf_{iber} is fibre volume fraction (0.67% in this case), and Afibre area of the fibre cross section.

The casting flow process, as shown in the upper part of Figure 5, was simulated by a CFD code (Polyflow 3D), shown

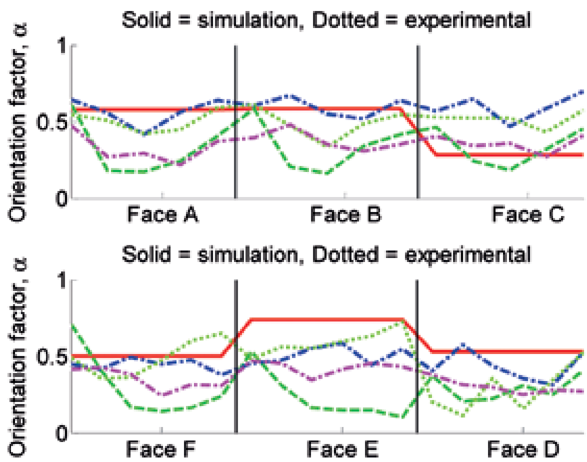

Figure 6. Comparison between experimental orientation factors in the 4 test slabs (A-F 1 to 4) and numerical ones, computed from shear rate vectors from CFD modelling.

in the lower part of Figure 5. For the sake of simplicity, a 2-D homogeneous single fluid simulation was performed by suitably calibrating the input parameters (Bingham fluid $\tau 0$ = 100 Pa, μ = 100 Pas) for the fresh state behaviour of the SCSFRC composite. The orientation of the fluid concrete flow lines (shear rate vectors) as computed with respect to relevant surfaces within the slab, has been compared with the fibre orientation factor. Considering the 2D features of the simulation, numerically computed orientation factors always provide an upper bound estimate of the experimental ones.

The results (Figure 6) are encouraging and stand as an interesting step in paving the way towards a more widespread use of simulation of fresh concrete flow, including at the industrial scale.

5 IMPROVED SLIPFORM PAVING WITH SCC

The slip-form paving process is used extensively to create highways and other pavements worldwide. This process combines concrete placing, casting, consolidation, and finishing into one efficient process. The stiff concrete used in slip-form paving machines requires extensive internal vibration, a process that can lead to durability issues. It has been shown that overconsolidation caused by the internal vibrators contribute to the formation of premature cracks. Typically, pavements are designed to last 25-30 years, however in several instances in the United States, slip-cast pavements have shown significant cracks at three years. ACBM, in conjunction with the Centre for Portland Cement Concrete Pavement at Iowa State University, has developed several promising mixture proportions of a low compaction energy concrete which is tentatively called slip-form self-consolidating concrete, SF-SCC (Pekmezci et al. 2007).

Figure 7. (a) Minipaver slab with typical slipform concrete. Rough surfaces indicate poor consolidation. (b) Minipaver slab with SF-SCC mix. Smooth surface indicates proper consolidation while straight edges indicate adequate green strength.

Fundamental research on particle packing and flocculation mechanisms provided insight on how to eliminate internal vibration and durability issues associated with longitudinal cracking along the vibration trail. The development of SF-SCC required changing the microstructure by combining concepts from particle packing, admixture technology, and rheology. Specifically, the addition of different materials such as nanoclays and fly ash to the composition made it possible to maintain a balance between flowability during compaction and stability after compaction (Tregger et al. 2009). For this research, a model minipaver that simulates the slipform paving process without the application of internal or external vibration was developed. Concrete slabs of mixes modified with fly ash or fly ash and clay showed much better shape stability and surface smoothness than the slab with a standard slipform concrete mix as shown in Figure 7.

It was also demonstrated that very small amounts of clays (0.3% by volume of concrete) resulted in large increases in green strength (as high as 30%) while maintaining fluidity (Tregger et al. 2009). This was also shown to be the case for mixes used in formwork pressure tests containing clays. Future work at ACBM is focused on understanding the reasons for the change in green strength due to clays using rheology as well as FBRM methods.

6 NANO-MODIFICATION WITH CARBON NANOTUBES

Cement-based materials are typically characterised as quasi-brittle materials that exhibit low tensile strength. Typical reinforcement of cementitious materials exists at the millimeter scale and/or at the micro scale using macrofibres and microfibres, respectively.

However, cement matrices still exhibit flaws at the nanoscale. The development of new nanosized fibres, such as carbon nanotubes (CNTs), has opened a new field for nanosized reinforcement within concrete. The remarkable mechanical properties of CNTs suggest that they are ideal candidates for high performance cementitious composites. The major drawback however, associated with the incorporation of CNTs in cement based materials is poor dispersion (Groert 2007). To achieve good reinforcement in a composite, it is critical to have uniform dispersion of CNTs within the matrix (Xie et al. 2005). Few attempts have been made to add CNTs in cementitious matrices at an amount ranging from 0.5 to 2.0% by weight of cement. Previous studies have focused on the dispersion of CNTs in liquids by pretreatment of the nanotube's surface via chemical modification (e.g. Cwirzen et al. 2008). Preliminary research has shown that small amounts of CNTs can be effectively dispersed in a cementitious matrix (Konsta-Gdoutos et al. 2008).

At ACBM, the effectiveness of the dispersing method was investigated through nanoimaging of the fracture surfaces of samples reinforced with 0.08% CNTS by weight of cement. Results from SEM images of cement paste samples reinforced with CNTs that were added to cement as received (without dispersion) and CNTs that were dispersed following the method described elsewhere (Konsta-Gdoutos 2008) are presented in

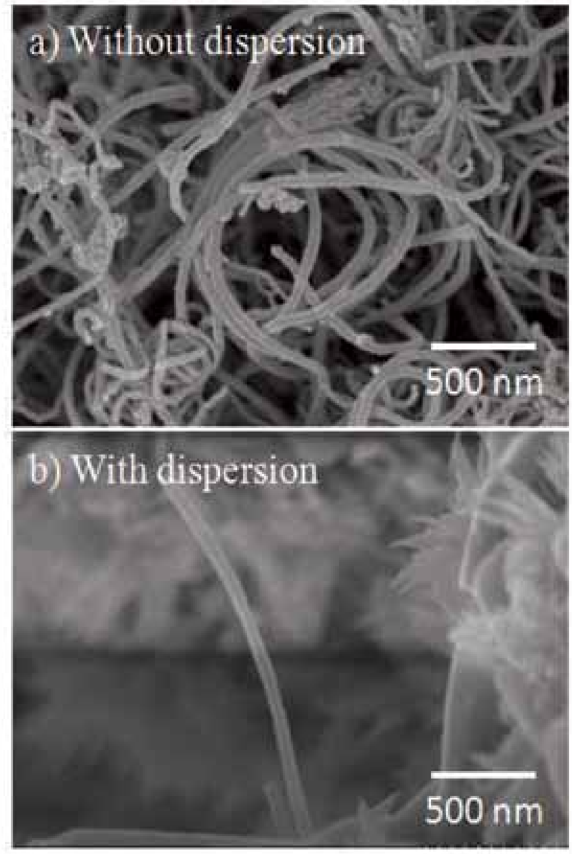

Figure 8. SEM images of cement paste reinforced with CNTs dispersed with (b) and without (a) the application of ultrasonic energy and the use of surfactant.

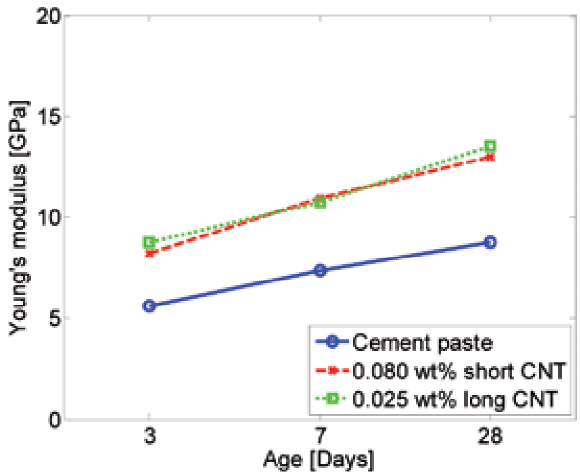

Figure 9. Young's modulus results from fracture mechanics tests of CNTs nanocomposites which exhibit the best mechanical performance among the different mixes tested.

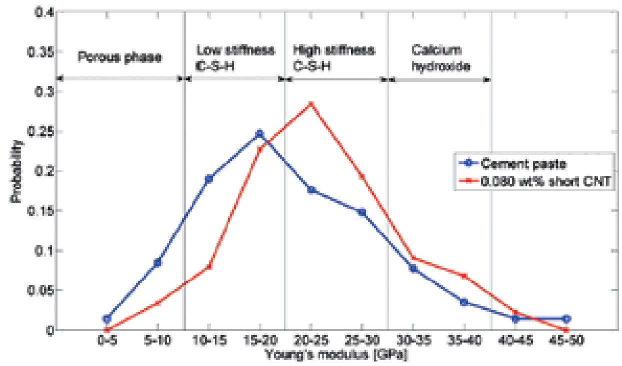

Figure 10. Probability plots of the Young's modulus of 28 day cement pastes with and without 0.08 wt% short CNTs for a w/c of 0.5.

Fig. 8. As expected, in the samples where no dispersing technique was used [Figure 8 (a)] CNTs appear poorly dispersed, forming large agglomerates and bundles. On the other hand, in the samples where dispersion was achieved by applying ultrasonic energy and using a surfactant [Figure 8 (b)] only individual CNTs were identified on the fracture surface. The results indicate that the application of ultrasonic energy and the use of surfactant can be employed to effectively disperse CNTs in a cementitious matrix.

To evaluate the reinforcing effect of CNTs, fracture mechanics tests were performed using MWCNTs with aspect ratios of 700 and 1600 for short and long CNTs, respectively. Additionally, to investigate the effect of CNTs concentration, cement paste samples reinforced with lower and higher amounts of CNTs (0.048wt% and 0.08wt%, respectively) were tested. The Young's modulus results from the fracture mechanics tests are shown in Figure 9. In all cases, the samples reinforced with CNTs exhibit much higher Young's modulus than plain cement paste. More specifically, it is observed that the specimens reinforced with either short CNTs at an amount of 0.08wt% or long CNTs at an amount of 0.048wt% provide the same level of mechanical performance. Generally, it can be concluded that the optimum amount of CNTs depends on the aspect ratio of CNTs. When CNTs with low aspect ratio are used a higher amount of close to 0.08wt% by weight of cement is needed to achieve effective reinforcement. However, when CNTs with high aspect ratio are used, a smaller amount of CNTs of close to 0.048 wt% is required to achieve the same level of mechanical performance.

Comparing the 28 days Young's modulus of the nanocomposites with that of the plain cement paste, a 50% increase is observed. Based on the parallel model [16] the predicted Young's modulus of cement paste nanocomposites reinforced with either 0.048wt% or 0.08 wt% CNTs at the age of 28 days (~9.1 GPa) is much lower than the experimental values obtained (~13 GPa). In addition, nanoindentation was performed on samples with and without CNTs. Figure 10 shows the probability plot of the 28 days Young's modulus of plain cement paste and cement paste reinforced with 0.08wt% short CNTs.

The probability plots are in good agreement with results from the literature (Constantindes & Ulm 2008, Mondal et al. 2008). Young's modulus values less than 50 GPa represent four different phases of cement paste corresponding to the porous phase, low stiffness C-S-H, high stiffness C-S-H and calcium hydroxide phase, while values greater than 50 GPa are attributed to unhydrated particles (Constantindes & Ulm 2008, Mondal et al. 2008). The different phases have been found to exhibit properties that are considered as inherent material properties and are independent of the mix proportions. As expected, the peak of the probability plots of plain cement paste with w/c=0.5 falls in the area of the low stiffness C-S-H, which is the dominant phase of cement nanostructure. On the other hand, the peaks of the probability plots of the nanocomposites are in the area of 20 to 25 GPa which corresponds to the high stiffness C-S-H, suggesting that the addition of CNTs results in a stronger material with increased amount of high stiffness C-S-H. Moreover, it is observed that the probability of Young's modulus below 10 GPa

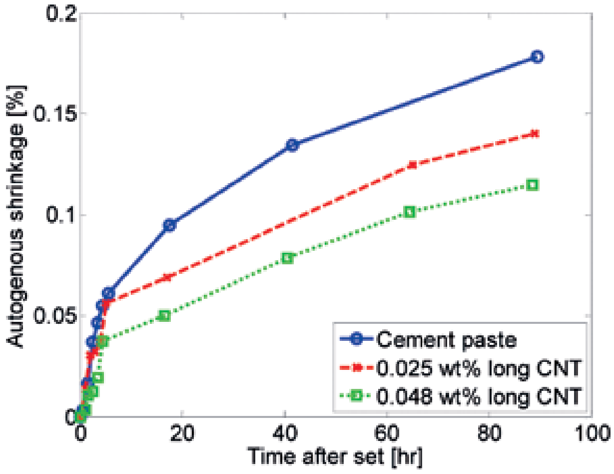

Figure 11. Improvement of autogenous shrinkage for cement pastes containing 0.025 and 0.048 wt% of CNTs for w/c of 0.3.

is significantly reduced for the samples with CNTs for both water-to-cement ratios. The nanoindentation results provide an indirect method of estimating the volume fraction of the capillary pores, indicating that the CNTs reduce the amount of fine pores by filling the area between the C-S-H gel (Shah et al. 2009), which may be one reason why current research has shown other improved properties with CNTs including autogenous shrinkage. Autogenous shrinkage measurements are shown in Figure 10, comparing plain cement paste with paste containing long CNTs at 0.025% and 0.048% by weight, all with a w/c of 0.3.

7 CONCLUSIONS

To meet the increasing need for high-performance, durable construction materials, ACBM has taken a back-to-basics approach to improve understanding of the properties of cement-based materials at a small scale and to develop new materials. Innovative ways to improve SCC in terms of formwork pressure, fibre dispersion and green strength have been developed through concepts of particle packing and flocculation, admixture technology, and rheology.

Incorporation of carbon nanotubes has seen very promising results, while the nanoscale characterisation of cement paste samples showed that the mechanical properties of the C-S-H gel—the glue in concrete—vary in a wide range, requiring complex modelling. Yet understanding cement-based materials at this scale can provide new ways to improve the high-strength and high performance concretes of today.

8 ACKNOWLEDGEMENTS

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9 REFERENCES

Curcio, F. & DeAngelis, B. 1998. Dilatant behaviour of superplasticised cement pastes containing metakaolin. *Cementand Concrete Research* 28(5): 629-634.

Constantinides, G. & Ulm, F. 2007. The nanogranular nature of C-S-H. *Journal of the Mechanics and Physics of Solids* 55(1): 64-90.

Cwirzen, A., Habermehl-Chirzen, K. & Penttala, V. 2008. Surface decoration of carbon nanotubes and mechanical properties of cement/carbon nanotube composites. *Advances in Cement Research* 20(2): 65-73.

Fedroff, D. & Frosch, R. 2004. Formwork for self consolidating concrete. *Concrete International* 26(10): 32-37.

Ferrara, L. & Meda, A. 2006. Relationships between fibre distribution, workability and the mechanical properties of SFRC applied to precast roof elements. *Materials and Structures* 39(4): 411-420.

Ferrara, L., Park, Y.D. & Shah, S.P. 2007. A method for mix design of fibre reinforced self compacting concrete. *Cement and Concrete Research* 37(6): 957-971.

Ferrara, L., Park, Y.D. & Shah, S.P. 2008. Correlation among fresh state behaviour, fibre dispersion and toughness properties of SFRCs. ASCE *Journal of Materials in Civil Engineering* 20(7): 493-501.

Ferrara, L., di Prisco, M., & Khurana, R.S. 2008. Tailoring optimum performance for the structural use of self consolidating SFRC. In Proc. BEFIB08, 7th RILEM International Symposium on Fibre Reinforced Concrete: Design and Applications, Chennai, India: 739-750.

Ferron, R. 2008. Formwork Pressure of Self-Consolidating Concrete: Influence of Flocculation Mechanisms, Structural Rebuilding, Thixotropy and Rheology. Department of Civil and Environmental Engineering. Evanstion, Ph.D. dissertation, Northwestern University.

Ferron, R. Gregori, A., Sun, Z., & Shah, S.P. 2007. Rheological method to evaluate structural buildup in self consolidating concrete cement pastes. *ACI Materials Journal* 104(3): 242-250.

Groert, N. 2007. Carbon nanotubes becoming clean. Materials Today 10(1-2): 28-35.

Konsta-Gdoutos, M.S., Metaxa, Z.S., & Shah, S.P. 2008. Nanoimaging of highly dispersed carbon nanotube reinforced cement based materials. In Proc: BEFIB08, 7th RILEM International Symposium on Fibre Reinforced Concrete: Design and Applications, Chennai, India: 125-131.

Mondal, P., Shah, S.P. & Marks, L.D. 2008. Nanoscale characterisation of cementitious materials. *ACI Materials Journal* 105(2): 174-179.

Ozyurt, N., Woo, L.Y., Mason, T.O. & Shah, S.P. 2006. Monitoring fibre dispersion in fibre reinforced cementitious materials: comparison of AC-Impedance Spectroscopy and Image Analysis. *ACI Materials Journal* 103(5): 340-347.

Pekmezci, B.Y., Voigt, T., Kejin, W., & Shah, S.P. 2007. Low compaction energy concrete for improved slipform casting of concrete pavements. *ACI Materials Journal* 104(3): 251- 258.

Roussel, N., Geiker, M., Dufour, F., Thrane, L., and P. Szabo.2007. Computational modelling of concrete flow: Generaloverview. *Cement and Concrete Research* 37(9): 1298-1307.

Shah, S., Konsta-Gdoutos, M., Metaxa, Z., & Mondal, P. 2009. Nanoscale modification of cementitious materials. In Bittnar, Z., Bartos, P., Nemecek, J. ,Smilauer, V., Zeman, J. (eds.), *Nanotechnology in Construction 3; Proceedings of NICOM3, Prague, May 31-June 2, 2009*, Springer Berlin Heidelberg.

Stähli, P. Custer, R. & van Mier, J.G.M. 2008. On flow properties, fibre distribution, fibre orientation and flexural behaviour of FRC. *Materials and Structures* 41(1): 189-196.

Struble, L. J. 1991. The Rheology of Fresh Cement Paste. In S.Mindess (ed.), *Advances in cementitious materials; Ceramic Transactions* 16: 7-29.

Sun, Z. Gregori, A. Ferron, R. & S.P. Shah. 2007. Developing falling-ball viscometer for highly flowable cementitious materials. *ACI Materials Journal* 104(2): 180-186.

Tregger, N. Knai, H. & Shah, S.P. 2009. Flocculation behaviour of cement pastes containing clays and fly ash. *ACI Special Publication* 259(10).

Xie, X.L., Mai, Y.W., & Zhou, X.P. 2005. Dispersion and alignment of carbon nanotubes in polymer matrix: A review. *Mater. Sci. Eng. Rep*. 49:89-112.

Western Cape Chatter

The Western Cape chapter has held a number of interesting and successful events during the past six months.


An external view of the Oostenberg Refuse Transfer Station.

In February Dr Robert Ratay from the University of Columbia, New York, gave a presentation on 'Forensic Structural Engineering Practice and Expert Witnessing in the United States'. Although his talk was based on the American legal system most aspects were universal and applicable to the South African industry.

Ratay says that in the US the law trumps logical engineering judgement unless it demonstrates that the judgement is based on a sound foundation, and does not violate the state-regulated building code.

At the branch AGM in March, Andrew Fanton, Construction Manager of Green Point Stadium, delivered an inspiring presentation on construction management of a FIFA World Cup 2010 stadium.

The newly elected chairman and committee members were announced at the AGM: Heinrich Stander, chairman; Etienne van der Klashorst, vice-chairman; Dr Billy Boshoff, past-chairman; Christo Adendorff, treasurer; Paul Zietsman, secretary; members: Dr Hans Beuhaussen, Kevin Kimbrey, Joseph Mofokeng, Jerome Fortune and Elsje Fraser.

In March, the annual golf day was well supported with 18 four balls at the Parow Golf Club and everyone enjoyed the prizegiving afterwards.

Members of the Western Cape Branch had an opportunity to conduct a site visit to the Oostenberg Refuse Transfer Station (ORTS), in April. Haw & Inglis hosted the event, which is part of the City of Cape Town's solid waste handling infrastructure programme. Members were briefed on the design of the main structure, outbuildings and material handling areas and other facts, which determined the layout.

A technical meeting showcasing exciting research developments in the field of concrete was held at the University of Cape Town, in June.

We are looking forward to the remainder of the year and especially to our next event, 'Concrete – It is greener than you think', by Bryan Perrie, Managing Director of C&CI.


An internal view of the Station.

Eastern Cape Chatter

After a frantic 2009, this year started off at a moderate pace with the Eastern Cape Chapter holding its regional AGM in March.

The event was rescheduled and held at the Master Builders Association offices. Unfortunately there was a low turnout of members. But despite this, the guest speaker, Nico Pienaar, President of the South African Ready Mix Association, entertained and informed members on the benefits of using an accredited supplier of ready mix concrete.

The professional team that worked on the major refurbishment of the Newton Park Swimming Pool addressed the Eastern Cape chapter. The team including the architect, structural engineer, steel fabricator, contractor and client provided Eastern Cape members with insight into the complexities of design and construction of the unique roof structure, which spans the width and length of the pool. The committee has further events planned and there is a possibility of including a seminar in concrete mix design and aggregate selection.

Rob McSporran has agreed to become a committee member as we no longer have a vice-chair.

Inland Chatter

For the first time, the Inland Branch held an Egg Protection Device Competition for students, from Wits and the University of Pretoria, at PPC's Jupiter Works in Johannesburg in May.

Students used concrete mixes donated by WR Grace and Chryso SA. The winning structure took 103 hits before cracking the egg below.

The main sponsor for the event was PPC, which provided the venue, refreshments and cash prizes to the top three winning teams. This successful competition will become an annual event on the Inland calendar, and we will utilise new, improved, concrete mixes.

During May the branch held a mini seminar on architectural concrete. The topics ranged from an overview of the contemporary use of concrete in architecture to some innovative uses of cementitious products and practical advice on precast concrete elements. The Inland Branch is grateful for the support from sponsors: Stucco Italiano, Ash Resources, BASF, C&CI, Chryso SA, Doka Formwork, Lafarge Readymix and RMS Solutions (Reckli). The seminar provided valuable information and networking opportunities. The National Concrete Symposium and Exhibition 'Concrete for a Sustainable Environment', will take place on August 3-4th at Emperor's Palace, in Kempton Park.

The symposium scope and themes will include durability, recycling, the carbon footprint of concrete, life cycle costing and effective use of materials and new technologies.

The extremely popular annual Concrete Boat Race will take place on September 18th. The event serves to introduce students to the cementitious and concrete industry and facilitate networking between the various groups in a fun way. It is an ideal opportunity for members to offer employees a family day, or use it as a team building exercise culminating perhaps in an inter-departmental challenge, or reward.

The teams that take part in the race will have to abide by the rules and regulations. Prizes will be awarded for originality in design, construction of the boats as well as the race winners.

Other upcoming events include a mini seminar about 'Innovation in Concrete', which will be held on October 21st. The Chairman's Breakfast and 'Concrete Achiever of the Year Award' will be held on November 5th., The venue still has to be finalised.

Low-density concrete

Low-density concrete is used for thermal insulation and also low density screeds and low density back-fill for utility trenches or other excavations. It has also been used in cast-in place building systems and pre-cast walling systems to perform a limited structural function.

Typically there are three types of low-density concrete mix currently available in South Africa these include: a mix of cement, light-weight aggregate, sand, water and admixtures; a mix of cement, fine sand, and foaming agent or a no-fines concrete mix, where the sand is omitted from the mix.

Three types of light-weight aggregate mixes available include the polystyrene beads and chips; exfoliated vermiculite, which is available from Mandoval Vermiculite in Gauteng and perlite, which is available from Pratley.

These aggregates are typically batched by volume, as errors can occur when batching by mass because of the materials low bulk density.

Typically they are supplied in 100 litre bags and the usual mix is one bag of cement to one bag of light-weight aggregate, i.e. 1:3 by volume. Sand may be added to increase the density and strength of the concrete and it helps with the mixing process. Often up to one volume of sand is added. Leaner mixes (around 1: 6) are used for mixes at the lower end of the density range.

Admixtures may also be used. Air-entrainers and pumps aid are useful and prevent the light-weight aggregate from floating out of the mix. Teepol has also been used successfully. Batching should be done in a wind-free area as the aggregates tend to blow around. Mixing can be done in drum-mixers but pan-mixers give better results.

The concrete is placed in the normal way but does not respond well to internal vibration. Compaction should therefore be carried out with surface, form, or table vibrators. Curing is important as these concretes have high drying shrinkage. Vermiculite concretes often have a very high water requirement and take a long time to dry out after curing.

Densities as low as 400 kg/m^3 are achievable and range up to 900 kg/m^3 .

Strength varies inversely with density and ranges from less than 1 up to 5 MPa. This type of concrete is not suitable for traffic areas.

Foamed concrete is made by diluting a concentrated foaming agent and passing it through a foam generator. The foam is then poured into the mixer containing the sand-cement mortar and the concrete is mixed. Mortar proportions vary from 2 sand: 1 cement, to 1 sand: 1 cement depending on the density required. Densities vary from 400 to 1600 kg/m^3 and strengths from 1 to 10 MPa. Again, this type of concrete is not suitable for high traffic areas, but if it needs to be used in a traffic area then the surface must be protected.

With no-fines concrete the mixes are in the region of 8 to 10 parts of single-sized stone to 1 part cement by volume. Traditionally 19-mm stone is used but smaller stone size can be used. Up to one part of fine sand can be added to the mix to increase the contact areas at the fillets between the stone particles. The amount of water added is critical. If too little water is added the paste will not coat the stone, while too much water will make the paste run off the stone. No-fines concrete has a density of around 1600 kg/m^3 depending on the compacted bulk density of the stone being used. This type of concrete is used for drainage layers, soil stabilisation and porous dams.

No-fines concrete has very good insulating properties and very little capillarity, which makes it ideal for cast-in-place walling for houses. It is easy to render and because the walls are porous behind the plaster they are self-draining. The unconfined compressive strength of no-fines concrete is of the order of 3 to 5 MPa.

PPC Tip 24: *Further reading:*

1. Fulton's Concrete Technology, 8th ed, 2001, pp287 - 292
2. Technical Information Pamphlet No 110A, 'Low Density Concrete, Polystyrene Bead Concrete', Cement and Concrete Institute, 1981
3. 'Foamed Concrete', leaflet, Cement and Concrete Institute.

CONCRETE SOCIETY OF SOUTHERN AFRICA
INTERNATIONAL EVENTS 2010

DATE	MEETING/EVENT	VENUE	CONVENOR
22 – 24 September	34th IABSE Symposium 'Large Structures and Infrastructures for Environmentally Constrained and Urbanised Areas'	Venice Italy	IABSE Organising Committee
27 – 29 April	2010 US- Africa Infrastructure Conference	JW Marriott Hotel, Washington DC, USA	Stephen Hayes
30 September – 1 October	6th 'CCC' Central European Congress on Concrete Engineering	Marianske Lazne, Czech Republic	Vlastimil Sruma
26 – 28 November	Workshop on Optimisation of Construction Method for CFRD's	Pinghu Hotel, 53 Dongshan Road, Yichang, China	Chen Qian
17 – 22 January 2011	BAU 2011	New Munich Trade Fair Centre, Munich, Germany	Johannes Manger Andrea Hack

CONCRETE SOCIETY OF SOUTHERN AFRICA NATIONAL OFFICE PROGRAMME 2010			
DATE	**MEETING/EVENT**	**VENUE**	**CONVENOR**
03 – 04 August	Concrete for a Sustainable Environment Symposium (CSE Symposium)	Emperor's Palace	CSE Symposium Organising Committee
05 August	Council Meeting	Emperor's Palace	CSSA President
10 October	Council Meeting	To Be Confirmed	CSSA President
End November	Concrete Beton Issue 126	Distributed to all members	Crown Publications

CONCRETE SOCIETY OF SOUTHERN AFRICA INLAND BRANCH PROGRAMME 2010			
DATE	**MEETING/EVENT**	**VENUE**	**CONVENOR**
12 August	Branch Committee meeting	C&CI, Waterfall Park, Midrand	Armand van Vuuren
02 September	Branch Committee meeting	C&CI Waterfall Park, Midrand	Armand van Vuuren
18 September	Annual Concrete Boat Race Day	Victoria Lake Club, Germiston	Trevor Sawyer
07 October	Branch Committee meeting	C&CI, Waterfall Park, Midrand	Armand van Vuuren
21 October	Mini Technical seminar - Innovation in Concrete	TBA	Hanlie Turner
04 November	Branch Committee meeting	C&CI, Waterfall Park, Midrand	Armand van Vuuren
5 November	Chairman's Breakfast, Concrete Achiever of the year Award	TBA	Johan van Wyk

CONCRETE SOCIETY OF SOUTHERN AFRICA EASTERN CAPE PROGRAMME 2010			
DATE	**MEETING/EVENT**	**VENUE**	**CONVENOR**
August	Red Location Site Visit and Technical Talk	TBC	Nick van den Berg
October	Ubuntu Centre Site Visit and Technical Talk	TBC	Nick van den Berg

CONCRETE SOCIETY OF SOUTHERN AFRICA WESTERN CAPE PROGRAMME (July 2010)			
DATE	**MEETING/EVENT**	**VENUE**	**CONVENOR**
22 July	TM on "Concrete – It is Greener that you Think"	UCT	Bryan Perrie
19 August	TM on "Concrete Developments and Trends in India"	UCT	Dr. Manu Santhanam
23 September	Cube Casting Date	NA	Elsje Fraser
30 September	Site Visit	TBC	Jerome Fortune
21 October	Cube Crush-In	University of Stellenbosch	Elsje Fraser
28 October	TM on "Widening of Durban Harbour"	TBC	Phil Smith
18 November	Cocktail Party	CPUT Hotel School	Heinrich Stander

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