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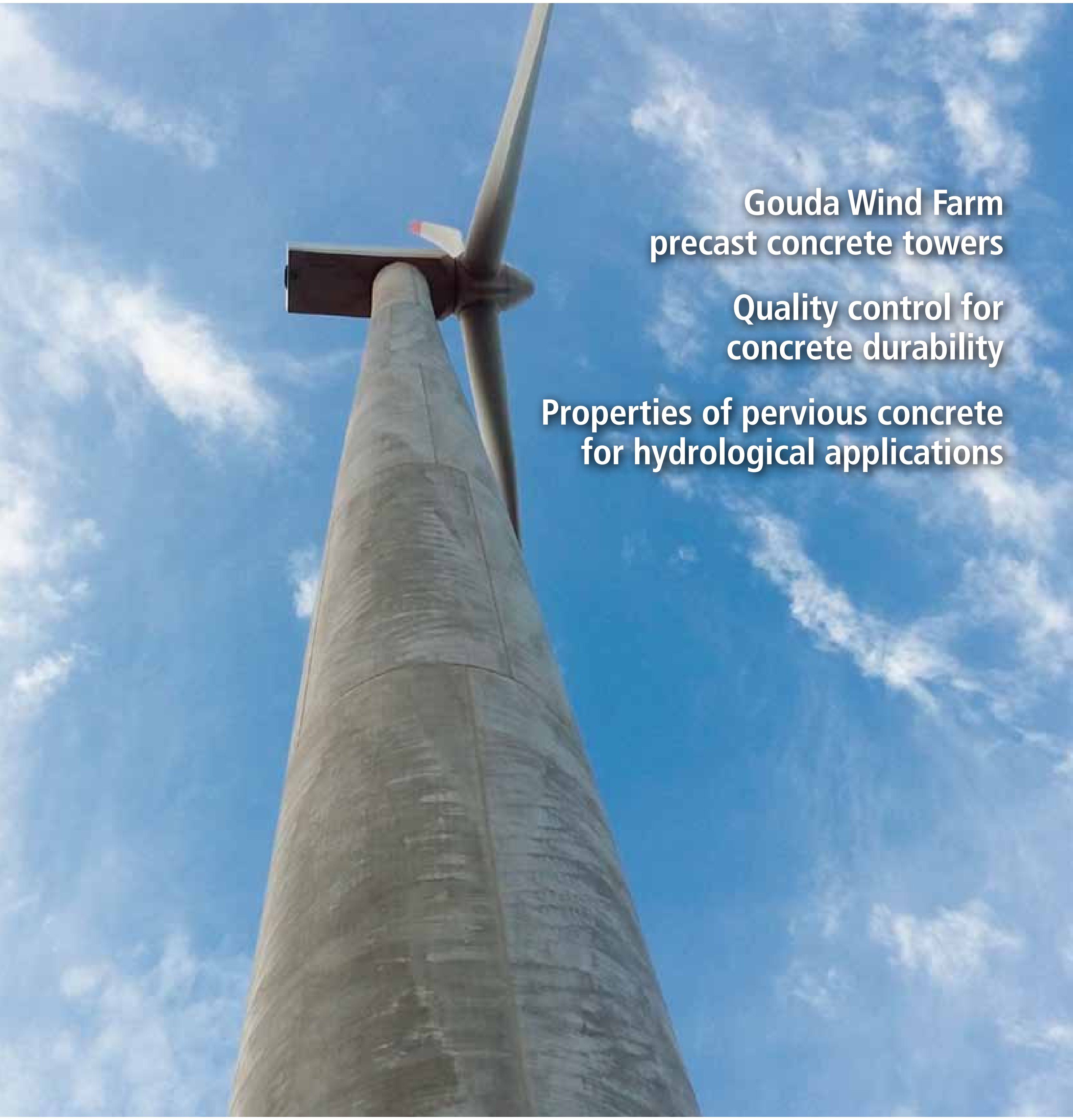
CONCRETE SOCIETY OF SOUTHERN AFRICA

CONCRETEBETON



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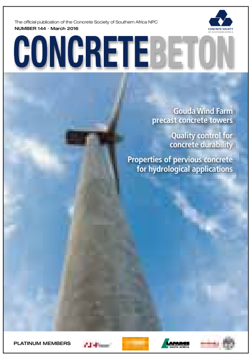
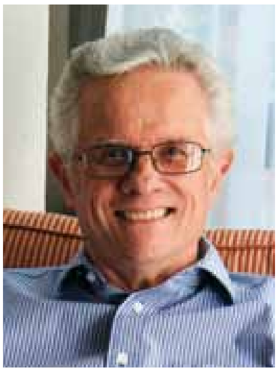


COVER: The Gouda Wind Farm Precast Concrete Towers project in the Western Cape was declared the winner in the Innovation in Concrete category in the 2015 Fulton Awards. It was also awarded a judges' commendation in the Civil Engineering Structures (more than R100 million project value) category. The judges were impressed by the fact that concrete rather than steel was the primary construction material for the tower support structures, which are 100 metres high and which support turbine and blades weighing 170 tons.



Embracing the future

Succession planning, as an element of sustainability, is an essential part of doing business, no matter how certain the future appears. It's easy to put off planning when everything seems to be going so well, but that is the time to begin or review succession planning.

Just as business practices have evolved over the years, succession planning has also grown and changed. It's no longer a plan that can only be accessed when leadership is going to change; a succession plan can be used before its "real" intent is necessary. It can be used to build strong leadership, help an organisation survive the daily changes in the marketplace, and force executives to review and examine the company's current goals.

Change – a major component of a succession plan – is challenging, but can bring an organisation unforeseen rewards. Still, change can be a source of tremendous stress, especially when people's livelihoods are at stake. Planning for the future is exciting and, if done correctly, can inspire stakeholders to stay involved and maintain loyalty. It's true that a plan is often put into place to avert catastrophe, but it is also an organisation's way of embracing the future – a business strategy that is essential for survival.

With this background the Board of Directors of the Society agreed at the last Board meeting to increase the number of elected Directors from three to five. In this way, the succession planning process for the Society can begin. Nominations from the membership for candidates for directorship have already been circulated and the response has been very positive. So much so in fact, that by the time this issue is distributed, we would have had to seek member votes, to elect 4 out of the 5 nominations to the board. We await the results with great interest.

On a completely different, but no less important topic, we believe that the Society's offering to members of technical seminars, Concrete Beton, an interactive website, site visits, student events, golf days, chairmen's awards and Fulton Awards, are all in line with our mission of promoting excellence and innovation in the use of concrete, and providing a forum for networking and for the sharing of knowledge in concrete. But it really doesn't matter what WE think, it's what YOU the members think – whether or not you feel that you are getting value from your membership.

We would like to know the answer to this, and I therefore invite members to please write to me with your thoughts on this critical issue. You can reach me on ceo@concretesociety.co.za or discuss it with us on LinkedIn.

Enjoy this first issue of 2016. For the love of concrete!

John Sheath
Editor
CEO, Concrete Society of Southern Africa

Fierce competition at the Inland Branch Annual Concrete Boat Race Day.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Rewarding growth achieved

The expression "time flies especially when one is having fun" is definitely true. In my case and the CSSA, two years flew by and it was a hectic but definitely rewarding period of growth, hard work and marked achievements of the CSSA. This has to be the most rewarding and exciting two years of my career in the Concrete Industry. This being my last President's Message for this Publication, its time to reflect!

Throughout the whole world across all industries "going green" is the buzz word that has now become a norm and the concrete industry is no exception. In the CSSA, this year kicked off with the ReCon2016, our first roadshow seminar of the year, where local and international speakers presented on Reduction in dumping, Reuse and Recycling of concrete. ReCon2016 covered both local and international knowledge, technology, equipment and developments in the use of recycled concrete in our structures.

In the past two years I have had the privilege of being at the helm of the CSSA at a time when several strategic changes were being implemented as directed by the Board in order to keep the CSSA relevant, innovative, progressive and to add value to the members and the industry as a whole. One of these strategic changes was to publish this very journal (Concrete Beton) in-house. This has been another of the success stories of the CSSA and continues to grow to new heights with every issue. Thanks once again to the Editor and his team, keep up the good work.

The Fulton Awards 2015 that took place at the Champagne Sports Resort in the Drakensberg in June 2015 will remain as top of the list of events in my two-year term as the President of the CSSA. This event brought together dignitaries from the construction industry, from Clients, Owners, Engineers, Developers and Contractors. The best most innovative projects were showcased in this event, and I had the honour and privilege of addressing this prestigious gathering. A definite highlight in both my life and career as a concrete engineer.

In a nutshell, I can safely say, the CSSA is alive, relevant and will continue to grow to even greater heights.

I would like to express my hearty thanks to the Board of the CSSA and its members for entrusting me with the responsibility of leading the organization in the last two years. I take this opportunity to wish our incoming President, Hanlie Turner, all the best in her term of office and I am looking forward to supporting all her endeavours to take the CSSA to new heights.

Lastly, but definitely not least, a huge thank you to the CSSA Head Office staff, led by the CEO, John Sheath, Natasja and Marike, thank you for your patience, hard work, efficiency and your ever present help.

In conclusion: I am proud to be an Engineer, I am even more proud to be a Concrete Engineer and most importantly, I am proud to be serving the Industry through the CSSA.

Enjoy the read and God Bless!

Yours Sincerely
Tseli Maliehe
President – Concrete Society of Southern Africa

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

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

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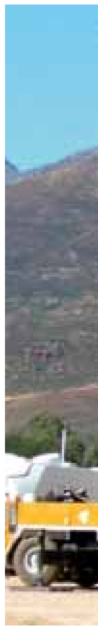
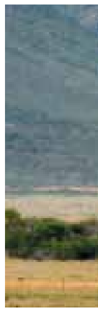




Gouda Wind Farm precast concrete towers

Gouda Wind Farm is situated just outside the town of Gouda in the Western Cape province of South Africa. It is capable of powering 200,000 households per year, or 400 gigawatt hours of electricity.

Forty-six precast concrete towers have been deployed at the farm, one of South Africa's largest wind farms to date. It is also Africa's first wind farm project in which concrete rather than steel was the primary construction material for the tower support structures. The towers stand at 100 m and support wind-powered turbines, each with a maximum generating capacity of 3 MW.

The wind farm is jointly owned by Spain's Acciona Energy and South Africa's Aveng Group and will feed up to 138 MW into the national grid daily. An agreement between the JV and Eskom will see ownership of the entire operation being transferred to the utility giant after 20 years.

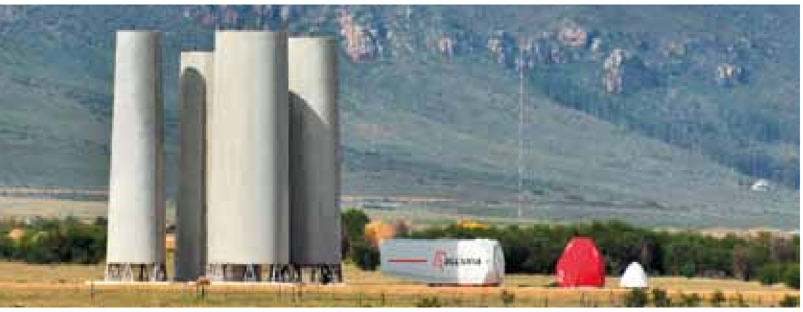
The precast concrete tower segments were manufactured by Cape Town-based precast concrete producer, Concrete Units, in a joint venture with another Spanish company, Windtechnic Engineering. The latter has extensive experience in the manufacture of precast concrete wind turbine towers and provided engineering input. The project utilised 16 500 m³ of concrete, 2 800 tons of reinforcing steel and 5 re-usable 6 m wide by 20 m long moulds.

To meet the contract deadline for the delivery of the towers' concrete segments, Concrete Units used its existing 2 000 m² factory to fabricate the reinforcing cages and extended its casting factory to 2 400 m² to accommodate the moulds and a concrete pump. The handling of the 60 ton segments at the factory was facilitated by the addition of two new 35 ton gantries, designed and commissioned by Concrete Units, as well as upgrading the capacity of an existing crane to 70-ton capacity. Additional 16-ton and 10-ton gantries were also designed and commissioned by the company to handle the reinforcing.

The on-site assembly of the towers and the manufacture and installation of the turbines was handled by Acciona Energy's sister company, Acciona Wind Power. Another local company, Concrete Growth, a civil engineering consultancy specialising in advanced concrete technology applications, was appointed by Acciona Wind Power as an external quality auditing agency. It was responsible for quality management in the manufacturing process, and ensured that

One of the concrete segments in Concrete Unit's yard.

Pre-Assembly



Tower segments stacked together prior to assembly.

the tower segments were manufactured to Acciona Windpower's drawings and specifications. For this purpose, Concrete Growth deployed a team of six, most of whom were qualified civil engineers. They included a quality and technical manager, four quality inspectors and a quality controller.

Each completed tower comprises five 20 m tapered concrete sections, each section being assembled with individual precast concrete segments.

The base section, T1, comprises four segments and is mounted on an in-situ concrete foundation. T2 which is mounted on T1, and T3, which is mounted on T2, are also assembled using four precast concrete segments each, whereas T4 is constructed with three parts and T5 requires only two.

T5 sections were assembled at Gouda's storage yard where they were made ready for supporting the turbines. Turbines consist of the nacelle and hub which weigh 140 tons, and three blades, each weighing 10 tons. Sections T1 – T4 were assembled at the actual tower sites where individual segments were lifted off trucks and then lowered vertically onto circular concrete bases by a giant mobile crane. They were then joined to matching segments using 'bowtie' connections. This was achieved by inserting reinforcing into the hollow chambers formed by the segments' two opposing vertical channels. A proprietary high-strength grout was then pumped into the joint to create a permanent seal.

The 20 m sections were attached to each other in a horizontal plane using male starter bars at the bottom end of the higher section and female ducting at the top end of the lower section and these joints were sealed with grout. The flawless execution of this process required extremely accurate casting to very tight tolerances.

Close up of the top end of a T5 segment.

Internal view of a T1 section showing the bowtie joint.

One of the 5 moulds used on the project.

The towers were designed to bend with the wind and can move up to 700 mm at their apexes during strong winds. This flexibility was facilitated by the use of steel reinforcing inside the tower walls. Any lateral movement is counterbalanced by the installation of six 90 mm steel cables, which attach the inner wall of T5 to the concrete base and provide additional strength to the overall structure. Once installed, they were post-tensioned.

The segments, 782 in all, were cast at Concrete Units' factory using five moulds which were shipped to South Africa from Poland and Brazil by Acciona Wind Power. Each mould section was 2 m long and the sections were assembled into 20 m long moulds using precision-based laser technology. Special jigs were used to ensure the accurate layout of the steel reinforcing.

A maximum of five segments were cast daily with production peaking at 32 segments per week. Various types of inserts and sockets were cast into specific positions to locate the mechanical (ladders, lifts and landings) and electrical equipment (cable trays, etc.) required inside the towers. Door spaces were cast into every fourth T1 segment. Mould stripping took place either late into the night shift or first thing every morning, by which time the segments had reached a compressive strength of 25 MPa.

Concrete segments prior to assembly.

Some fully assembled precast concrete towers.

After three days the segments were given a light post-tensioning prior to being transported to Gouda on extendable heavy-duty low-bed trucks. Segment T1 which was 5,5 m wide and T2, which spanned 4,8 m, required police escorts. The smaller segments, using normal escorts, were generally shipped first to allow the trucks to return for a second load.

The Gouda Wind Farm project represents cutting-edge precast concrete manufacture.

For example, the tower segments were designed according to European as opposed to SANS codes. This allowed for designs up to 115 MPa cube strength rather than the 60 MPa as per the SANS structural concrete code. The Gouda towers' concrete segments have a characteristic strength of 75 MPa, the strength required to handle the loading of both the turbines and the wind. This high characteristic strength allowed Acciona's engineers to opt for lighter concrete sections which added a further eco-friendly dimension to the project through less material usage and lower transport costs.

Secondly, the tower segments were manufactured with self-compacting concrete (SCC). SCC is comparatively new to this country and besides being one of the largest local wind farms to date, Gouda is also the country's largest Self-Compacting Concrete (SCC) project thus far and required approximately half the amount of concrete used for the precast segments of the Gautrain project. Without SCC, the Gouda project would have been much more complex, involving external vibration and more expensive moulds.

SCC was supplied by Megamix, which has a batching plant close to Concrete Units. The SCC mix was one of the critical components of the whole manufacturing process and a member of the Concrete Growth team was permanently based at Megamix to monitor the batching process. Wet weather can affect the mix because the amount of water used is critical. Even a slight water overdose can cause segregation and a loss of strength. However, ongoing monitoring and slump testing ensured that there were few problems with the mixes.

Turbine towers generally amount to approximately 15 to 20% of a wind farm's capital cost, a figure which does not include the foundations. In most instances, the higher one goes, the better the wind, and for heights above 80 m, concrete towers tend to be less expensive than imported steel towers, thus impacting on the cost of the electricity generated positively. To date, most wind turbines in South Africa have been mounted on steel towers which have the disadvantage of being imported and of carrying a comparatively low local labour and job-creation component.

By contrast, concrete wind turbine towers come with high local-content inputs, and by default carry a much higher job generating capacity. For example, over 95% of the raw materials for Gouda's concrete towers including the 500 MPa reinforcing steel, were sourced locally.

Moreover, wind power forms part of the Government's renewable energy strategy which was formulated by the Departments of Energy and of Trade and Industry in 2011. The CSIR was tasked with researching its job creation and economic development potential, and it was on the basis of the CSIR's report that the DTI increased the local-content wind-farm requirement for Round Three of its Renewable Energy Programme, of which Gouda forms a part.

Alternative energy is scheduled to add 9 000 MW (equivalent to two coal-fired power stations) by 2030, and it seems a safe bet that precast concrete towers will play a major role in Rounds Four and Five of the programme. ▲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Quality control for concrete durability

A case study provides comparisons of work performed under performance and prescriptive specifications.

by Odd E. Gjørv

In 2005, a new development project began in the Tjuvholmen neighborhood in the harbor region of Oslo, Norway. This project comprises a number of business and apartment buildings built on concrete substructures positioned in seawater (Fig. 1). The substructures, for which the highest possible durability and service life were required, were finished by 2010.

In shallow water, the structures typically include a solid concrete bottom slab on the sea bed. The slab is surrounded by concrete walls partly protected by riprap or wooden cladding and partly exposed to the tides. In deeper water, some structures include an open concrete deck on columns of driven steel pipes filled with concrete, while other structures comprise four large concrete caissons extending as much as 20 m below the surface. Three of these caissons provide up to four levels of parking (Fig. 2). The caissons were prefabricated in dry docks, floated into position, and submerged (Fig. 3).

For all concrete substructures, the owner and developer of the project required a service life of 300 years, which meant that the highest possible durability and long-term performance were needed. As a minimum, all durability requirements had to be fulfilled for a 100-year service life according to then-current European concrete standards. To obtain greater durability and service life of the structures, the owner would have preferred having all contracts based on the DURACON (Durability Design of Concrete Structures) Model.[1,2] This model provides for probability-based durability design, performance-based concrete quality control, quality assurance with documentation of achieved construction quality, and condition assessment during operation of concrete structures in severe environments (Fig. 4). While application of the DURACON Model became an option in the final contract, the contract still required documentation of the achieved construction quality based on the DURACON procedures.

Fig. 1: The new city development on Tjuvholmen in the Oslo harbor (photo courtesy of Terje Løchen).

Fig. 2: Large, prefabricated concrete caissons shown in rendering provide up to four levels of submerged parking.

The project was carried out by two different contractors. One of them (Contractor A) applied the DURACON Model as a basis for the contract. This contractor was in charge of the first four parts of the project, mainly including the solid concrete bottom slabs with perimeter concrete walls exposed to the tidal and splash zones. The experience obtained from the durability design and concrete quality assurance of these concrete structures has been reported in a previous article.[3]

The other contractor (Contractor B) applied the prescriptive-based durability requirements according to the then-current European concrete standards but with some additional requirements and protective measures as a basis for the contract. Contractor B was in charge of the last four parts of the project. These structures mainly included the four large caissons prefabricated in dry docks at two different construction sites. In addition, a number of open concrete decks were also included, partly as prefabricated elements, but mostly produced on site.

Because documentation based on the DURACON procedures was required to determine the achieved construction quality of all concrete structures, the project created a unique opportunity for comparing the results obtained through the use of performance and prescriptive specifications. Further results and experience from the durability design and concrete quality control of the project's concrete structures are described and discussed in more detail elsewhere.[2]

Specified Durability

For design according to the DURACON Model, the overall durability requirement is based on the specification of a given "service period" before the probability for onset of steel corrosion exceeds a certain upper level. In accordance with current standards for reliability of structures, a probability of 10% is adopted for this level. To calculate the probability of corrosion, durability analyses are carried out, providing a basis for selecting proper combinations of concrete quality and concrete cover which would meet the required service period for the given environment.

Procedures and input for durability design are described and discussed in more detail elsewhere,[1,2] but it should be noted that in the DURACON Model, the concrete quality is characterized by the chloride diffusivity (D) according to the rapid chloride migration (RCM) method.[4] The RCM method does not require pre-curing of the concrete and so can be carried out very rapidly, independent

(a)

(b)

Fig. 3: Large concrete caissons were: (a) prefabricated in dry docks; and (b) moved into position and submerged in water up to 20 m (66 ft) deep

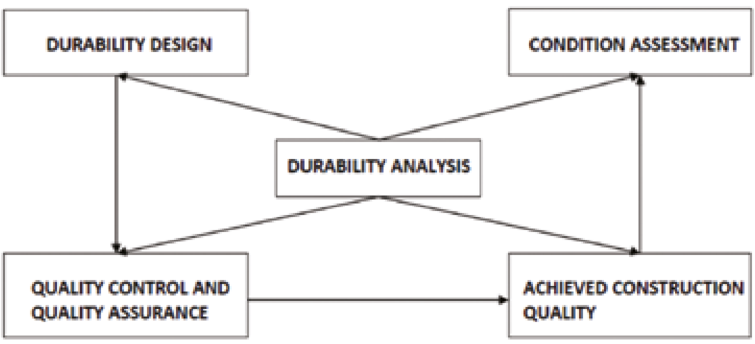


Fig. 4: The DURACON Model includes concrete quality control and quality assurance measures, documentation of achieved construction quality, and condition assessment during operation of concrete structures in severe environments[1,2]

of concrete age. Because the method provides a very strongly accelerated test, the results can be considered only as a simple relative index. However, the results vary with the density and permeability of the concrete as well as the ion mobility in the pore solution of the concrete, so they do reflect a concrete mixture's resistance to chloride ingress and thus its general durability properties. Using the 28-day chloride diffusivity (D_{28}) as an input parameter for durability, design can be compared to using the 28-day compressive strength as an input parameter for structural design – both parameters are actually relatively simple indices that can be used to establish that a concrete mixture is fit for purpose. However, it should be noted that the 28-day chloride diffusivity is a much more sensitive concrete quality parameter than the 28-day compressive strength.

Performance-based durability requirements (Contractor A)

Because the current procedures for probability-based durability design according to the DURACON Model are not considered valid for a service period of more than 150 years, the overall durability requirement to the concrete structures in the first four parts of the project (Contractor A) was based on a probability of corrosion as low as possible and not exceeding 10% for a service period of up 150 years. To further ensure the durability of the structures, some additional protective measures were applied. For the first concrete structure constructed by Contractor A, provisions were provided for future cathodic protection in combination with embedded probes for chloride control. For the other three structures, the additional protective measure was based on a partial replacement of plain carbon steel reinforcing bars with EN 1.4301/AISI 304 stainless steel bars.

To select a proper combination of concrete quality and concrete cover, an initial durability analysis was carried out. Because the concrete quality in the durability design was based on the RCM diffusivity, current experience with the RCM diffusivity of different types of concrete had to be reviewed.[2] On this basis, a concrete with blast-furnace slag cement with 70% slag (CEM III/B 42.5 LH HS) in combination with 10% silica fume was adopted. This mixture typically provides a D_{28} of 2.0×10^{-12} m^2/s. A nominal concrete cover of 100 ± 10 mm was also adopted, while all the other input parameters needed for the durability design were based on current experience for the local marine environment. As a result, a probability for corrosion of less than 0.3% after a 150-year service would be attained for the most exposed parts of the structures. Therefore, the aforementioned values for the D_{28} and the nominal concrete cover were adopted as intended values for the first concrete substructure. Resistance to freezing was also required, and to reduce the risk for early-age cracking of the 100 mm concrete cover, synthetic fibers were required in the mixture.

While provisions for future cathodic protection were applied as an additional protective measure for all exposed walls of the first concrete substructure, no additional protective measure for the continuously submerged bottom slab was considered necessary due to the very low oxygen availability.

For the second concrete structure, which consisted of an open concrete deck on columns of driven steel pipes filled with concrete, the additional protective measure was based on partial replacement of plain carbon steel reinforcing bars with stainless steel bars. Because this protective measure very soon proved to be a simple and robust technical solution and even proved to be economically competitive, a partial use of stainless steel was adopted for the most exposed sections of the remaining parts of the project.

When plain carbon steel was replaced by stainless steel in the outer layer of the reinforcing bar system, the effective concrete cover to the carbon steel reinforcement increased to more than 150 mm. As a consequence, the nominal concrete cover to the stainless steel bars could be reduced to 85 ± 10 mm while still maintaining a very low probability of corrosion. At the same time, the addition of fibers to the concrete for these parts of the structures was no longer considered necessary. For all the solid bottom slabs, however, plain carbon steel with a nominal concrete cover of 100 ± 10 mm and concrete with synthetic fibers were still applied.

Prescriptive-based durability requirements (Contractor B)

For all the concrete substructures in the last four parts of the project (Contractor B), the durability requirements were primarily based on the prescriptive durability requirements according to the then-current European concrete standards for a 100-year service life. These provisions included a maximum water-binder ratio (w/b) of 0.40 and a minimum binder content of 330 kg/m^3 . Provisions also included nominal concrete covers for the permanently submerged parts and the tidal/splash zones of 60 and 70 mm, respectively. To further increase the durability, however, the nominal concrete cover for the permanently submerged slabs of the caissons was increased from 60 to 80 mm, while for all external walls with tidal and splash exposure, it was increased from 70 to 90 mm. For the submerged parts of the structures, cathodic protection in the form of sacrificial anodes was also applied, while above water, provisions were made for future installation of cathodic protection in combination with embedded instrumentation for future chloride control.

Concrete Quality Control

As a basis for the performance-based concrete quality control, ongoing control of both the chloride diffusivity (RCM) of the concrete and the concrete cover were carried out throughout concrete construction. For all the concrete structures for which the probability-based durability design was applied, the specification called for a D_{28} of 2.0 × 10^{-12} m^2/s or less, while for all the other concrete structures that were only based on prescriptive durability requirements, the D_{28} value had to be determined for the given concrete of each new concrete structure before concrete construction started.

Although the RCM method is a very rapid test method which provides data on the chloride diffusivity within a few days, this is not good enough for the regular quality control during concrete construction. Based on the DURACON procedures, therefore, a calibration curve relating the chloride diffusivity and the electrical resistivity of the given concrete mixture must be established before concrete construction starts (Fig. 5). Then, the D_{28} value is indirectly controlled by regular nondestructive testing of the electrical resistivity of the concrete during concrete construction. All of the quality control measurements of the electrical resistivity were made on compressive strength test specimens (immediately before the specimens were tested for strength) using the four-electrode (Wenner) method.

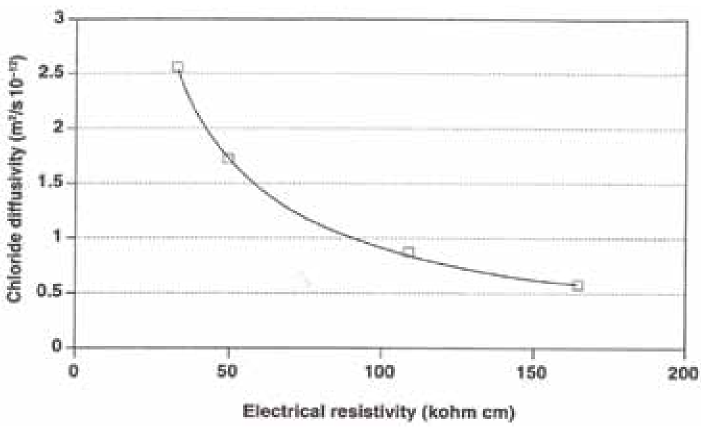


Fig. 5: Typical calibration curve for an indirect control of the 28-day chloride diffusivity (RCM) based on electrical resistivity measurements

Because the specified concrete covers were substantial and the reinforcement system was mostly highly congested, it was very difficult to measure the cover thickness accurately using conventional cover meters. The use of stainless steel reinforcement further complicated the quality control measurements. While sophisticated scanning equipment for control of thick concrete covers does exist,[2] a more pragmatic approach, based on manual readings of the cover depth on protruding bars in all construction joints during concrete construction, was applied. If the quantity of such control measurements was sufficient to produce reliable statistical data, this simple approach was considered adequate for the regular quality control and quality assurance during concrete construction.

Achieved Construction Quality

Upon completion of the concrete construction of each new structure, all data from the regular concrete quality control tests were incorporated as new input parameters for durability analyses used for documenting the achieved construction quality. Because the control of the 28-day chloride diffusivity was only carried out on small and separately produced concrete specimens cured in the laboratory for 28 days, the values may be quite different from that obtained on the construction site. Therefore, some additional documentation of achieved chloride diffusivity on the construction site and the long-term diffusivity of the various types of concrete are also required according to the DURACON approach. As a basis for the documentation, it should be noted that the achieved construction quality is characterized and quantified in the form of the obtained corrosion probability for the required service period of 150 years.

Compliance with durability requirements

For all concrete substructures in the first four parts of the project (Contractor A), a probability of corrosion as low as possible and not exceeding 10% for a 150-year service period was specified. To show compliance, a new durability analysis had to be carried out upon completion of each new concrete structure. These analyses were carried out with input parameters based on the achieved average values and standard deviations of both the 28-day chloride diffusivity and the concrete cover from the regular quality control. All of the other previously assumed input parameters were kept the same. Hence, this documentation primarily reflects the results obtained from the regular control of concrete quality and concrete cover during concrete construction, including the scatter and variability observed. For all the structures where a given value of the 28-day chloride diffusivity had

Table 1: Probabilities of corrosion based on regular quality control measurements of the 28-day chloride diffusivity and concrete cover (Contractor A)

Part of project	Bottom slab, %	External walls, %	Open deck, %
1	0.24	2.1	0.13
2	0.92	0.02	NA
3	0.64	0.002	NA
4	0.01	<0.001	NA

Table 2: Probabilities of corrosion based on regular control measurements of the 28-day chloride

Part of project	Bottom slab, %	External walls, %	Open deck, %
5	15	3	6
6	*	11 to 13	NA
7	14	1.3	NA
8	NA	NA	4.5

**No quality control measurements for the bottom slab were carried out*

been specified, any unacceptable deviation from this value could be detected and corrected for during concrete construction.

For the first concrete substructure in Part 1 of the project, delivered concrete was somewhat retarded compared to the intended type of concrete. Thus, the obtained average 28-day chloride diffusivities of 3.0 and 5.0 × 10^{-12} m^2/s for the bottom slab and the external walls of this structure, respectively, were higher than the specified maximum value of 2.0 × 10^{-12} m^2/s. However, because this concrete showed a very rapid further reduction of chloride diffusivity over time, it was accepted for the project.

For all the external walls in the first concrete structure where a nominal concrete cover of 100 mm was specified, an average concrete cover of 102 mm with a standard deviation of 8 mm was obtained. For one of the sections in these walls, however, the quality control tests revealed a distinct deviation. For this particular section, an average concrete cover of only 74 mm with a standard deviation of 8 mm was observed, and as a consequence, the contractor was required to apply an additional protective surface coating on this particular section of the wall. For this first concrete structure as a whole, however, as well as the open concrete deck with stainless steel in the second structure of Part 1 of the project, the probabilities of corrosion were significantly below the specified 10% (refer to Table 1). The specified durability was also achieved with very good margins for all of the additional concrete structures in Parts 2 to 4 of the project.

For the concrete substructures in Parts 5 to 8 of the project, which were only based on prescriptive durability requirements (Contractor B), it was not possible to provide any documentation of compliance with the durability specification. Because a performance-based concrete quality control program was also carried out for all these structures, however, documentation of the achieved construction quality in the form of corrosion probability after 150 years could also be calculated (Table 2). The durability analyses were based on the average values and standard deviations of both the 28-day chloride diffusivity and the concrete cover from the regular quality control evaluation of each structure.

The generally higher corrosion probabilities obtained for all the concrete substructures in Parts 5 to 8 (Table 2) compared to that in Parts 1 to 4 of the project (Table 1) may be ascribed to several sources. For all the concrete structures in Parts 1 to 4, the concrete was based on a blast-furnace slag cement with 70% slag (CEM III/B 42.5 LH HS) in combination with 10% silica fume, while all the concrete structures in Parts 5 to 8 were produced with concrete based on fly ash cements in combination with 5% silica fume. For most of these structures, a fly ash cement with 30% fly ash (CEM II/B-V 32.5 N) was applied, but some structures comprised a fly ash cement with 20% fly ash (CEM II/A-V 42.5 N). It is well known that blast-furnace slag cements generally give both very low chloride diffusivities and a very rapid reduction of chloride diffusivity, even at low curing temperatures, while fly ash cements generally give both higher chloride diffusivities and a very slow reduction of chloride diffusivity, particularly at low curing temperatures. For all the external walls in Parts 2 to 4 of the project, stainless steel was also used, while the much higher probabilities for the bottom slabs in Table 2 compared to that of the bottom slabs in Table 1 primarily reflect the different concrete covers of 80 and 100 mm, respectively.

Although the mixture compositions of the various types of concrete applied to the structures in Parts 5 to 8 of the project were basically the same, the 28-day chloride diffusivities obtained at the different construction sites were quite different from one construction site to the other. Thus, for one of the construction sites, the diffusivity varied from 6.4 to 8.9 × 10^{-12} m^2/s, while for another construction site, it typically varied from 12.1 to 16.7 × 10^{-12} m^2/s.

In-place quality

For documentation of the achieved in-place quality during the construction period, a number of concrete cores were removed from each concrete structure and tested for chloride diffusivity at different ages up to 1 year (Fig. 6). As part of this testing, a number of concrete cores removed from corresponding dummy elements were also included. Upon removal, all of these cores were wrapped in plastic and sent to the laboratory for testing as soon as possible. Based on the achieved chloride diffusivities after 1 year of site curing combined with the achieved site data on concrete cover as new input parameters, new durability analyses were carried out for each concrete structure. Also, all the other previously assumed input parameters to the analyses during durability design were kept the same. The typical values of achieved in-place quality expressed as corrosion probability after a 150-year service period are shown in Table 3. For all concrete substructures in Parts 1 to 4 of the project (Contractor A), Table 3 shows very low corrosion probabilities compared to that in Parts 5 to 8 (Contractor B).

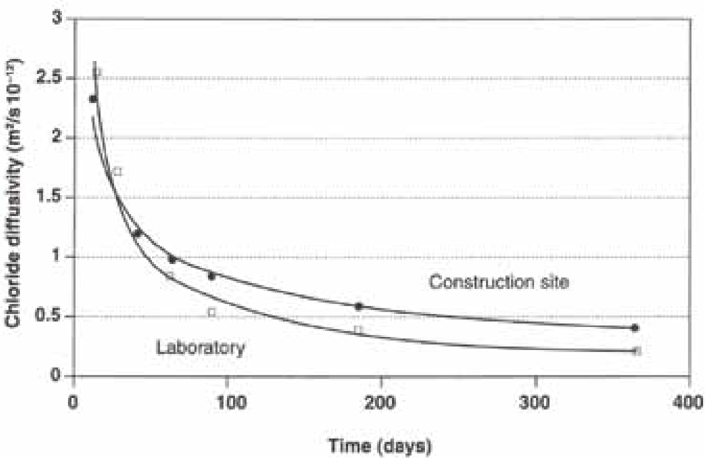


Fig. 6: Typical development of chloride diffusivity (RCM) on the construction site and in the laboratory for up to 1 year

Table 3: Probabilities of corrosion based on in-place data collected during the first year

Part of project	Bottom slab, %	External walls, %	Open deck, %
1	<0.001	<0.001	0.02
2	<0.001	<0.001	NA
3	<0.001	<0.001	NA
4	<0.001	<0.001	NA
5	70	25	35
6	*	30	NA
7	20	0.6	NA
8	NA	NA	1.2

**No quality control measurements for the bottom slab were carried out*

Also, a high variation of corrosion probability was obtained for the open concrete decks. The generally slow development of chloride diffusivity for concrete based on fly ash cements has already been pointed out. In particular, this was true for those structures produced during the winter seasons at low curing temperatures. For marine concrete construction, this may have some implications for an early-age exposure of the concrete to seawater before the concrete has gained sufficient maturity and density.[2]

For the concrete structure in Part 6, it should be noted that the in-place data on achieved chloride diffusivity were based only on concrete cores from the separately produced dummy element. Thus, the obtained probability of 30% for the external walls of this structure is not very representative. For one of the external walls of this structure, a severe segregation of the self-consolidating concrete during concrete construction took place. Therefore, separate investigations based on extensive concrete coring of this particular wall were later on carried out. The investigations clearly demonstrated that the durability properties of this segregated concrete were distinctly reduced. However, it was not possible to provide any documentation of increased w/b of the segregated concrete beyond what was specified as a basis for the contract. Also, because the in-place compressive strength of the segregated concrete was just high enough to be acceptable according to the current concrete standard, the owner had to accept the reduced durability properties in this particular structure according to the applied durability specifications in the contract.

Potential quality

For most types of binder system, the development of chloride diffusivity tends to plateau after about 1 year of water curing at 20°C in the laboratory. To provide information about the potential construction quality of the various structures, the chloride diffusivity was also tested on a number of separately produced and water-cured specimens in the laboratory for up to 1 year, as shown in Fig. 6. These chloride diffusivities combined with the achieved site data on concrete cover were used as new input parameters for further durability analyses. As with the previous analyses, all the other originally assumed input parameters were kept the same. Typically achieved values of the potential construction quality of the various concrete structures are shown in Table 4.

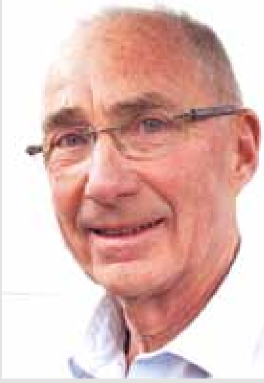
For all structures, the potential construction quality was extremely good. The corrosion probability was hardly detectable for structures in Parts 1 to 4 of the project (Contractor A) and very low for the concrete structures in Parts 5 to 8 of the project (Contractor B).

The results demonstrate that the concrete based on high-volume fly ash cements could reach quite a good potential construction quality given good curing conditions.

Table 4: Probabilities of corrosion based on laboratory-produced specimens, water cured in the laboratory for 1 year

Part of project	Bottom slab, %	External walls, %	Open deck, %
1	<0.001	<0.001	0.002
2	<0.001	<0.001	NA
3	<0.001	<0.001	NA
4	<0.001	<0.001	NA
5	0.04	0.01	0.01
6	*	0.05	NA
7	0.5	0.01	NA
8	NA	NA	0.5

**No quality control measurements for the bottom slab were carried out*



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Concluding Remarks

For all the concrete structures where a performance-based durability specification was applied as basis to the contract, the durability requirements were achieved with very good margins. For the owner and developer of the project, it was very important to receive a documentation of compliance to the durability specification before the structures were formally handed over from the contractor, because this may have implications both for the future operation and expected service life of the structures.

Also, it was observed that the performance-based durability specification distinctly clarified the responsibility of the contractor for the quality of the construction process. During concrete construction, any unacceptable deviations from the performance-based requirements for concrete quality and concrete cover could be detected and corrected. The required documentation of compliance to the durability specification clearly resulted in improved workmanship with reduced scatter and variability of achieved construction quality.

In contrast, where a prescriptive-based durability specification was applied as basis for the contract, it was not possible to provide any documentation of compliance to the durability specification. Also, the achieved construction quality of the various concrete structures typically showed a higher scatter and variability. ▲

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Selected for reader interest by the editors.

Properties of pervious concrete for hydrological applications

Stephen O. Ekolu, Souleymane Diop and Firehiwot Azene

ABSTRACT

This paper presents an experimental investigation that was conducted to examine those properties of interest with regard to the passage of water through pervious concrete. A total of 30 mixtures of pervious concrete were prepared at water-cementitious ratios (w/cm) varied from 0.25 to 0.40. Three aggregate types and sizes were used consisting of 13.2, 9.5 and 6.7 mm granite stone; 6.7 mm shale and 9.5 mm dolomite. Extenders were incorporated into mixtures in proportions of 20, 30 and 50% fly ash (FA) or 30% and 50% ground granulated blast furnace slag (GGBS). Compressive strength development in the mixtures was monitored at 7, 14, and 60 days. It was found that strength gain after 14 days generally occurred mainly in mixtures containing pozzolans. A unique behavior in property relations of pervious concrete was found, showing compressive strength to increase as w/cm increased, while porosity showed inverse proportionality with w/cm, both trends being contrary to the behavior of normal or conventional concrete. It was found that mixtures made with 6.7 or 9.5 mm granite stone gave porosity and permeability characteristics that were most suitable for hydrological applications. Similarly, incorporation of 20% FA, 30% or 50% GGBS in the mixtures gave the most appropriate mechanical and transport properties.

KEY WORDS: Pervious concrete; Compressive strength; Porosity; Permeability; Aggregates; Fly ash; Slag

1. INTRODUCTION

The global interest towards sustainability and use of environmentally friendly materials and scientific technologies has seen increased promotion of pervious concrete in the construction industry. Pervious concrete is a special form of concrete whose uniqueness lies in its hydrological properties. This type of concrete has been in existence since 1852 [1] but did not attain wide applicability in its early years and was mostly in oblivion until recent years when it has seen resurgence. The main engineering applications of interest responsible for this resurgence are associated with its use in storm water management and pollution control.

1.1 Pervious Concrete Applications

Also referred to as *permeable concrete* or *no-fines concrete*, this type of concrete is different from conventional concrete squarely due to complete absence of or presence of a fairly small amount of, fine aggregate in its mixtures. It therefore turns out to be porous to the extent of allowing free flow of water through the concrete. This hydrologic behaviour is controlled by permeability and porosity properties of the mixture.

As mentioned earlier, storm water management is the foremost application for which pervious concrete is predominantly used. Surface run-off is particularly a problem in urban areas and cities, due to densely built environment along with paved or concrete surfaces. Pervious concrete has been used in construction of parking lots, sidewalks, walkways and low volume roads in order to drain off stormwater hence reducing run-off, effectively recharging the ground water-table. This application is of benefit to the environment and is of particular interest to government agencies, municipal authorities, and also private property owners. Beyond the control of run-off, use of pervious concrete may result in significant pollution control benefits due to its ability to trap debris, motor oil or petroleum products and other contaminants that would normally be carried into rivers and waterways [2,3]. In the early ages of pervious concrete inception, it was also used in Europe as a structural material in building construction. The structural applications for which pervious concrete has been employed include its use in walls of two-story houses, use as infill panels and load-bearing walls for tall buildings of up to 10 storeys. Tennis et al.[2] lists an extensive range of construction applications for pervious concrete.

Quite interesting are also recent investigations [4,5] that have shown that pervious concretes contain water purification properties in which it acts as a filter to remove heavy metal concentrations giving prospects for its potential use for water treatment applications. Two forms of pervious concrete failures have been cited, being clogging and structural failures. Clogging results from accumulation of debris and contaminants both at surface and interior of the concrete, causing reduction in porosity and permeability and ultimately affecting its hydrologic performance. However, it has been argued that this is a maintenance issue and regular sweeping or vacuuming can restore porosity; pressure flushing is reported to restore 80 to 90% of its original permeability. Structural failures arise from load-bearing uses that may exceed its relatively low compressive strength of typically 2.8 to 28 MPa based on concrete cylinders [6], such as may occur from heavy traffic loads. Also, reports have indicated poor resistance of pervious concrete to freeze-thaw damage leading to failures. But investigations [3] have shown that proper mix design can result in improved performance against freeze-thaw attack.

1.2 Typical Mixtures and Properties

Suitable pervious concrete typically has 15 to 30% porosity, and pore sizes may range from 2 mm to 8 mm diameter. As previously mentioned, the compressive strength of concrete is quite low while permeability or drain rates of 120 to 700 litres/min/m^2 have been reported [2]. Small aggregate sizes of 6.5 to 13 mm are used, with 9.5 mm being most commonly employed along with cement contents of 270 to 400 kg/m^3 and water/cement ratios that may range from 0.25 to 0.40. The aggregate /cement ratio is typically 4 to 4.5. Due to low water/cementitious ratios typically used in pervious concrete, the mixtures are usually dry mixes with zero slump. For this reason, the use of superplasticizers in pervious concrete is necessary for achievement of workability. Normal cementitious materials including extenders (such as fly ash, slag, silica fume) may also be used.

It has been shown that the behaviour of pervious concrete is remarkably different from that of conventional concrete while its hydrologic properties are affected by mixture proportions. Kevern et al. [3] found a linear inverse relationship between compressive strength and porosity, but the permeability-porosity relation was reported to be non-linear, becoming exponential at porosity values exceeding 25%. Pervious concrete technology is not widespread in developing countries and further understanding of its diverse use is of interest. In the present experimental study, a wide range of variables are investigated in relation to their effects on mechanical and hydrologic properties of pervious concrete. The variables include water/cement ratio, use of different extenders of varied proportions, different aggregate types and sizes. The properties measured were the density and porosity of fresh pervious concrete; compressive strength and its development, and water permeability of hardened pervious concrete.

2. EXPERIMENTAL

2.1 Materials and Mixtures

A range of mix variables were applied to examine their influence on the properties of pervious concrete:

- Cementitious materials consisted of CEM I 52.5N with or without incorporation of extenders of 20, 30, 50% FA; 30 or 50% GGBS. Also used in the mixtures was CEM V/B 32.5R which typically contains a high volume of (at least 80%) FA/GGBS extenders [7-10].

Table 1: Varied mix ingredients and proportions: Gr = granite, Sh = shale, Dol = dolomite, w/cm = water/cementitious ratio, FA = fly ash, GGBS = ground granulated blast-furnace slag, SP = superplasticizer Chryso Fluid Premia 310

Mix No.	Stone size (mm) and type	Cementitious type	w/cm	SP (mls)
1	6.7 Gr	CEM I 52.5N	0.25	61
2	13.2 Gr	CEM I 52.5N	0.25	60
3	6.7 Sh	CEM I 52.5N	0.25	120
4	9.5 Dol	CEM I 52.5N	0.25	60
5	6.7 Gr	CEM I 52.5N	0.28	60
6	6.7 Sh	CEM I 52.5N	0.28	120
7	6.7 Gr	CEM I 52.5N	0.31	60
8	13.2 Gr	CEM I 52.5N	0.31	60
9	6.7 Sh	CEM I 52.5N	0.31	120
10	9.5 Dol	CEM I 52.5N	0.31	60
11	6.7 Gr	CEM I 52.5N	0.35	35
12	6.7 Sh	CEM I 52.5N	0.35	50
13	6.7 Gr	CEM I 52.5N	0.4	30
14	6.7 Sh	CEM I 52.5N	0.4	40
15	6.7 Gr	20% FA	0.25	60
16	6.7 Gr	30% FA	0.25	70
17	13.2 Gr	30% FA	0.25	30
18	6.7 Sh	30% FA	0.25	100
19	9.5 Dol	30% FA	0.25	45
20	6.7 Gr	50% FA	0.25	50
21	6.7 Gr	30% GGBS	0.25	35
22	6.7 Gr	50% GGBS	0.25	45
23	13.2 Gr	50% GGBS	0.25	30
24	6.7 Sh	50% GGBS	0.25	90
25	9.5 Dol	50% GGBS	0.25	40
26	6.7 Gr	CEM V	0.25	40
SMix1	9.5Gr	CEM I 52.5N	0.25	
SMix2	9.5Gr	CEM I 52.5N	0.30	
SMix3	9.5Gr	CEM I 52.5N	0.35	
SMix4	9.5Gr	CEM I 52.5N	0.40	

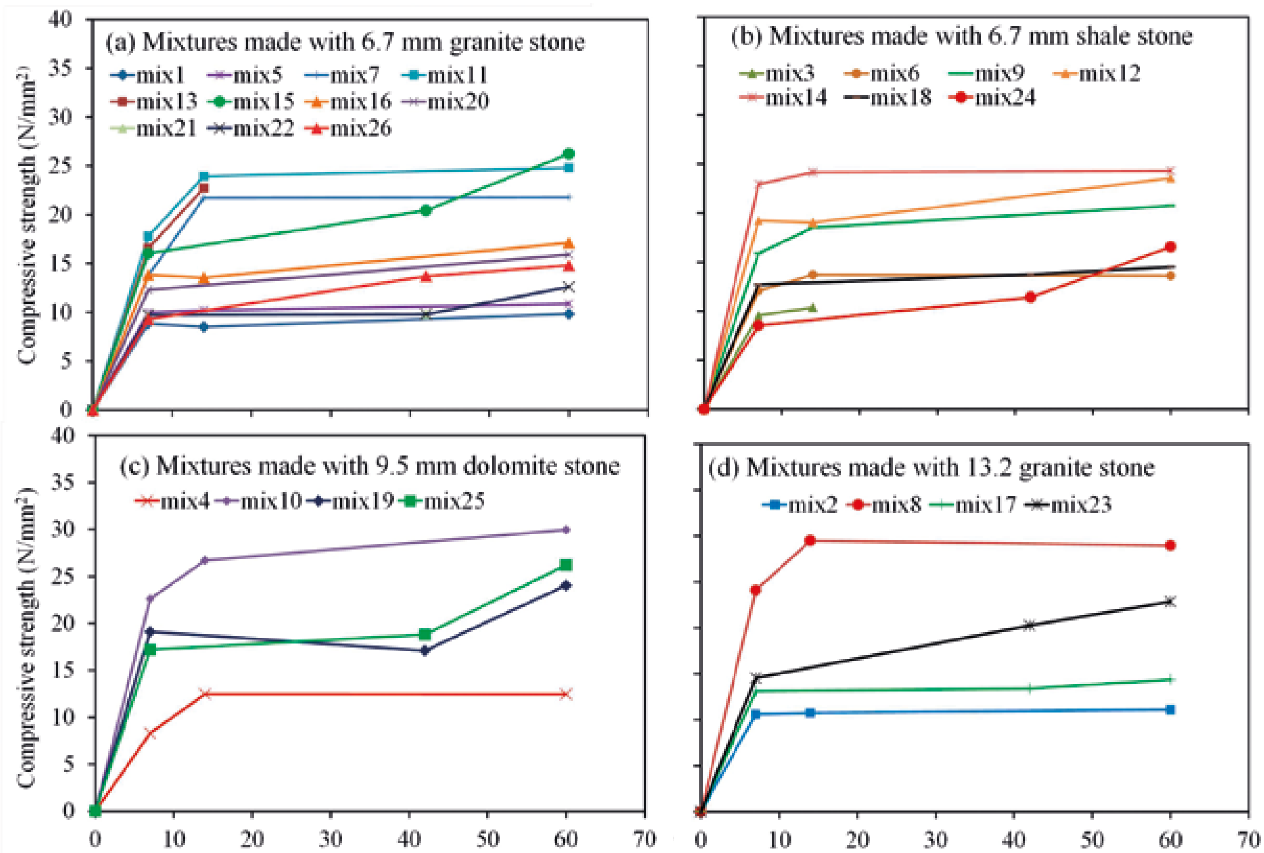

Figure 1a-d: Compressive strength gain in pervious concrete mixtures

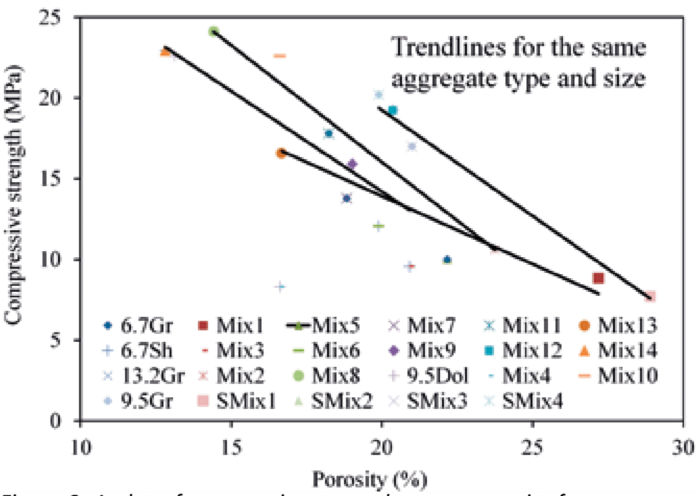

Figure 2: A plot of compressive strength versus porosity for aggregates of different types and sizes

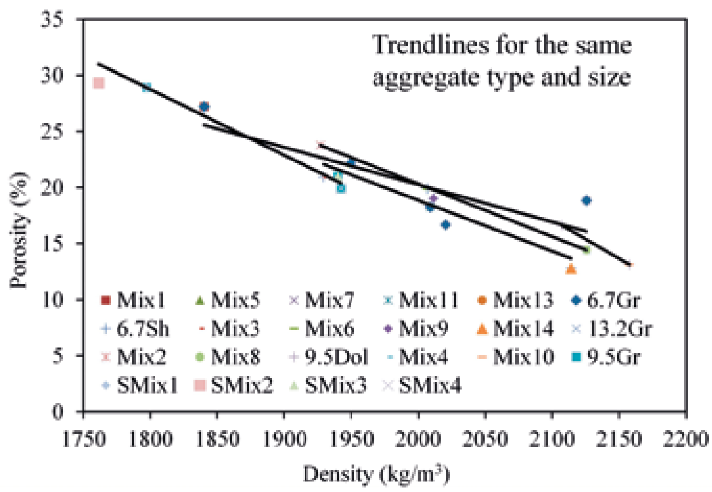

Figure 3: Plot of porosity versus density of pervious concrete mixtures for different aggregate types and sizes

- Three aggregate types of varied sizes were used comprising 6.7, 9.5, 13.2 mm granite; 6.7 mm shale, 9.5 mm dolomite. In all cases, single sized commercially available aggregates, satisfying the requirements of SANS 1083 [11] were used. They consisted of: (1) 6.7 mm single size stone with gradation of 100% passing sieve size 9.5 mm and 100% retained on 6.7 mm sieve, (2) 9.5 mm single size stone with gradation of 100% passing sieve size 13.2 mm and 100% retained on 9.5 mm sieve, and (3) 13.2 mm single size stone with gradation of 100% passing sieve size 19 mm and 100% retained on 13.2 mm sieve. The pervious concrete mixes were designed as 'no fines' mixtures [12]. Accordingly, fine aggregates were not used in mixes.

The w/cm ratios of the mixtures were varied from 0.25 to 0.40, while a cementitious content = 360 kg/m^3 and aggregate/cement ratio = 4.0 were maintained constant for all mixtures. It was found necessary to use a superplasticizer in all mixtures in order to achieve desirable workability. Table 1 gives the range of mixture variables used in the experiment.

2.2 Test Methods

A total of 30 mixtures were prepared. In each mix, twelve 100 mm cubes were cast and used for the various tests viz:- compressive strength tests at 7, 14, 42 and 60 days; density, porosity and permeability.

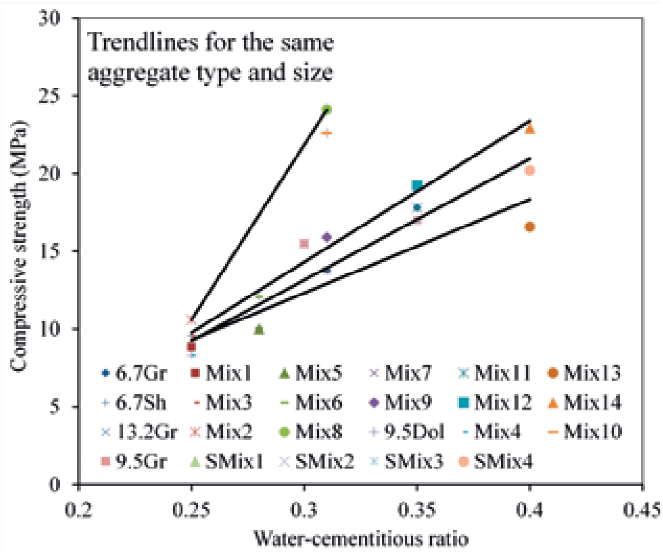

Figure 4: A plot of compressive strength versus water-cementitious ratio for different aggregate types and sizes

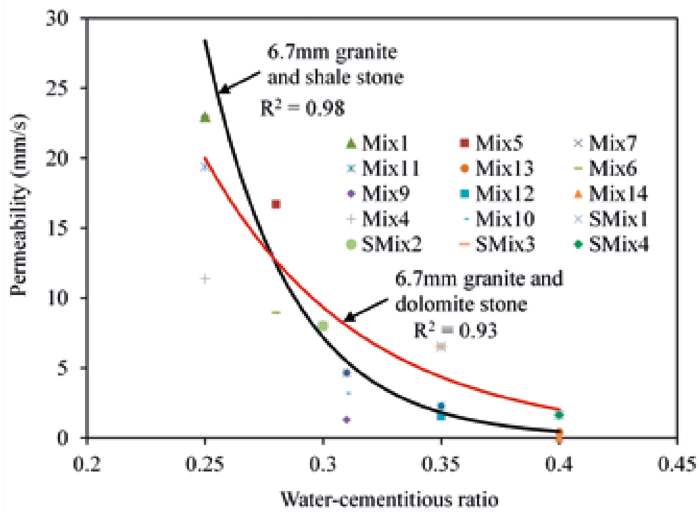

Figure 6: A plot of permeability against water-cementitious ratio for different aggregate types and sizes

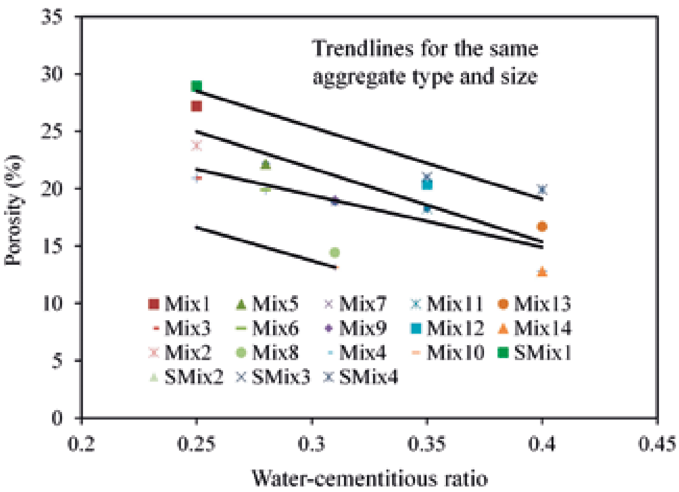

Figure 5: Plot of porosity versus the water-cementitious ratio for different aggregate types and sizes

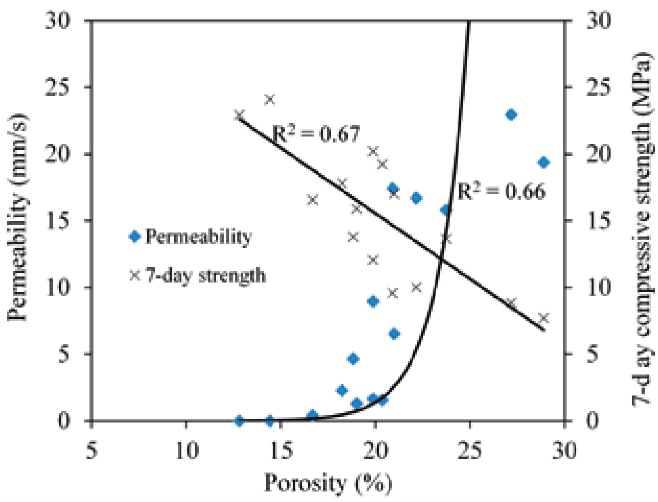

Figure 7: A dual plot of permeability and compressive strength versus porosity for various aggregate types and concrete mixtures

During casting of the cube samples, concrete was placed in moulds in two layers, each layer being rodded 10 times. The concrete-filled moulds were then placed on a vibrating table and vibrated for about 5 seconds to improve compaction and uniformity before finishing by trowelling. The cast samples were then covered with a plastic sheet for 24 hours, demoulded and stored under water at room temperature until the prescribed time periods of testing. Measurement of the density and porosity of fresh mixtures was conducted in accordance with ASTM C 1688 [13]. As prescribed by the test method, a cylindrical container 250 mm diameter x 200 mm height was filled with compacted concrete and weighed. Density was determined as the ratio of net weight of compacted concrete to volume of the container. Porosity or void content was determined as the percentage difference between theoretical density and density, the former being the total weight of all mix ingredients divided by their total absolute volume [13].

Water permeability was tested using drilled cores from cube samples. Tests were conducted after a 28-day curing period. The cores were 68 mm in diameter and 100 mm long. A falling head permeameter was constructed to test the specimens. The permeameter consisted of a 500 mm plexiglass tube with an inside diameter of 72 mm. The samples were wrapped in a membrane to prevent radial seepage and were placed inside the tube attached to the stand and fitted with an O-ring to ensure a water tight seal. The time taken for the water to drain over a given height of 150 cm was measured. The test was repeated three times on each sample. All samples were saturated in water for a minimum of 48 hours prior to permeability testing. Water permeability was calculated from the expression [14]:

$$k = \frac{aL}{At} LN\left(\frac{h_1}{h_2}\right)$$

Where:

k is permeability of specimen (m/s).

a is cross-sectional area of the tube (m²).

L is thickness of specimen (m).

A is cross-sectional area of specimen (m²).

t is time taken for water to drop from h_1 to h_2 (seconds).

h_1 is the top water level (m).

h_2 is the lower water level (m).

LN is the natural logarithm

3. RESULTS

3.1 Strength Gain with Age

Strength development in the porous concrete cube samples, monitored at ages of 7, 14, 42 and 60 days, is plotted in Figure 1a-d for mixes 1 to 26 of varied aggregate sizes, cement types and extenders, and varied w/cm of 0.25 to 0.40. Results indicate that compressive strength gain mostly occurs within the first 14 days, with only a slight strength increase between 7 and 14 days. Beyond 14 days, long-term strength gain is mainly realized in mixtures containing extenders such as seen in mixes 15 to 26. It therefore suffices to use 7 or 14 days compressive strength values to assess the mechanical properties of pervious concrete.

3.2 Mechanical Properties and Physical Properties

Results show that while some relationships between concrete properties follow recognized conventional behaviour, other characteristics of pervious concrete relate in an opposite trend to established understanding of normal concrete properties. Figures 2 and 3 respectively show that compressive strength decreases with increase in porosity, while porosity decreases with increase in density. These relations are well established norms in conventional concrete. However, the observations in Figures 4 and 5 showing compressive strength increasing with increase in w/cm, and porosity correspondingly decreasing with increase in w/cm are clearly the reverse of established trends in conventional concrete. These observed trends can be attributed to improvement in workability and compaction as the w/cm increases, in turn leading to lower porosity and higher compressive strength. This reverse behavior appears to be unique to pervious concrete and these results are consistent with findings in the literature including earlier work by the present authors[3,15-17]. An interesting feature in Figure 4 is the convergence whereby aggregates of different sizes and types tend to show similar strength behavior at lower w/cm ratios down to 0.25.

3.3 Relations between Transport Properties and Mix Proportions

The main hydrological properties of pervious concrete that are of interest concerning water flow, are the porosity and permeability characteristics. The permeability of pervious concrete is found to be non-linearly related to w/cm as shown in Figures 6. Figure 7 is a combined plot showing the dual relationships of porosity against permeability and against compressive strength, also similarly reported in the literature [3]. Note that the mixes used here are limited to concretes not containing FA and GGBS extenders. This was conducted in an attempt to isolate the general pattern of behavior without involving extender materials, since these are known to significantly impact the permeability characteristics in conventional concrete. The permeability results involving extenders are presented in Figure 9.

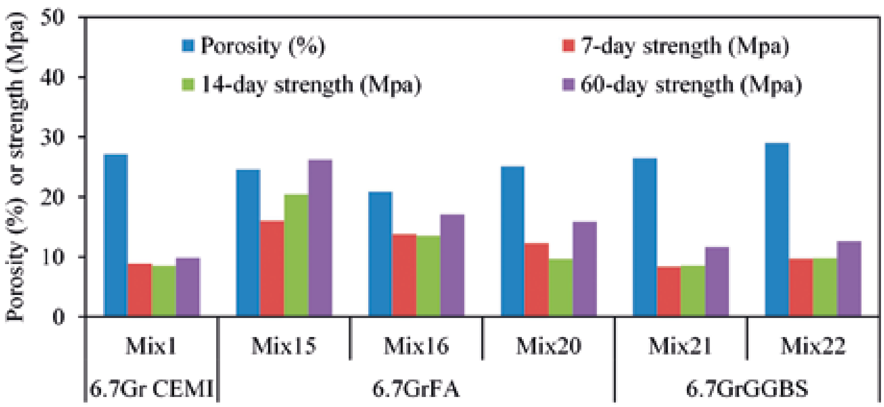

Figure 8: Influence of extenders on porosity and strength gain

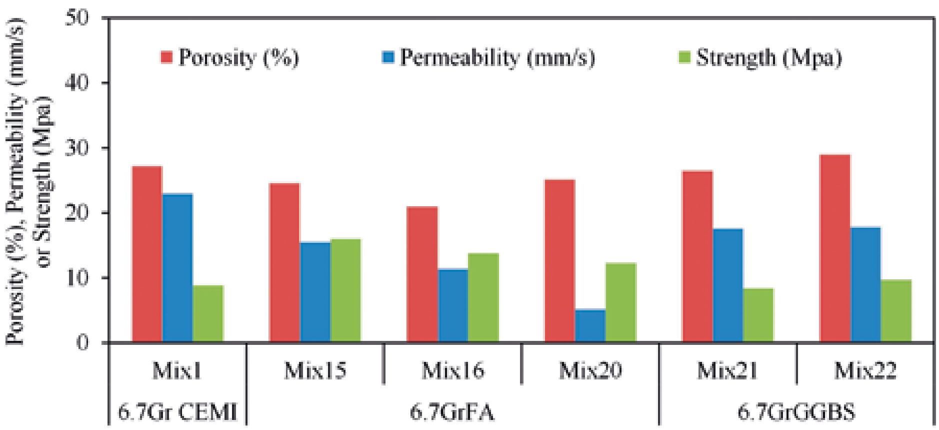

Figure 9: Comparison of compressive strength, porosity and permeability in mixes containing extenders

4. DISCUSSION OF RESULTS

4.1 The influence of Aggregate Types and Sizes

It may be recalled that three aggregates sizes of 6.7 mm, 9.5 mm and 13.2 mm were used in mixtures along with three aggregate types consisting of granite, shale and dolomite. Higher compressive strengths were exhibited by the higher aggregate sizes of 13.2 and 9.5 mm granite stone relative to their smaller size counterparts of 6.7 mm granite and shale types as seen in Figure 2. Shale stone generally gave lower porosities relative to its corresponding granite stone of the same size. These results are also evident in Figure 5 with porosities of the mixes decreasing in order of 9.5 mm granite > 6.7 mm granite > 6.7 mm shale stone. Over the range of w/cm = 0.25 to 0.40 used in the mixtures, the 9.5 mm granite stone gave the highest porosities of 20 to 30% (and corresponding lower densities) compared to 15 to 25% porosities for 6.7 mm granite while the 6.7 mm shale gave the lowest porosities of 13 to 21 %. For any given aggregate type, it is seen that porosities generally decrease as the aggregate size reduces. The aggregate types significantly affect porosity. In the results observed, granite aggregates give higher porosity than shale and dolomite aggregates.

It is also interesting to note in Figure 6 that granite aggregates always gave higher permeability relative to the shale aggregate. However, the relative influence of the different granite stone sizes appeared to depend on the mixture design, with mixes of w/c = 0.25 to 0.27 showing the permeability of 6.7 mm granite to be higher than that of the 9.5 mm granite stone while the reverse appears to be true for mixes of w/c = 0.27 to 0.40. Either way, the aggregate sizes of 6.7 or 9.5 mm granite stone are evidently most suited to produce appropriate permeability and porosity properties for water transport in a pervious concrete system, in comparison to the other aggregate types.

4.2 The Influence of Cement Extenders

Extenders were incorporated into concrete mixtures in proportions of 20, 30, 50%FA or 30, 50%GGBS. These particular mixes were made at a w/cm of 0.25.

4.2.1 Effect of the Extenders on Porosity and Compressive Strength

It can be seen in Figure 8 that the porosities of all the mixtures generally lay between 20 to 30% with the fly ash mixes showing slightly lower porosity values of 20 to 25%, while GGBS mixes were higher than 25% and similar to porosity of the control mix. However, the FA mixes gave generally higher strengths at all ages compared to the control or GGBS mixes. The mix 15 containing 20% FA appears to show better overall results with higher strengths and porosities relative to the mixtures containing 30 or 50%FA. The strength of the 20% FA mix is also greater than strengths of the GGBS mixes. The strength gain in the 20% FA mix

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is quite steady and relatively higher than the corresponding strength increase in the other FA mixes or GGBS mixes. Infact the strength gain in the GGBS mixes between 7 days and 60 days is relatively small and subdued compared to the corresponding gains in the FA mixes 15 to 20.

4.2.2 Effect of Extenders on Permeability

The influence of FA and GGBS extenders on permeability of the pervious concrete mixes can be seen in Figure 9. It is interesting to see that the results of 30 or 50% GGBS mixes were similar to the values of the control mix with slightly higher permeability for the latter.

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However, the behavior of FA mixes was widely different with mixes containing higher proportions of the extender showing a significant decrease in permeability and strength, in proportion to the amount of the extender incorporated into the mix. The 20%, 30% and 50% FA mixes had permeability values of 15, 11 and 5 mm/s compared to about 17 mm/s for the GGBS mixes and 23 mm/s for the control mix.

5. CONCLUSIONS

In the foregone investigation, the influence of various mix proportions on the mechanical and transport properties of pervious concrete were examined. The following conclusions have been reached:

1. Pervious concrete exhibits some unique properties that contradict the relationships known in conventional concrete by exhibiting strength increase and porosity decrease as the w/cm ratio increases.
2. Permeability shows an exponential relationship with porosity. Permeability becomes continuous at porosity values exceeding 20%. On the other hand, compressive strength shows an inverse linear relationship with porosity.
3. Aggregate types and sizes significantly influence the transport properties of pervious concrete. The 9.5 mm granite stone gives higher porosities of 20 to 30% relative to the 6.7 mm granite or shale stone.
4. Concerning the permeability and porosity properties, the 6.7 mm and 9.5 mm granite stone aggregates were found to produce pervious concrete mixtures of the most suitable hydrologic characteristics.
5. Incorporation of FA into the mixtures in proportions of 20 to 50% leads to a corresponding decrease in strength and permeability values of the mixes. In contrast, mixes containing 30 or 50% GGBS showed only slight changes to the porosity and permeability results, and gave similar results as the control mix. Mixtures containing 20% FA, 30 or 50%GGBS appear to be the most appropriate proportions for achievement of suitable hydrologic properties.

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PMSA celebrates it's 40th anniversary

PMSA, the leading manufacturer of brick, block and paving machines on the continent, will be celebrating its 40th anniversary at Totally Concrete 2016 from 9-11 May at the Gallagher Convention Centre in Midrand.

As part of its automated brick, block and paving manufacturing equipment, PMSA also offers locally-developed automation and handling systems for large-scale brick and block plants to increase productivity and improve the end quality of the final products.

Quintin Booysen, sales and marketing manager at PMSA

"We have been building on our technology, leadership, expertise and experience in the concrete products sector for the past 40 years and have an array of options to suit all client needs without compromising on end product quality," MD Walter Ebeling comments.

An example of PMSA's ongoing product development is its new Eco range of automated handling systems, which will be officially unveiled at Totally Concrete 2016. This latest technology gives customers the option of automated handling plants at a far more affordable price compared to the more costly top-of-the-range systems. The new Eco range of handling systems includes forklift options as opposed to more conventional, but higher-cost, finger and transfer car systems.

"With the building and construction sector in particular facing pressure from reduced margins and a dearth of new products, PMSA is ideally positioned to help its customers fine-tune their existing assets in order to boost productivity and final quality," Ebeling stresses.

"We are unique in the industry in being a specialist manufacturer that is able to cover the entire business spectrum, from establishing a business to boosting the bottom line through the application of appropriate technology."

MD Walter Ebeling

PMSA will use Totally Concrete 2016 as a showcase to launch various new products, including a new range of vibrators for its entire range of brick-and-block machinery. These vibrators are subject to arduous working conditions and resultant high fatigue, which reduces the lifespan of the bearings.

"Our new vibrators, all designed and built locally, will be sealed units with a three-year lifespan, thus enabling us to offer an extended warranty on our manufacturing equipment, thereby giving our customers even greater peace of mind," Quintin Booysen, sales and marketing manager at PMSA, comments.

Booysen adds that Totally Concrete 2016 provides an important platform for PMSA, a Silver Sponsor of this flagship expo, to showcase both its technology and customised solutions for the African continent.

Co-located with African Construction, Totally Concrete 2016 is an all-encompassing cement, concrete and construction event in Africa that not only focuses on innovation, but how to achieve sufficient return on investment with existing products and customisable solutions.

The expo takes place against a background of the sub-continent requiring 40 million tonnes of new cement capacity to meet rising urbanisation and growth rates. The region's population is expected to grow from 1.1 billion people in 2013 to 2.4 billion by 2050.

About Pan Mixers South Africa (PMSA)

PMSA is a leading manufacturer of a wide range of concrete block, brick and paving machinery, turbine and counter-current pan mixers and batching plants for the concrete, refractory and ceramic industries. PMSA has been servicing the needs of local and overseas customers since 1976. PMSA brick-making machinery produces two million bricks a day in the Johannesburg area alone. ▲

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Kelibone Masiyane has been appointed new Managing Director of PPC Zimbabwe

Kelibone Masiyane has been appointed the new Managing Director of PPC Zimbabwe. His leadership of the country's executive team will be supported by new Commercial Director Iain Sheasby and new General Manager of Finance Karen Mhazo, as well as by Trust Mabaya – who will assume his role as Group Human Resources Manager in March 2016.

Following the recent re-deployment of former Managing Director of PPC Zimbabwe Njombo Lekula as the Managing Director of PPC's international operations, the country's executive team has been further strengthened through a number of new appointments. Most notable is that of former General Manager of Colleen Bawn and the Bulawayo Factory, Kelibone Masiyane, as PPC Zimbabwe's Managing Director.

"Kelibone's promotion will see him assume overall responsibility for PPC Zimbabwe's business, with his key focus our Harare factory," notes Lekula. "His extensive operational experience in the business is sure to stand him in good stead in his new role, and we are confident that his leadership will see the company work to implement its strategy effectively against the back of PPC's new group vision."

Lekula added that the complementary promotions of Iain Sheasby and Karen Mhazo to the roles of Commercial Director and General Manager of Finance respectively, and that of current Group Human Resources Manager designate Trust Mabaya in March have further strengthened the country's executive and management teams. "They are also a clear indication of the Group's succession planning strategy in action – and our ability to develop and groom internal members of PPC Zimbabwe's family to assume vital leadership roles."

"As we take the reins and engage with the ExCo and management teams already in place, we're looking forward to building the legacy of PPC Zimbabwe in our new positions," comments Masiyane. "We invite government and our customers and suppliers to continue partnering with us on this journey as we strive to bring PPC's brand promise of 'Our strength. Your vision' to life." ▲

gcp applied technologies

GRACE CONSTRUCTION & PACKAGING

W. R. Grace & Co. to separate into two independent public companies

In the first quarter of 2016, Grace Construction Products and Darex Packaging Technologies will become GCP Applied Technologies Inc. – a global leader in these industries. Their global headquarters will move from Columbia, Maryland to Cambridge, Massachusetts, USA.

W. R. Grace & Co. will continue as a leading global supplier of catalysts and materials technologies.

This separation is intended to enable both companies to grow faster, accelerate innovation and improve our service to customers by becoming more focused on our distinct market segments.

While their products, service, and delivery will not change as a result of the separation, some transactional details of their business relationship will begin to change from January, 2016, ahead of the actual legal separation. These details will differ country to country, but may include some payer information details and their legal entity name. In the coming months they will communicate with the appropriate members of their customers' teams regarding these changes.

In addition, a new blue logo and new name, GCP Applied Technologies, will be seen on promotional materials, packaging, invoices, and other transactional documents. This transition will continue over the coming months, so for some time Grace will be seen on many of their packages and some of their promotional material. When the separation is official a new website, www.gcpat.com, will have all products in the same familiar user interface. The exact timing of the separation will be determined by financial markets and other factors, and is anticipated to be in the first quarter of 2016.

As they gradually change over product labels, product datasheets and specification documents, safety data sheets, packaging documents, and promotional materials, customers can be assured that all of these documents will remain in compliance with regulations and be easy to identify.

The majority of the product names will remain the same, and for a period of time after the separation is effective, they will continue to bear the Grace name and trademark.

"We are excited about what lies ahead for our ability to serve the customers who have made our growth possible. More than ever, we will focus on the technologies and services that have contributed to the success of our customers in building many of the world's most recognised structures", says Deon van den Berg, General Manager of GCP South Africa. ▲

Quality control and traceability; the guarantee for reliable product in cement manufacturing or in other words – does a cement manufacturer really need quality control laboratories?

Concrete is the most used material on earth and the essential ingredient is cement. As the construction industry developed in level of sophistication in design and engineering, the demands placed on cement manufacturers increased.

Maggi Loubser. PPC Ltd, Group Quality Services

Today complex mix designs are used to prepare a concrete for a specific application and the client demands consistency and strength performance from the cement. In the production of cement, it is the manufacturer's task to ensure that the properties of cement are kept at a certain level, with variations as small as possible to meet the standard specifications and to comply with the demands and needs of the market. This implies that variability in material composition and processing throughout the manufacturing process must be minimised.

Cement is manufactured to the specifications of the European standard, EN 197-1 for Common cements (SANS 50197-1, SANS 50197-2). The standard covers cement types based on composition and strength classes, with specifications for performance and conformity criteria (South African Bureau of Standards, 2000; 2004; 2011).

At the beginning of the 20th century, quality control in cement production essentially consisted of $CaCO_3$ titration, litre weight determination on clinker and Blaine fineness determination of cement to control the product quality. Today the demands for consistent product quality are far higher for both the finished product and the in-process materials. The control parameters include chemical composition, chemical ratios, particle size distribution, colour, mineralogical composition and free lime content. The sample throughput rate of a modern cement production line had increased substantially with changes in technology, with shorter kiln and mill residence times and material and environmental challenges. As a consequence quality assurance systems must be developed to control the composition of all inputs to the manufacturing process and all process conditions in the manufacturing process.

Regarding management systems, all PPC factories are also ISO9001:2008 and OSHAS 18000 and ISO 14001:2004 certified. Group Laboratory Services are also ISO17025:2005 accredited, but as a company PPC is striving not just for conformity but operational excellence and in this paper the internal systems and procedures aimed at continually improving performance over the long term will be addressed.

Figure 1: PPC Products

Quality Assurance is planned and systematic activities implemented in a quality system so that quality requirements for a product or service will be fulfilled. Periodic conformance audits of the operations of the system are part of this process. QA is a managerial tool, but everyone on the team involved in developing the product is responsible for quality assurance. The system needs to be driven from the CEO down though, without management commitment, it can never succeed.

Quality Control is the observation activities or techniques used to achieve and maintain the product quality, process and service. Finding & eliminating sources of quality problems through tools & equipment so that customer's requirements are continually met. Quality control is usually the responsibility of a specific team that tests the product for defects. Validation/Software Testing is an example of QC.

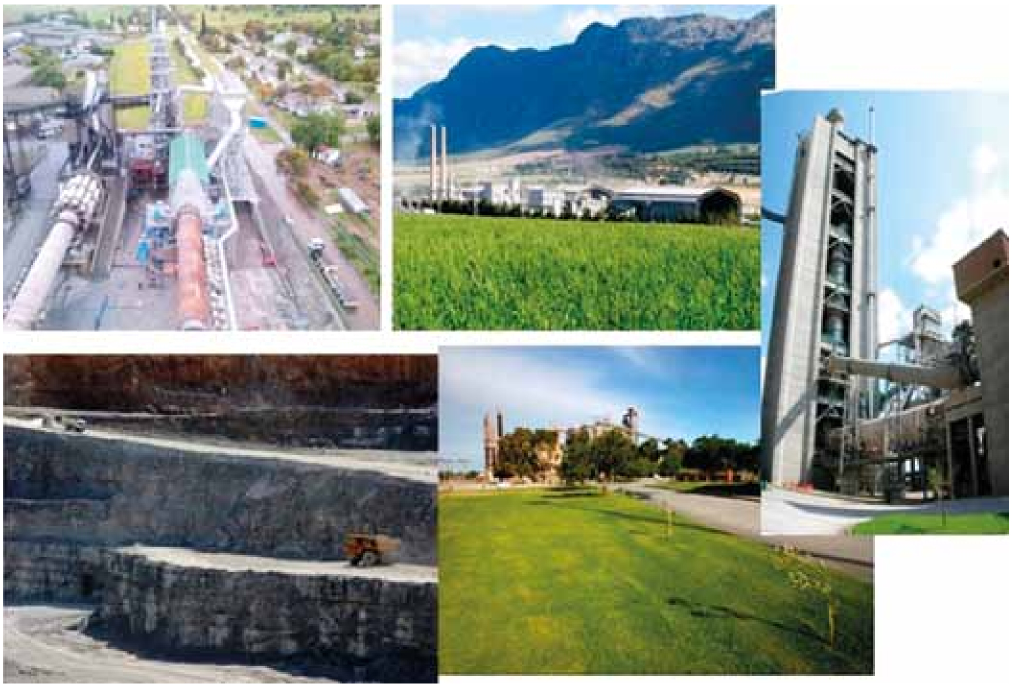
Instead of using quality control as a reactive process where products and processes are tested and action taken when these are found to be outside specifications, a pro-active approach where quality is the golden thread running throughout the entire process is the approach taken in PPC. Effective quality control ensures continually

Blaine apparatus

Litre weight determination

improving performance – but we need quality control on our test methods too and this is what will be addressed in this paper.

Every factory has its own quality control laboratory which operates on a 24/7 basis to ensure that each of these indicated steps in the manufacturing process, as well as all raw materials and product is carefully monitored. These facilities are supple-mented and supported by the Group Laboratory Services facility in Germiston, where they are ISO17025 accredited for most routine test methods, but where additional analytical capacity and research and development facilities also exist. Some of the techniques available include: Classical Wet methods, Instrumental Methods amongst which are: Colorimetric analysis, Atomic Absorption/Emission spectroscopy, X-Ray Fluorescence spectroscopy, X-Ray Powder Diffraction, Microscopy, Inductively Coupled Plasma – Mass Spectrometry, Ion Chromatography, UV-VIS Spectrophotometry, Scanning Electron Microscopy, Thermo Gravimetric Analysis, Mercury Porosimetry, Combustion techniques, Fourier Transform Infra-red spectroscopy amongst others. Physical testing includes Setting Time testing apparatus, Compressive Strength testing, Calorimeter, Rheology apparatus, Heat of Hydration Calorimeter etc.



Eleven factories, numerous quarries with QC on all parts of the process

The real value-add of a good quality system is when you have confidence in your analytical results, and can thus use the data with the assurance that process decisions made on the analytical data is of a sound base. This makes it easier to trouble shoot problems in both the laboratory and the process. It also enables data mining to optimise processes and reduce standard deviations on process controls. To do this, control systems for all your analytical methods and data needs to be in place.

X-ray Fluorescence as example

X-ray Fluorescence analysis is used as an example as it is the most used analytical technique in the cement manufacturing process. Best practises are used throughout the group regarding the calibration, validation and maintenance of XRF instruments and methods. Accurate and precise XRF analysis is crucial when a production process is monitored using mainly this technique.

Each analytical measurement in the laboratory has to be accompanied by quality control measures, for example: Running in each batch a blank sample and check samples that include an in-house standard prepared with the batch to evaluate sample preparation, as well as stability monitors analysed to evaluate the performance of the instrument. An additional type standard, of the same material as the unknown analyses, could also be included to evaluate the suitability of the calibration to specific sample matrix.

Reference materials

Quality control of an analytical method starts with the calibration of the system. Selection of reference materials is a crucial step. Within the PPC group, analytical data collected over a period of time is evaluated to ensure that the XRF calibrations cover the different analytical ranges for different elements and materials analysed in a specific factory. This has been a challenge to adhere to, due to the difficulty in obtaining suitable reference materials. Analytical data are even more crucial when the process goes out of specification, and it is in these instances that routine calibrations often do not have the range to accurately analyse the "outliers".

Commercially available certified reference materials (CRM's) are limited in number and range for cement raw materials and clinkers. Even cement reference materials do not necessarily cover the specific products produced in the group's factories. In the past, reference materials were collected and prepared for each factory individually, but this made it very difficult to obtain a decent analytical range. A cement kiln for instance is run along strict operational parameters and the product composition is thus tightly controlled making it difficult to obtain concentration ranges on the constituent elements. The same applies to raw materials where a particular limestone quarry has a specific compositional finger print.

Firstly, raw materials, intermediate products and final products were collected from all the different factories. The materials were then homogenized and split followed by homogeneity testing. Samples were then taken and prepared for duplicate XRF analysis by fused bead method against a calibration set up with CRM's.

Some samples were also outsourced to other XRF laboratories for comparative analysis along with some samples being analysed using ICP-OES. A further evaluation of data was done by preparing pressed powder pellets and setting up calibrations using the fused bead data obtained to ensure linear fit. Outliers were re-analysed. During implementation at the factories, any outliers were identified and re-analysed ensuring proper certification at the end of the process.

When calibrating the factory spectro-meters with the combined set of reference materials the necessary analytical range was obtained, and mineralogical effects due to locational differences and kiln conditions did not prove to be a major problem.

Drift correction and check samples

In a high throughput analytical environment it is very difficult to schedule instrument time to recalibrate regularly, so it is of utmost importance to have good drift correction systems to ensure long term stability. Most


State of the art Group Laboratory Services.

instrumental software packages include drift correction software to ensure long term stability and modules like Statistical Process Control (SPC) to monitor this.

Drift correction is a method to maintain constant intensity output on a spectrometer. Over time, due to X-ray tube aging, crystal and detector deterioration and possible contamination on the X-ray tube window, instrument drift occurs. This can be quite significant, and it is not feasible to re-calibrate a spectrometer regularly, especially in an industrial process control environment, thus an alternative method is needed to compensate for intensity drift. It is done by calculating a correction factor that is then applied to raw intensities to produce corrected intensities comparable to the day zero (at time of calibration) intensities. These corrected intensities are used in subsequent calculations in the data reduction process. Note: drift correction does not have any influence on the calibration curves, it adjusts raw intensities to those at the time of the original calibration.

It is important not to execute a drift correction when a serious mechanical defect is present i.e. detector failure, serious contamination on tube, etc., thus the functionality in most software programmes does not automatically apply drift correction if the drift exceeds 10%, but flag an alarm. Also, drift correction should not be applied when the decrease in intensity is due to a peak shift (can be caused by temperature of certain crystals, or goniometer problems); in such a case the problem should be addressed firstly.

The selection of drift monitor standards is important. The drift monitor standards should have polished, flat surfaces and be stable over a long period of time. Metals or glasses are preferred materials, as they can easily be cleaned; as dust or vacuum oil vapour could settle on the monitor samples with time. Pressed powder briquettes and fused beads deteriorate over time and are unsuitable. The drift monitor standards should have high enough concentration of elements of interest to ensure high intensities to eliminate unnecessary counting statistical errors, which could induce error instead of eliminating it. This is why the measurement times should be about four times your normal measurement times. The drift monitor standards do not have to be of the same matrix as the analysed samples, but it is crucial to cover the analytical range. Ideally a low point (blank) and high point monitor is used. A midpoint monitor could also be included and in these cases, a linear regression is used to calculate correction factor and slope and intercept is adjusted. Note: not related to the slope and intercept of calibration curve.

It is not advisable to measure drift monitors daily and execute corrections each time – therefore most software programmes have an option to set limits under which corrections should be executed – e.g. upper and lower limits.

A better method is having check samples/quality standards in place to monitor the instrument drift for each analytical line. Such a sample should be separate from the drift monitor standards but with similar characteristics (count rates in same range as analysed materials, stability, and flat homogenous surface). Such a sample can be measured daily, or once per shift and the data plotted in a Statistical Process Control (SPC) software with upper and lower warning and control limits. Normal SPC rules can be applied and drift monitors only measured and drift correction executed when the control sample falls outside the control limits or show a serious trend (i.e. seven consecutive measurements increasing etc.).

At time of calibration a set of drift monitors are introduced together with an instrument check sample and a preparation check sample called "sample 99" with control charts. The sample 99 is a general plant sample that is prepared from scratch once a shift and measured and plotted on a control chart – this serves to evaluate the sample preparation whereas the check sample evaluates the instrument stability. I.e. if the check sample still analyses within the control limits, but the sample 99 is out – the problem does not lie with the spectrometer but with the sample preparation equipment.

Proficiency tests

Round Robins are an extremely valuable method to evaluate an instrument's performance against other instruments in the group. This is even taken further with proficiency tests where a laboratory can measure itself against not just laboratories from all over the world, but also different analytical techniques.

Proficiency testing is a pre-requisite when a laboratory is accredited. It is good laboratory practice for any analytical facility to participate in proficiency testing schemes. The Z scores give an indication of an individual laboratory's performance and ability to analyse a specific analyte in a specific matrix measured against other laboratories and methods. This should never be seen as a "test" as such, samples should be prepared according to routine methods and results can be used to evaluate strengths and possible fields of improvement.

Routine Instrument checks

The instrument has to be maintained properly and all auxiliaries checked regularly, i.e.

- water chiller flow and temperature,
- detector gas flow and levels,
- de-ionised water flow, temperature and conductivity,

- temperature of room and instrument,
- vacuum etc.

Analytical batch checks

If everything else is in order, it is still crucial to include certain QC checks with each batch of samples, for your own and your client's piece of mind:

- Running in each batch a blank sample and check samples.
- Check samples should include an in-house standard prepared with the batch to evaluate sample preparation, as well as reference materials analysed to evaluate the performance of instrument.
- An additional type standard, of the same material as the unknown analyses, could also be included to evaluate the suitability of calibration to specific sample matrix.

Conclusion

In conclusion, when it is possible to have confidence in the data produced by a laboratory because of the internal quality control systems, it is possible to use the data effectively for quality control in a process, or quality assurance of a product. This is easy to obtain by a few common sense steps, that may look time consuming if not in place, but once implemented becomes part of the circulation of a laboratory as all quality systems should. What was indicated in this paper for XRF can be applied to any other analytical technique.

As stated in the beginning, the modern day concrete user is a sophisticated customer who develops his own mix designs, and consistency of his raw materials (cement) is crucial for his process. As example, different minor constituents in cement may react differently with concrete additives like plasticisers or retardants.

This is why Quality Control is not just conformity, it becomes part of who we are and what we do, but buy-in only comes through positive reinforcement and the result is confidence in the product leaving our gates. ▲

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A polished performance from Lafarge Readymix

Polished concrete floors have increasingly become the flooring of choice for many applications ranging from residential to high traffic retail stores.

However, it is often considered a utility option and mistakenly viewed as simply a case of polishing standard concrete. In reality, to achieve the beauty of the polished aggregate and have the benefits of minimal long-term maintenance at a lower overall cost requires a technically competent concrete mix and an experienced flooring contractor.

A supermarket floor is inherently challenging with the need to add aesthetic value to the appearance of the store, provide a smooth surface for trolleys with minimum joints, and the high requirement for durability. Any shortcomings are soon apparent and, in the case of the refurbishment of the Moreleta Park Spar floor in Pretoria, use of the concrete from the first supplier had to be abandoned. Spar's appointed contractor, concrete flooring specialists, JCE Concrete Solutions, asked Lafarge Readymix to provide a solution.

"We have the most extensive range of innovative proven concrete products, as well as excellent local and international technical support," says Lafarge Readymix's District Sales Manager for Gauteng, Carl Trollip. "We could see that the ideal product to upgrade the Spar store floor was our highly-regarded Artevia™ Polish."

At the Moreleta Park Spar, Artevia™ Polish is achieving a thin but strong, durable concrete overlay on the existing concrete floor. The product's high stone content is minimising shrinkage and the requirement for saw cut joints, while also maximising the abrasion resistance provided by the 13 mm stone. Uniform consistency is one of the product's primary features, together with its high strength of 30 MPa. As at the end of February, the contractor is still busy with the project but both he and the client are extremely pleased with the finish that is being achieved.

As the convenience store is operating during the floor refurbishment, the contractor's work has to be planned to minimise interference with the customers.

"This demanding floor project is one of those jobs where Lafarge's experience and service is proving invaluable," comments the owner of JCE Concrete Solutions, Charlie Nienaber. "Artevia™ gives very good results, while the mix workability and consistency is 100 per cent. In addition, the company's reliable deliveries contribute to the efficient working of my team. Lafarge gives us on-site help and makes sure that their laboratory people are also on hand. Over the seventeen years I have worked with Lafarge on a variety of projects, I have come to know that their products and great technical support can always be relied on to see any concrete project through to a successful quality outcome."

About LafargeHolcim

With a well-balanced presence in 90 countries and a focus on Cement, Aggregates and Concrete, LafargeHolcim (SIX Swiss Exchange, Euronext Paris: LHN) is the world leader in the building materials industry. The Group has 115,000 employees around the world and combined net sales of CHF 33 billion (EUR 27 billion) in 2014. LafargeHolcim is the industry benchmark in R&D and serves from the individual homebuilder to the largest and most complex project with the widest range of value-adding products, innovative services and comprehensive building solutions. With a 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.

About Lafarge South Africa

Lafarge South Africa, a member of the LafargeHolcim group, manufactures and supplies cement, aggregates, ready-mixed concrete, and fly ash products through its various business units. It focuses on providing solutions to help the sustainable development of better cities that benefit the country's people. Through having a strong presence in all of its business lines, it is in a unique position to contribute to urban construction, while also helping to build better cities, rural towns and villages. For further information, visit our website on: www.lafarge.co.za ▲

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ARTEVIA™ DECORATIVE CONCRETES

Aesthetically pleasing, strong and durable, Lafarge Artevia™ is an extensive range of decorative concretes for indoor or outdoor use. They eliminate the need for expensive floor coverings by producing a strong structural concrete floor in a wide choice of colours and textures. The range includes Artevia™ Polish, which produces smooth, marble-like finishes that are durable and slip-resistant; Artevia™ Colour with an integral UV stable colour pigment; Artevia™ Exposed, which has the aggregates exposed during the finishing process, resulting in a robust, slip-resistant finish; and Artevia™ Stone with the look and feel of natural stone.


Métier

10 reasons to specify readymix concrete

South Africa's readymix concrete manufacturing industry is among the best in the world with well established manufacturing and delivery infrastructure, supported by a strong industry association that regulates and guides the industry to uphold international standards.

Despite the good work being done by the industry, more than two-thirds of all construction projects in the country are still completed using unsophisticated and potentially unreliable site-mixed concrete. Johan van Wyk, general manager of the Southern Africa Readymix Association suggests that the main reason for this is rooted in contractors sticking to tradition and making concrete the 'good old fashioned' way.

Also, the price paid over the counter for cement, sand and stones is at face-value cheaper than ordering readymix concrete. But Johan says there are many misconceptions about readymix concrete and offers 10 compelling reasons why readymix concrete could be used on 90% of projects.

1. Convenience

Nothing beats the convenience of ordering concrete that is manufactured exactly to your specifications and delivered to your site when you want it, where you want it. What's more is it can be ordered to suit the consistency and workability you need on site to make sure the job at hand is carried out more easily and correctly.

2. Quality

Sarma accredited readymix suppliers conform to international standards pertaining to quality and road ordinance requirements. Strict management systems are put in place at each company and annual audits ensure that Sarma members comply with these requirements. This means that buyers get exactly what they ordered and that the concrete is manufactured in accordance with local and international standards every step of the way. Also, readymix plants make use of dedicated measuring and mixing equipment and use qualified concrete technicians and staff to make quality concrete.

3. Speed

On a construction site time is money! With readymix concrete preparation work can go ahead without being hindered by cumbersome and slow mixing operations. Arrangements can be made in advance and concrete dispatched where it is needed when it is needed. This means that all hands can be available on deck to pour and place concrete wherever it is required. Another benefit that cannot easily be achieved by site mixers is the delivery of multiple different types of concrete to a site at the same time for plastering, foundations, brickwork, formwork or whatever is required. No waiting.

4. Cost efficiency

Often contractors look at the price per m³ equivalent at the tills and then presume that site mixed concrete is cheaper. However, when one looks at losses as a result of damage, theft and wastage when mixing on site the calculation is not quite as clear-cut. In addition, extra labour costs are incurred for unskilled and semi-skilled labourers to mix and supply the site. As a result, the costs are about equal so becomes a matter of taste and convenience.

5. Productivity

Construction companies are under pressure to produce more square metres of structure, quicker and at the lowest possible price. To do this, every person on the site needs to be productively employed every hour of the day. The use of readymix enables projects to be easily broken up into dry and wet phases where only the labour that is required is on site on any given day. That means that those who are not required can be more meaningfully used elsewhere on the project or on other projects.

6. Flexibility

You name it you can specify it. If your project requires that foundations are to be poured on one side of the site, while plastering is being done elsewhere and bricks and mortar somewhere else, it can be achieved no problem. With readymix you have endless choices and can even specify designer mixes for any application including architectural concrete, high strength quick setting concrete or almost anything else that you need. You set the specification, arrange a time and place and choose a method of delivery whenever suits you.

7. Risk

Using readymix from a reputable Sarma accredited supplier allows you to transfer the risk of failure from you to the readymix supplier. In the event of concrete failing (cracking, crumbling or not reaching required strengths) the project owner or engineer may test the concrete to determine the cause of the failure. In the event of it being as a result of the concrete supplied not meeting the required specification then the readymix supplier can be held liable and responsible for the removal and replacement of concrete to the correct specification. Failure of site mixed concrete will be for the contractors own account.

8. Insurance

Sarma members have access to tailored liability insurance in the event that properly manufactured concrete fails. The insurance covers the removal and replacement of the concrete in a timeous manner in order to prevent unnecessary interruption of work on site. This means that in the event of unforeseen circumstances the concrete will still be replaced if it was correctly specified and manufactured accordingly - but still fails. Members also have access to insurance to cover their trucks and operations which limits their risks and contributes to more cost effective operations.

9. Site cleanliness

A clean site is a productive site. With the use of readymix it is entirely possible to run a clean site that is free of concrete waste, sand and stone. Provided the concrete is effectively transported on site there is no reason for concrete to land up anywhere other than where it is intended to be used. A clean site is safer as there are less obstacles and no unnecessary mixing equipment and tools lying around on site. Remediation of a building site where concrete has been mixed on the premises is considerably more expensive to cleanup compared with sites that use readymix.

10. Sustainability

Apart from well documented environmental benefits of concrete as a building material, there are a number of other benefits for using readymix. Sarma members have to comply with strict international standards relating to safety, health, environment and road transport. This means that that workers in the plants are well looked after, the environment is not damaged unnecessarily, quality is consistent with specifications and that vehicles are properly maintained and drivers trained (and regularly tested) to ensure their competence. The plants also create long-term jobs which in turn translate to uplifting communities in which they operate. ▲

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Chryso appointed Adfil Construction Fibre distributor in Africa

In a considered move, and one which underpins the strength of Chryso Southern Africa's position on the African continent, the Adfil Construction Fibre division of the UK-based Low & Bonar Group has announced it is partnering with this leading supplier as a vehicle for the growth for its fibre business into Africa.

"Many countries in Africa have huge infrastructure programmes to build roads, water systems and power stations to meet the demands of the world's second most populous continent. Adfil recognises the growth opportunities and chose Chryso as its preferred partner with the view to increasing our fibre market share in Africa," Mark Mitchell, technical sales manager for Adfil Fibres, UK explains. Adfil has almost three decades of experience in the development, production and distribution of fibres in over 60 countries.

Adfil will also be doing a lot of development work with a South African company called Oxyfibre – who has treated and supplied fibres to Chryso Southern Africa for nearly 20 years. Oxyfibre has developed patented surface technologies and nano technologies for polypropylene fibres, thereby offering the construction and mining markets bespoke fibre solutions for every application.

Oxyfibre and Chryso will also be able to utilise a design service offered by Adfil for concrete slabs and precast concrete elements. This programme looks at certain parameters specified by engineers and fibre dosages for cost effective and optimum performances.

"Fibre reinforced concrete is increasingly specified by engineers. There are an expanding number of project references, case studies and test results that engineers can consult proving that the use of fibres in concrete can create cost savings, good performance results, safety benefits and a reduced carbon footprint. However, it is important that concrete is designed to accommodate fibres and this brings in Chryso's much needed admixtures and technical expertise with regards to concrete mix design," Mitchell adds.

From left; Mark Mitchell, Adfil UK technical sales manager, and Izak Louw, operations manager of Oxyfibre.

Chryso Southern Africa's Hannes Engelbrecht, general manager: marketing and inland sales, believes that distributing Adfil fibres will bring significant benefits to the company's customers. "Initially Chryso will distribute Adfil's micro fibres and then roll out their macro fibres as well as a concrete slab design programme in the next few months. We believe that Chryso now has a fibre solution that no other admixture company can offer. Both Chryso and Adfil are respected brands synonymous with quality and Adfil will provide technical backing and resources to support our customers with any fibre related requirements. We have already supplied technical fibre training to our own sales staff as well as a few of our customers," he says.

Part of the performance materials company, Low and Bonar PLC, Adfil Construction Fibres has access to and draws from many areas of expertise, including concrete technology, design, production, quality engineering, logistics as well as health and safety. ▲

Contact: Kirsten Kelly, Chryso Southern Africa (Pty) ltd, Tel : +27 11 395 9700, E-mail: kirsten@chrysosa.co.za www.chryso.com

Chryso conducts short course on admixtures and concrete rheology

Dr Pascal Boustingorry, the Interface Physical Chemistry team manager at Chryso France, recently visited South Africa to give a short course on the 'Effect of Admixtures on Concrete Rheology'. This was part of a two day programme put together by the South African Society of Rheology (SASOR) and the Cape Peninsula University of Technology.

"I focussed on superplasticisers as these admixtures have the greatest effect on concrete rheology. It is extremely important to realise that one superplasticiser will not suit every type of concrete application and every type of cement. This is the reason why Chryso has such a large range of superplasticisers, as each superplasticiser is specifically designed to achieve a maximum performance with a certain type of cement chemistry. Chryso has the ability to manufacture and design polymers (the building blocks for admixtures) that can achieve targeted performances and can be modified to suit certain conditions," explains Boustingorry.

A key figure at Chryso France's international research and development in Sermaises, Boustingorry focuses on how the interaction between molecules and cement affects the performance of admixtures. "Chryso is a global company, with 20 subsidiaries and a presence in over 70 countries. It is therefore important to acknowledge that people do not work with concrete in the same way in every country and each country faces a different set of technical challenges with regard to concrete. Therefore, the same admixture will not work everywhere," he says.

Looking at trends, Boustingorry has noticed that customer requirements with regard to concrete are increasing: "Traditionally, customers were only concerned with water retention, workability retention and strength. Today, customers are demanding greater performance and a lot more properties from concrete. For instance, they want concrete to flow in a certain way and they are looking at finishability. This ties in with concrete rheology." ▲

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Echo slabs used for Stanger Hospital extension

Echo Durban's prestressed hollow-core slabs have been used for the construction of one of two additional storeys, each measuring 1 230 m², at Stanger Hospital in KwaZulu- Natal.

The additional space is being used to house a new maternity section and the prime reason for using prestressed slabs was that the existing suspend roof was not designed to carry the weight of a new in-situ slab. To strengthen it would have necessitated back propping, either through the elaborate staging of existing load-bearing walls or through the installation of temporary beams at floor level.

Neither of these options were feasible as the wards below were fully functional and occupied by patients. Prestressed slabs, which are 30% lighter and provide favourable span to depth ratios, provided an alternative solution which allowed normal hospital activities to continue uninterrupted during construction.

The first floor section, which houses an NVD anti-natal ward, was constructed on existing suspended roof. It was the floor above it, which accommodates a post-caesar and gynaecology ward, which was constructed with Echo's hollow-core slabs.

At 150 mm and 200 mm deep, the slabs were erected using steel cellular beams and in-situ beams. Support for some of the new beams and slabs had to be created by bolting steel sections to concrete columns.

Echo Group marketing director, Melinda Esterhuizen, says the prestressed slab option offered other advantages. "Slab installation takes hours as opposed to the weeks it takes to construct in-situ flooring. Secondly, and most importantly for a hospital environment, there is far less attendant noise to disturb and upset the patients during construction." ▲

Contact: Melinda Esterhuizen (011) 589 8800, David Beer (011) 478 0239 or 082 880 6726

Risks from off-site manufacture and hybrid construction

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.

The works under investigation comprised a circular shaft 20 m in diameter and 20 m deep, which required an L-shaped shelf or balcony some 5 m from the top.

The balcony is just under 4 m wide at its widest point and has a chord shape in plan, being against the shaft wall on one side, and in free air on the other. Its overall length is around 16 m. It should be noted that the plan shape and location do not cause the balcony to be trapped by its geometry, should it begin to move away from the shaft wall. The shaft wall is built from pre-cast shaft lining units of standard design, with the exception that certain of the units feature a corbel, onto which the balcony is placed. The main structure of the balcony itself is constructed from 3 pre-cast planks, the first being of a chord shape to fit against the shaft wall, the second being rectilinear but with bevelled ends and the third, the edge-most unit, being L-shaped, again with bevelled ends. The purpose of the concrete construction is to provide a Combined Sewer Overflow. In normal circumstances, water is to flow across the balcony and be contained by the it's upstand. At periods of high flow, water is to build up on the balcony (the in-flow pipe being larger in diameter than the outflow pipe) until it weirs over the upstand into the shaft, which serves as a storage tank. In-situ concrete was used to provide headwalls for the in-flow and out-flow pipes. The headwalls are in fact large blocks of concrete, each approximately 2,500 mm long and 1,650 mm high. They were built using the balcony upstand to contain the concrete. During concreting, the upstand of the L-shaped pre-cast beam therefore acted as a 'shutter' and, owing to the geometry, had on it the same horizontal force as would a shutter giving a force of around 220 kN. It had been assumed that the weight of the L-shaped pre-cast unit, 460 kN, plus the weight of the in-situ concrete itself (around 190 kN) was sufficient to ensure enough friction between the beam ends and the corbel to allow the in-situ concrete to be contained without any need for the beam to be fixed in place. This proved not to be the case and the edge-most unit slid towards the corbel's edge, but did not quite fall off. It should be noted that, as the pre-cast units are parts of the permanent works, the temporary state was not identified as Temporary Works and so the management procedures of BS5975 were not applied. In fact, no calculations at all were made in relation to the temporary condition of the permanent works.

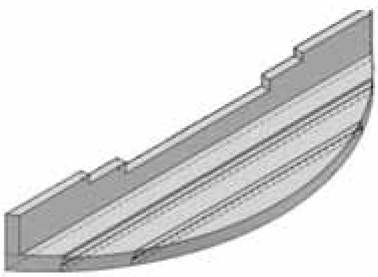


Fig 1: Isometric view of balcony slab

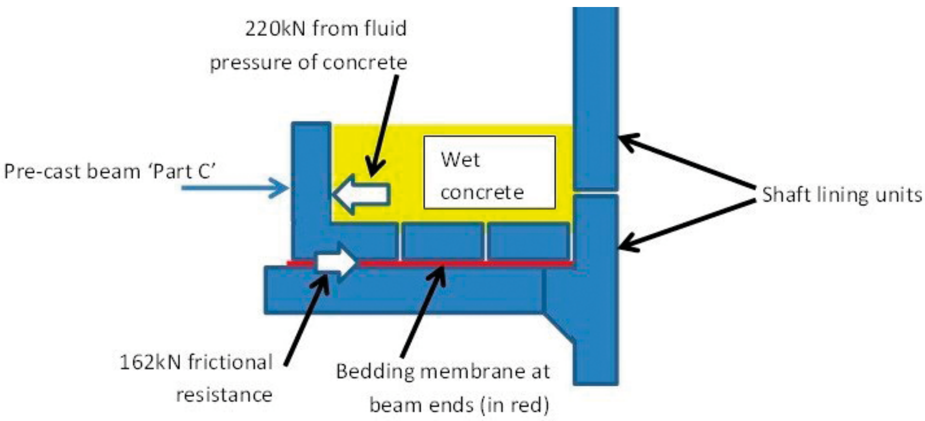


Fig 2: Diagram illustrating the forces acting on the 'Part C' upstand beam during the temporary condition of placing wet concrete The reporter asks the industry to be mindful on the following points. While they are drawn from this case specifically, they often apply in all cases where off-site manufacture or hybrid construction are used.

- In developing the design, be clear about who is responsible for what aspects of the design and for what phase of the assets lifecycle. In this case The Principal Contractor was a JV with a design consultant as a member of the JV. It was assumed that this member of the JV would be responsible for all issues associated with the permanent works design. Any such assumption needs to be made explicit as typical JV arrangements will not review matters such as this and all parties will be jointly and severally liable.
- Aspects of the design and pre-cast erection methodology were sub-let to the pre-cast supplier. While responsibility for the detailing of the elements was clear enough, the responsibility for ensuring that the elements were able to fulfil temporary works, temporary condition and permanent works roles needed to be clearer. Sub-let contractors design portions need coordination, and both the Principal Contractor and the Lead Designer (under CDM2015, the Principal Designer) have responsibilities.
- Principal Contractors should refresh their memories that they are expected to co-ordinate all temporary works and construction methodology to ensure the safety and welfare of all on and adjacent the site; the role of the Temporary Works Coordinator is clear: it is to coordinate the work of all who have an influence on the temporary works irrespective of commercial boundaries. The involvement of sub-contractors does not detract from this duty; if anything the involvement of sub-contractors enhances it.
- Notwithstanding explicit design responsibilities, design management processes need to involve cross-checking (is what

we are assuming to be happening, actually happening?) and double-checking (is what I am told to be correct, actually correct?)

- The edge-most pre-cast beam weighed 460kN and the weight of concrete it supported was around 190 kN. While it might seem natural that these weights are sufficient to provide the necessary friction, this was not the case. The matter at hand concerns pressures not weights, the active pressure pushing the edge-most unit being around 220 kN, and the frictional resistance being around 162 kN. The frictional resistance would have been somewhat reduced by the bedding membrane. The industry is asked to be very careful when making assumptions concerning the adequacy of concrete (or other dead weights) to resist loads by friction: the structural forces and frictional behaviour must be fully understood and worked out, and a high factor of safety (at least 2) allowed for friction. (It is noted that even a concrete-to-concrete bearing, with a coefficient of friction of say 0.4, would have given too low a frictional resistance for a full fos).
- The bedding membrane was introduced during construction in the spirit it being 'industry good practice' to place a membrane between heavily loaded pre-cast units. The construction team did not appreciate the criticality of the reduction of friction this would cause.
- It is noteworthy that the permanent works designer was not sufficiently au fait with pre-cast detailing to include a bedding detail, or, knowing that it is common practice to have one but actively not want one, to specifically exclude it. The importance of designers being familiar with the craft, or site, aspects of what they are designing is again emphasised, as is the importance of the site team building to the design details or, if they think they should be changed, raising this matter formally.
- This being an industrial structure, it was not tied, as would been the case for a residential or building structure. Tying would (i) probably have given the restraint needed in the temporary condition (ii) be good practice for the permanent works in any case. Designers are asked to give thought to robustness of all structures.
- It should perhaps be noted that the shaft is sited under a public carpark; in the long term a failure of the landing slab could have knocked out the columns supporting the roof slab which in turn could have brought down the roof; a gapping 20 m diameter by 20 m deep hole suddenly appearing in such a location certainly has the potential to be a catastrophic structural failure. Such consequences should be considered when determining the level of robustness required. ▲

COMMENTS

It is a useful reminder of the dangers stemming from divided responsibility which also shows the need to appreciate basic engineering principles. The recommendations from the reporter are most sensible and, as he says, there are several lessons to be learned.

To reinforce the points:

- Sub-letting can easily introduce risk in its own right and is often done for commercial reasons without realising the need for technical input to ensure 'interface issues' are covered.
- When sub-letting any element of the works, design responsibility for each of the various elements should be made clear, for example, via a Design Responsibility Matrix.
- The increasing use of precast concrete hybrid superstructures adds further complexities to design and detailing responsibilities.
- Temporary Works Co-ordinators may reflect best practice but are generally not a legal requirement. The requirement for a Principal Designer under CDM 2015 is, however, mandatory for qualifying projects, and this includes responsibilities in relation to temporary works.
- There should always be a 'lead designer' which co-ordinates the overall design, specifically from a robustness perspective. This individual, or the specific designer, would be expected to think through the means by which the components were to be used in the construction process.
- The need to have robustness and lateral restraint should be essential considerations for every structure in both the temporary and permanent conditions.

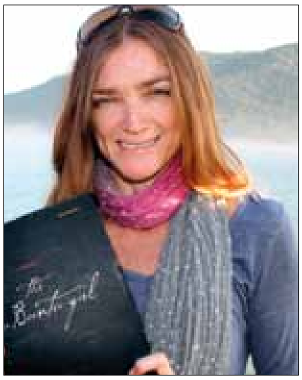
** If you found value in this material, please consider submitting issues that you have come across, such that others may, in turn, benefit from your experience. This is done through Confidential Reporting on Safety (CROSS) at www.structural-safety.co.za*

Western Cape branch activities

uBuntu – The art of giving

In December, the Western Cape Branch of the Concrete Society thoroughly enjoyed an 'event with a difference' at their annual cocktail function: Sonja Kruse, otherwise known as the uBuntu Girl, shared her stories of her year-long, solo trip, walking and hitchhiking around South-Africa.

Sonja set out with little more than a backpack, camera and a R100 experiencing the generosity of 150 families and proving the spirit of uBuntu in South Africa is alive. She did this without a back-up team, tent or bank cards and without pre-planning the route.



It was to be a journey of discovery – discovery of the sincere hospitality offered by complete strangers and the uncovering of her own fears, apprehensions, preconceived ideas and, finally, changing perceptions. She left without a tent, sleeping bag or bank cards. Instead she carried a deep belief that she is, because of others.

She stayed in affluent suburbs and dusty townships, in shacks and in mansions. She met pensioners, school children and students, farmers and labourers, rich businessmen, poor widows, artists, housewives, truckers and curio sellers.

I think we can safely say that everyone in the room was enthralled by her stories, and a fantastic evening was had by all members. Sonja is the author of 'The uBuntu Girl' – a book about this epic journey. She also facilitates reading & writing workshops with FunDza Literacy Trust.

Committee dinner

The Western Cape Committee enjoyed a dinner together to celebrate a successful 2015 at the Italian Club in Cape Town – here are the members who have worked very hard to make our branch events worthwhile and interesting. Left to Right: Philemon Arito, Mfundo Taliwe, Adrienne Taylor, Jan Ellis (Chair) and Ken Newton.

Half-day workshop

The WC Branch joined forces with the University of Cape Town and CoMSIRU to host a half-day technical workshop on Binders and Admixtures for concrete. We were fortunate to have the expertise

"uBuntu is the essence of being human. It speaks of the fact that my humanity is caught up and is inextricably bound up in yours. I am human because I belong. It speaks about wholeness; it speaks about compassion. A person with uBuntu is welcoming, hospitable, warm and generous, willing to share. Such people are open and available to to others, willing to be vulnerable, affirming of others, do not feel threatened that others are able and good, for they have a proper self-assurance that comes from knowing that they belong in a greater whole. They know that they are diminished when others are humiliated, diminished when others are oppressed, diminished when they are treated as if they were less than who they are. The quality of uBuntu gives people resilience, enabling them to survive and emerge still human, despite all the efforts to dehumanize them"

Desmond Tutu

of Professor Pierre-Claude Aitcïn who is Professor Emeritus of the University of Sherbrooke, Quebec, Canada.

In addition to this, our two local presenters, Steve Crosswell from PPC Cement Cape Town and Mike McDonald, AfriSam shared their views. Special thanks to Professor Mark Alexander for helping us in putting this event together and for the wonderful venue at UCT.

Upcoming events

We are looking forward to an action packed 2016. Please mark your diaries for our AGM to be held on 17 March and our Golf Day on 7 April. Until then! Jan Ellis – Branch Chair ▲

Blue Valley Golf Estate

Inland Branch Chairman's breakfast 2015

More than 130 members and their guests attended last year's annual Chairman's Breakfast and Awards function, held at the Blue Valley Golf Estate in Midrand. This popular event provided an opportunity for the Branch Chair to review the year's activities, announce annual awards for excellence in concrete, and network with local members.

Proceedings were opened with a welcome from the Branch Vice-Chairman, Johan van Wyk, acting as master of ceremonies for the function. Chairman of the Inland Branch, Roelof Jacobs, then presented his report for the year covering the many successful activities that had been run in the region.

Roelof thanked members of the Inland Branch committee for their support and hard work over the year. He also thanked the Head Office staff: John Sheath - CEO, Natasja Pols - Administrator and Marike van Wyk - Membership & Events Coordinator, for their ongoing support of the Branch.

Special mention was made of AfriSam, who were not only the main sponsors of the breakfast function but who had also generously sponsored Academic Institution membership of the Concrete Society for 2015, which had included local universities – WITS, University of Pretoria and the University of Johannesburg. Appreciation of the ongoing support of the Society by the many Company Members of the organisation was also acknowledged.

The Undergraduate Research Achiever competition was a new initiative this year and the three finalists were present at the function. Roelof announced the winner of the competition, as well as the runner up and third place students:

There were:
Christiaan Swanepoel, University of Pretoria - Winner
Ilsaac Kamya, University of Pretoria - Runner Up
Sibusiso Mabunda, University of Johannesburg - Third place

The Chairman announced the winner of the Concrete Achiever Award for 2015 as George Evans from PPC. He described George as very passionate about concrete who understood its properties extremely well. "Words that come to mind when thinking about him, include - dedicated; honest; professional; committed, and an exceptional problem-solver. "I believe", Roelof continued, "that this award should not be just for the Inland Branch, but an honorable commendation for his contribution to the whole industry".

Proceedings continued with the announcement of the winner of the Chairman's Award for 2015, which went to the project team on the Precast Coal Bunker project at Sasol Shondoni Colliery, nr. Secunda, Mpumalanga. The project team comprised:

- Logiman
- Lyonell Fliss & Associates
- Stefanutti Stocks Civils

In presenting the award to Lyonell Fliss, Krzysztof Szymczak (Logiman) and Mike Stevenson (Stefanutti Stocks Civils), Roelof praised the team for the innovative concept used on this project, namely structurally integrating pre-cast with cast-in-situ concrete at all construction phases, providing superior performance compared with traditional in-situ construction, considering the cost, time, quality, operation, maintenance and safety.

Roelof Jacobs, Branch Chairman, presents Concrete Achiever Award certificate to winner George Evans.

L to R: Lyonell Fliss, Roelof Jacobs, Mike Stevenson, Krzysztof.

Following the awards presentations, guests were treated to a very entertaining and motivational presentation by John Ingram, on defining and developing one's own (personal) brand. Each person in the audience, he said, has a common interest – concrete, but what makes them all unique are their own personal attributes, which need to be nurtured and promoted.

John used a "no-nonsense"approach to inspiring and driving the audience to greater success and creating a "want to" attitude. ▲

Professor Pierre-Claude Aïtcin addresses the Inland Branch

Some 50 members and guests of the Inland Branch were treated to presentations by Professor Pierre-Claude Aïtcin, world authority on concrete technology, innovation and construction. Pierre-Claude Aïtcin, is Professor Emeritus of the Université de Sherbrooke, Canada, known and recognized for his visionary qualities, ability to innovate and social commitment, is a role-model for the engineering profession.

During his first brief visit to South Africa Professor Aitcin visited colleagues at the University of Witwatersrand, technical staff at PPC Cement, presented at Concrete Society techincal meetings in Johannsburg and Cape Town and finally, before spending some personal time touring the country, his colleagues at the University of Cape Town.

Prof Pierre-Claude Aïtcin

Two presentations were given to the Inland Branch members entiled "The sky's the limit' and "The Science and Technology of Concrete Admixtures".

The first presentation covered the history of concrete technology for high-rise buildings during the last fifty years, when concrete technology has made great progress, largely due to the control of concrete rheology through the use of superplasticizers and viscosity modifying admixtures. Thus, concrete rheology is no longer depending only on water, but rather on a judicious balance between water, superplasticizer and viscosity modifier dosages.

Professor Aïtcin went on to say that before the 1970's, it was impossible to produce concretes having, at the same time, both a slump of 100 mm and a w/c ratio lower than 0.40, due to the limited performance of the lignosulfonate-based water reducers that were then the only dispersing admixtures available on the market.

But, as soon as the very efficient dispersing properties of polymelamine sulfonates and polynaphtalene sulfonates were discovered in Germany and Japan, respectively, it became possible to decrease the w/c ratio below 0.40 while at the same time increasing its slump up to 200 mm.

More recently, a new type of admixture, known as a viscosity modifying admixture (VMA), has been developed to control concrete rheology. VMA is now used when pumping concrete, for underwater concreting and in self-consolidating concrete.

Burj Khalifa building - Dubai

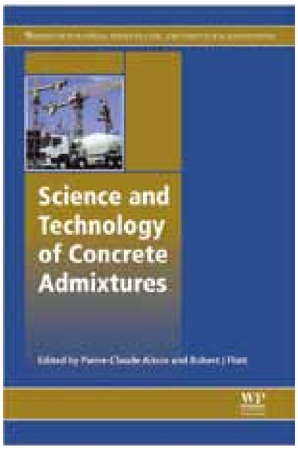
These two innovations resulted in a significant advantage for concrete over steel for the construction of high-rise buildings: it is no longer necessary to use cranes to raise and place concrete; concrete can be pumped from the first to the highest floor. Thus, concrete was pumped up to 586 metres using a single pump during the construction of Dubai's Burj Khalifa.

Professor Aïtcin predicted that in the near future, concrete pumping is expected to reach up to 1 000 metres, while steel beams and columns will still have to be raised with cranes, thus making concrete the preferred construction material for high-rise buildings

He then illustrated step by step, how the construction of high-rise buildings has evolved from entirely steel structures to entirely concrete structures, by describing the construction of some landmark structures built from 1968 to the present time.

In concluding his first presentation, Professor Aïtcin stated that due to the development of powerful dispersing admixtures and viscosity modifying admixtures, it is now possible to build very efficiently and economically high-rise concrete structures. Thanks to entrepreneurs who challenged the limits of the use of concrete, this became possible with progressive learning over the years of how to pump high strength concretes "up to the sky".

The Science and Technology of Concrete Admixtures".This presentation was based on Professor Aïtcin's book with that title.



The book presents admixtures from both a theoretical and practical point-of-view. The authors emphasize key concepts that can be used to better understand the working mechanisms of these products by presenting a concise overview on the fundamental behaviour of Portland cement and hydraulic binders as well as their chemical admixtures.

It also discusses recent effects in concrete in terms of rheology, mechanics, durability, and sustain-ability, but never forgetting the fundamental role played by the water/binder ratio and proper curing in concrete technology.

Part One presents basic knowledge on Portland cement and concrete.

Part Two deals with the chemical and physical background needed to better understand what admixtures are chemically, and through subsequent sections, presents discussions on admixtures technology and two particular types of concrete, self-consolidating and ultra-high strength concretes, with final remarks on their future.

In conclusion, Prof Aïtcin predicted that in the future the interaction between particular cements and particular superplasticizers will be more complex because:

- commercial cements will be blended cements
- alternative fuels will be used more and more
- different sources of calcium sulphate will be used

The presentations were followed by a lively question time and the Chairman of the Inland Branch, Roelof Jacobs thanked Prof Aïtcin for sparing the time to visit the branch. He also thanked PPC for their generous sponsorship of the day which made the event possible. ▲

INLAND BRANCH

DATE	MEETING/EVENT	VENUE	CONVENOR
08 April	Site Visit to Kusile Power Station project	R545, Emalahleni	Roelof Jacobs/Johan van Wyk
21 April	Technical Meeting	Polokwane	Martin Dube/Roelof Jacobs/Michelle Fick
27-29 May	Large Dam visits	Lesotho	Roelof Jacobs/Johan van Wyk
09 June	National Seminar	Premier Hotel O R Tambo, Rhodesfield	CSSA Head Office
21 June	Annual Golf Day	TBA	Johan van Wyk/Debbie Harvey
14 July	Technical Meeting – "Getting it Right"	University of Johannesburg	Roelof Jacobs/Johan van Wyk
28 July	Technical Meeting	Nelspruit	Debbie Harvey/Kim Twiname/Natalie Johnson
26 August	Egg Protection Device Competition – Cast-In		Jannes Bester/Johan van Wyk/ Kim Twiname
02 September	Egg Protection Device Competition – Cast-In	PPC Jupiter Works	Jannes Bester/Johan van Wyk/ Kim Twiname
08 September	National Seminar	Premier Hotel O R Tambo, Rhodesfield	CSSA Head Office
01 October	Annual Concrete Boat Race Day	Benoni Sailing Club, Homestead Lake, Benoni	Johan van Wyk/Michelle Fick/ Committee
October	Students' Research Papers Competition	TBA	Roelof Jacobs/Martin Dube/ Kim Twiname
18 November	Chairman's Breakfast and Annual Golf Day	TBA	Natalie/Johnson/Debbie Harvey/ Committee

**Excludes ad hoc Site Visits – to be announced later*

WESTERN CAPE

DATE	MEETING/EVENT	VENUE	CONVENOR
17 April	MTM and AGM	UCT	Adrienne Taylor westerncapecssa@gmail.com
21 April	Golf Day	Rondebosch Golf Club (TBC)	Adrienne Taylor westerncapecssa@gmail.com
26 May	Site Visit	TBA	Adrienne Taylor westerncapecssa@gmail.com
23 June	MTM	TBA	Adrienne Taylor westerncapecssa@gmail.com
27 June to 1 July	Concrete Academy	UCT	Philemon Arito ARTPHI001@myuct.ac.za
28 July	Site Visit	TBA	Adrienne Taylor westerncapecssa@gmail.com
25 August	Site Visit	TBA	Adrienne Taylor westerncapecssa@gmail.com
22 September	Site visit	TBA	
October	Cube Crushing	TBA	
November	Annual Cocktail function		
	Committee Meetings are held the first Tuesday of every month	UCT	

EASTERN CAPE

DATE	MEETING/EVENT	VENUE	CONVENOR
07 April	Committee Meeting	Concrete 4 U (109 Cape Rd)	Patrick Flannigan
05 May 2016	Golf Day	Wedgewood Country Estate	Patrick Flannigan/Fanie Smith
05 Mary 2016	Committee Meeting	Wedgewood Country Estate	Patrick Flannigan
May	Site Visit: Floor Job	To Be Confirmed	Patrick Flannigan/Fanie Smith
02 June 2016	Committee Meeting	Concrete 4 U (109 Cape Rd)	Patrick Flannigan
June 2016	MTM	To Be Confirmed	Patrick Flannigan/Fanie Smith

NATIONAL OFFICE

DATE	MEETING/EVENT	VENUE	CONVENOR
30 March	AGM 2016	Emperor's Palace, Kempton Park	CSSA President
31 March	1st Board Meeting	Emperor's Palace, Kempton Park	CSSA President
April	2016/2017 Source Book	Posted to All CSSA Members	CSSA Administration
09 – 11 May	Visit the CSSA Stand at the Totally Concrete Expo	Gallegar Estate	CSSA Adminstration
June	Concrete Beton	Posted to All CSSA Members	CSSA Administration
06 – 09 June	Seminar Road Show Topic to be Confirmed	Cape Town, Port Elizabeth, Durban, Johannesburg	Seminar Committee
23 June	2nd Board Meeting	Emperor's Palace, Kempton Park	CSSA President
September	Concrete Beton	Posted to All CSSA Members	CSSA Administration
05 – 08 September	Seminar Road Show: Topic to be Confirmed	Cape Town, Port Elizabeth, Durban, Johannesburg	Seminar Committee
20 October	3rd Board Meeting	Emperor's Palace, Kempton park	CSSA President
31 October	2017 Membership Renewals Notices	E-Mailed to All CSSA Members	CSSA Administration
November	Concrete Beton	Posted to All CSSA Members	CSSA Administration

INTERNATIONAL

DATE	MEETING/EVENT	VENUE	CONVENOR
13 – 15 June	2nd International Conference on Concrete Sustainability (ICC16)	Madrid, Spain	David Frenández-Ordóñez
28 – 31 August	11th International Conference on Concrete Pavements (ISCP)	San Antonio, Texas	Leif Wathne
29 – 31 August	The 11th fib International PhD Symposium in Civil Engineering	Tokyo, Japan	Koichi Maekawa
12 – 14 September	ConSec 2016 – 8th International Conference on Concrete Under Severe Conditions – Environment & Loading	Lecco, Italy	Laura Losapio
21 – 23 November	Fib 2016 Symposium	Cape Town, South Africa	A/Prof. Hans Beushausen

PLATINUM

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	Lafarge Industries South Africa (Pty) Ltd	Mrs Alta Theron	011-657-1025	alta.theron@lafargeholcim.com
	PPC Ltd	Mr George Evans	011-386-9273	george.evans@ppc.co.za

GOLD

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SILVER

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	Mapei SA (Pty) Ltd	Mr Christo Van Der Merwe	011-552-8476	c.vdmerwe@mapei.co.za
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BRONZE

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Concrete Testing Equipment	Mr Marius Grassman	PO Box 77110 FONTAINEBLEAU Gauteng 2032	011-708-6141	marius@cte-labsupplies.co.za
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BRONZE

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