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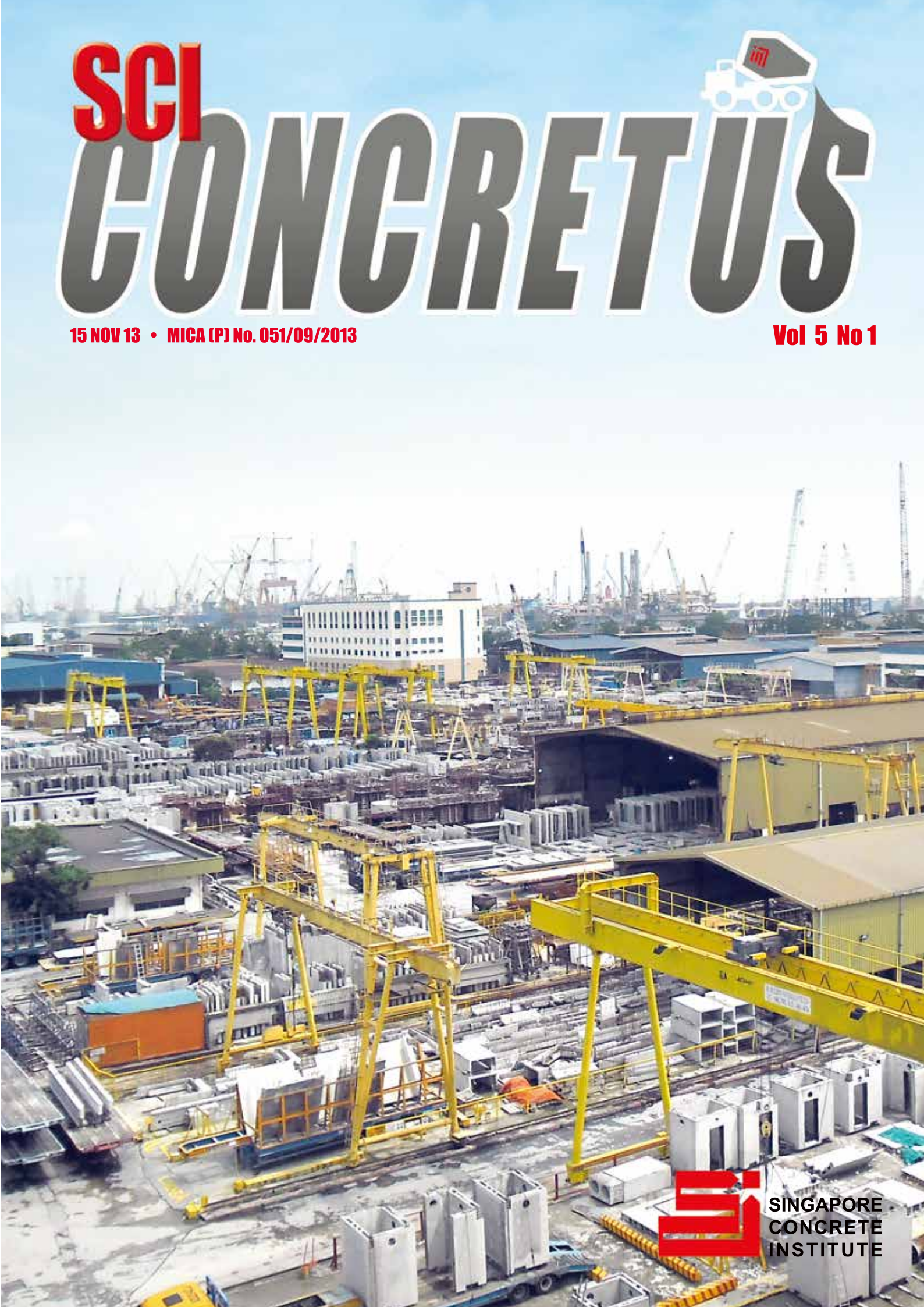

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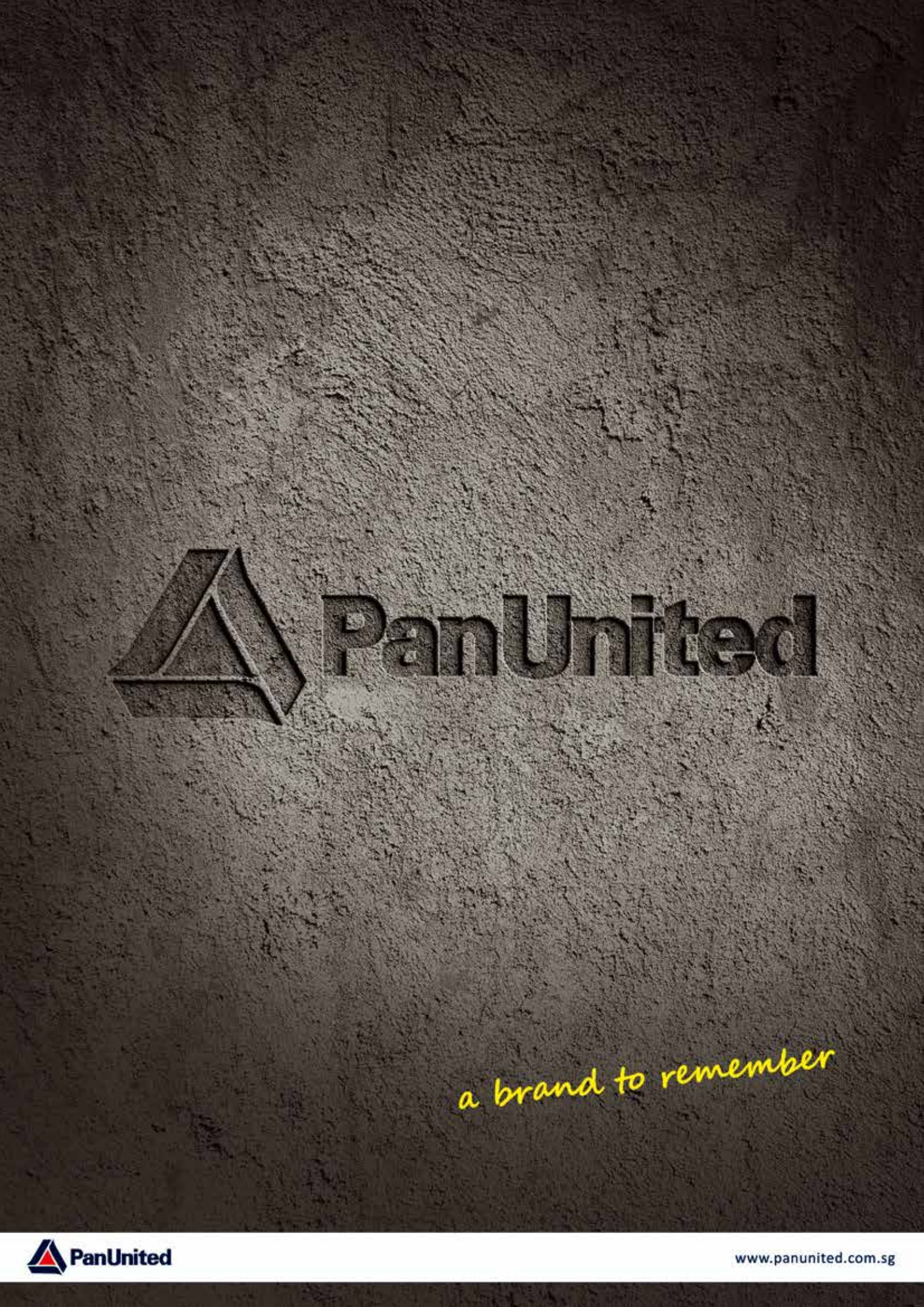
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President's Message

In conjunction with our 35th Anniversary Celebration of Singapore Concrete Institute this year, the publication of the sixth issue of the Concretus reflect importance of precast industry for sustainable construction in Singapore.

The theme of this year's celebration, "Sustainable Precast Concrete in Singapore" is to reinforce the importance of sustainable construction as well as speed and quality of construction. The concern of all stakeholders in the construction industry on the subject of precast construction is well reflected in current issue of SCI Concretus. Our readers should find these articles a timely update on the various developments to address the need for sustainable precast industry in Singapore.

This year, we have the pleasure of a special guest: DR ALFRED A. YEE a prominent engineer who has contributed much to Singapore's building and construction industry. Dr Yee has also been an advisor to HDB since the '80s where he introduced precast technology in public housing. We are privileged to have Dr Yee to deliver a speech on 'MY LIFE IN PRECAST CONCRETE".

The SCI Excellence Awards 2013 and the inaugural SCI Waterproofing Excellence Award will add to the celebration this year and assure the continuous innovation and improvement of construction quality in Singapore.

On behalf of the SCI Board of Directors, I would like to thank all our sponsors, SCI members, partners and supporters for the continuous support in providing generous financial contributions and technical knowledge towards the publication of Concretus. We look forward to your continuous support in making the Concretus a useful resource for the benefits of all our esteemed readers.

Thank you.

Er Koh Beng Thong
President

Singapore Concrete Institute
15 November 2013

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IF CONCRETE CAN SPEAK – HEALTH TESTING

Dr Tam Chat Tim
Associate Professorial Fellow
Department of Civil & Environmental Engineering
National University of Singapore

Health check is desirable for living beings, particularly at old age or when one's health is in doubt. How above health check for me, Concrete? There are many existing testing methods that can indicate my ability to perform, e.g. at my early age (fresh state), and at later age (hardened state). The types of performance include amongst others, how freely I can move (consistence), how long do I take to change from fluid to solid (setting times), how fast and strong can I become (strength development), how I respond to stress (modulus of elasticity, creep), to common environment (temperature, relative humidity) and to extreme cases (freeze-thaw, fire, chemical attack). Of course, I may also have inherent defects in my DNA (e.g. alkali-aggregate reaction) and resultant effect of higher than usual temperature (DEF). When subjected to very high stress, I can also break up into pieces or suffer fracture depending if I am hard pressed or pulled apart. When I join hands with my partner, reinforcement steel, I have to look after his health as well, otherwise he may cause me heaps of distress due to over-dose of chloride and lack of alkalinity on his health.

However, in the normal span of my intended working life, the most common concern is my compressive strength as most of my other strengths (tensile, flexure, shear, bond etc) are closely related to my ability to take compressive stress. More varied than the human beings, members of my family do not ever have identical twins, not to mention triplets or more. Even within a "concrete family" we do have our differences.

Over the years, many studies have been conducted on how best to assess my healthy in the form I have been created – a structure particularly by non-destructive approach. In addition to the many methods of measuring my structural health, including a biopsy (core test), there are also many schools of thought of how the test results are to be treated to quantify my state of health in terms, e.g. my compressive strength. One often adopted approach in Singapore is based on the guidance provided by BS 6089: 1981 [1]. No specific acceptance criterion is provided, although a reduction of the partial factor of safety adopted for me in design may be reduced from 1.5 to not less than 1.2. It is not clearly stated if the test results for my strength in the existing structure (in-situ strength) are to be considered at the level of mean value or including testing uncertainty in terms of a characteristic value on a statistical basis. The difference lies in the resultant risk associated with each value, the characteristic value being on the same basis as in design and is generally preferred.

The approach is now specified in SS EN 13791: 2009 [2]). My structural health in terms of compressive strength is now clearly stated to be the characteristic in-situ strength. It is preferably assessed from the concrete in the structure or structural element in which I exist by testing core samples (BS EN 12504-1: 2000 [3]) or by indirect tests for which a correlation is required. A minimum number of cores are still required as provided for in order to establish a reliable correlation curve by one of the two alternative methods specified. The three indirect test methods are the rebound hammer test (BS EN 20504-2: 2001 [4]), the ultrasonic pulse velocity test (BS EN 12504-4: 2004 [5]) and the pull-out test (BS EN 12504-3: 2005 [6]).

The guidance for accepting a reduction in the partial factor of safety for concrete from the design value of 1.5 to 1.2 (or other appropriate factor considered suitable in particular circumstances) given in BS 6089: 1981 is now replaced with the required ratio of 0.85 for minimum characteristic in-situ compressive strength to the characteristic strength based on standard specimens (as provided in SS EN 1992-1-1: 2008 [7]). Comparing this to the ratio of 0.80 (1.2/1.5) suggested in BS 6089: 1981 [1], it is noted that not only the ratio of 0.85 is more conservative and with a linkage to design (Annex A of SS EN 1992-1-1: 2008 [7]), but has also to be based on characteristic in-situ compressive strength. Prior to testing, I am to be exposed to a laboratory atmosphere for at least 3 days (SS EN 13791: 2009 [2]). On the other hand, BS 1881: Part 120: 1983 [8] requires that as a core, I should be soaked in water for at least 48 hours before testing in compression. When tested in air-dried condition, I can withstand 10% to 15% higher compressive stress due to the reduction of pore pressure within my pores (Annex A, SS EN 13791: 2009 [2]).

Further guidance on treatment of my structural health test results is provided in the revision of BS 6089: 2010 [9] which replaced the former BS 6089: 1981 [1]. This is now a complimentary British standard to BS EN13791: 2007 [10]. A new Singapore standard SS XXX: 201X [11] based on BS 6089: 2010 [9] has been approved for publication which provides specific guidance for use with SS EN 13791: 2009 [2]. This includes the recommendation that correction should not be applied for the presence of steel reinforcement in a core of length/diameter ratio up to 1.05 (National Annex ZZB of SS EN 13791: 2009 [2]). Neville [12] quoted the tests by Loo et al [13] which confirmed that at a length/diameter ratio of 1, presence of embedded steel has no effect on my measured strength.

"Where the in-situ strength is determined from cores: testing a core with equal length and a nominal diameter of 100 mm gives a strength value equivalent to the strength value of a 150 mm cube manufactured and cured under the same condition" – clause 7.1, SS EN 13791: 2009 [2] also clause 7.1, BS 13791: 2007 [10]. With the implementation of all these standards, the assessment of the level of my health in terms of in-situ strength in concrete structures or components now has well specified procedures in both testing and interpretation of test results. Hopefully, I can remain in a state of good health throughout my intended service life.

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THERMAL BEHAVIOUR OF CONCRETE MIXES WITH DIFFERENT POZZOLANIC ADDITIONS

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(2) Concrete technology consultant

Abstract

The evolution of heat generated during hardening of concrete causes, especially in massive elements, differential contractions between the nucleus and the surface that might generate thermal shrinkage cracks. The current study aims to identify the factors that allow to obtain the biggest reduction of the heat of hydration using products with pozzolanic effect, such as GGBS and silica fume. The goal is to identify the most efficient combination of pozzolanic materials able to reduce the heat of hydration of concrete through a reduction of the amount of cement, without affecting the long term compressive strengths. With such a pozzolanic compound, this study wants to propose an analytical method to assign an efficiency factor, in order to work out the amount of equivalent cement to replace. Thanks to adiabatic calorimetry it has been possible to experimentally evaluate the heat generated by a series of concrete samples designed with different amounts of pozzolanic materials. Comparing the best performance in terms of compressive strength and reduction of the heat of hydration, the most promising experimental product was identified and subsequently validated by field trial tests.

1. Introduction

Silica fume consists of fine vitreous particles with a surface area on the order of 20,000 m²/kg and particles approximately one hundredth the size of the average cement particle [1]. Because of its extreme fineness and high amorphous silica (SiO_2) content, silica fume is a very effective pozzolanic material.[2][3] Standard specifications for silica fume used in cementitious mixtures are ASTM C1240[4], EN 13263[5]. Prior to the mid-1970s, nearly all silica fume was discharged into the atmosphere. After environmental concerns necessitated the collection and landfilling of silica fume, it became economically viable to use silica fume in various applications, as high-performance concrete production[8]. The benefits derive from both the mechanical improvements resulting from addition of a very fine powder to the cement paste (filling properties) as well as from the pozzolanic reactions between the silica fume and free calcium hydroxide in the paste.[6] Addition of silica fume also reduces the permeability of concrete to chloride ions, which protects the reinforcing steel of concrete from corrosion, especially in chloride-rich environments.[7]
Ground granulated blast furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag from a blast furnace, to produce a glassy, granular product that is then dried and ground into a fine powder. Since GGBS is a by-product of steel manufacturing process, its use in concrete is recognized, for example by LEED, as improving the sustainability of the projects. The more gradual hydration of GGBS cement generates both lower peak and less total overall heat than Portland cement. This reduces thermal gradients in the concrete, which prevents the occurrence of microcracking which can weaken the concrete and reduce its durability. Concrete containing GGBS tends to have higher ultimate strength than concrete made with Portland cement only, mainly because of the higher proportion of Calcium Silicate Hydrates (CSH) than in concrete made with Portland cement only, and a reduced content of free lime, which does not contribute to concrete strength. In fact concrete made with GGBS continues to gain strength over time, and has been shown to double its 28-day strength over periods of 10 to 12 years. In this study a comparative analysis among concrete mixtures prepared with different percentages of cement replaced with ternary combinations of calcareous filler, SF and GGBS was carried out. The mentioned combinations of secondary cementitious materials have been named Compound PZ A, compound PZ B, and compound PZ C respectively, and the correspondent efficiency factors were evaluated. Preliminary results are reported in terms of variation in concrete compressive strength and temperature evolution measured in adiabatic condition.

2. Materials and setting

A series of three reference concrete mixtures were prepared adopting various dosage of Cement II/A-LL 42.5R while the amount of mixing water was kept constant as shown in Table 1. A superplasticizer was incorporated into mixtures in the range of 0.9-1.0% of the cement weight to obtain good rheology.

Table 1 : cement and water dosages for the reference concrete mixtures: resulting compressive strength values.

Ref. mixture #	Cement	Water			air (%)	Slump (mm) UNI EN 12350-3 *(after 7')*	Compressive Strength (MPa) (at 20°C and 95%RH)							
	Kg/m³	*L/m³*	*w/binder*	*w/c*			*7dd*	Weight *kg/m³*	*28dd*	Weight *kg/m³*	*60dd*	Weight *kg/m³*	*90dd*	Weight *kg/m³*
1	248	**195**	0.77	0.78	3.6	235	21.1	2286	24.1	2248	27.8	2265	28.3	2267
2	298	**195**	0.65	0.65	2.5	200	28.4	2295	34.7	2289	39.1	2295	40.0	2319
3	348	**195**	0.56	0.56	2.7	210	33.0	2303	42.0	2287	46.1	2296	48.3	2299

Three different values of the water to ce-

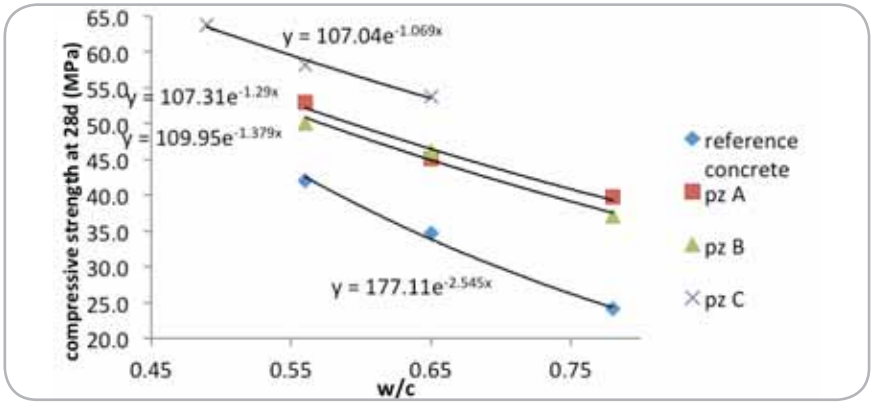

Fig. 1 : Concrete compressive strength (measured at 28 days from cast) as function of the water to cement ratio: experimental regressions.

ment ratio resulted, and the concrete compressive strength after 7, 28, 60 and 90 days were recorded. Figure 1 shows the variation in compressive strength at the age of 28 days as result of increased water to cement ratios.

Three ternary combinations of calcareous filler, SF and GGBS were prepared varying the silica fume to slag ratio. Mentioned combinations, hereafter referred to as "ternary compounds" or simply "compounds", have been named compound PZ A, PZ B, and PZ C respectively, and the correspondent efficiency factors have been evaluated. Determination of the efficiency factors was made possible by the preliminary execution of the following steps:

Step 1: 100 kg of compound PZ A was added to reference mixtures 1, 2 and 3 listed in Table 1, and new concrete mixtures named 1001 1002 and 1003 respectively were obtained: their composition is shown in table 2. Amount of the aggregates (sand and gravel) is adjusted to compensate for the addition of the fillers. Admixture dosage is calibrated to maintain the good rheology of the mixtures.

Table 2: cement and water dosages for concrete mixtures including compounds: resulting compressive strength values.

Mixture #	Addition		Cement Kg/m3	Water			density Kg/m³	Air (%)	Slump (mm) UNI EN 12350-3 (mm after 7')	Compressive Strength (MPa) (at 20°C and 95%RU)							
	Type	Dosage Kg/m³		l/m³	w/ binder	w/c				7dd	density kg/m³	28dd	density kg/m³	60dd	density kg/m³	90dd	density kg/m³
1001	PZ A	100	251	195	0.56	0.78	2310	3.2	180	**27.3**	2301	**39.7**	2312	**45.2**	2318	**47.1**	2312
1002	PZ A	100	302	195	0.49	0.65	2322	2.8	210	**34.0**	2315	**45.1**	2316	**51.1**	2318	**56.0**	2319
1003	PZ A	100	351	195	0.43	0.56	2326	3.0	210	**39.3**	2320	**53.0**	2304	**56.2**	2312	**61.2**	2335
2001	PZ B	100	250	195	0.56	0.78	2306	3.4	175	**25.4**	2281	**37.1**	2286	**40.0**	2273	**41.1**	2280
2002	PZ B	100	300	195	0.49	0.65	2313	3.6	170	**35.4**	2287	**46.1**	2308	**49.9**	2308	**54.4**	2317
2003	PZ B	100	350	195	0.43	0.56	2322	2.9	210	**39.3**	2298	**50.0**	2305	**57.8**	2305	**58.5**	2303
3001	PZ C	150	299	195	0.43	0.65	2300	3.0	210	**37.5**	2300	**46.7**	2295	**53.7**	2322	**58.8**	2302
3002	PZ C	150	350	195	0.39	0.56	2314	3.2	210	**39.2**	2268	**49.3**	2287	**58.2**	2286	**61.3**	2279
3003	PZ C	150	400	195	0.35	0.49	2316	3.3	210	**38.9**	2307	**54.9**	2291	**63.8**	2296	**67.1**	2293

Step 2: For the concrete mixtures obtained as in Step 1, values of the compressive strength were experimentally determined at the age of 7, 28, 60 and 90 days after cast, and data recorded as in Table 2.

Step 3: Step 1 and 2 were repeated for compounds PZ A and PZ B respectively so obtaining concrete mixtures 2001, 2002, 2003 as well as 3001, 3002, 3003. In Table 2 corresponding data of compressive strength at different ages are reported.

Step 4: Data from Table 2 are plotted in terms of compressive strength values vs. the water to cement ratios, so determining an experimental law (exponential type $Rc = a*e^{b*(w/c)}$) for each of the three compounds. Data in Figure 1 refers to compressive strength values measured at the age of 28days from the cast. Similar plots are obtained when strength values at different ages are considered.

Table 3 Coefficients a and b of the experimental regressions (exponential lows type $Rc = a*e^{b*(w/c)}$): data shown in Fig. 1 are marked in bold style.

Mixture	7 days			28days			60 days			90 days		
	a	b	R^2	a	b	R^2	a	b	R^2	a	b	R^2
Reference	105.4	-2.051	0.99	**177.11**	**-2.545**	**0.99**	205.76	-2.462	0.71	188.32	-2.43	1
Including PZ A	99.64	-1.658	0.99	**107.31**	**-1.290**	**0.97**	97.44	-0.987	0.99	120.72	-1.200	0.99
Including PZ B	125.68	-2.024	0.97	**109.95**	**-1.379**	**0.98**	147.90	-1.675	0.99	151.03	-1.644	0.95
Including PZ C	44.17	-0.241	0.67	**107.04**	**-1.069**	**0.99**	98.51	-0.808	0.92	102.85	-0.756	0.95

Step 5: Numerical coefficient a and b of the regressions lows plotted as in Step 4 are recorded. Table 3 resumes the coefficients of all the regression, referring to any different series of concrete mixtures at any different age of tests. Concerning compressive strength values at the age of 28 days, coefficient a and b are listed in Table 3 as they are readable from Fig. 1.

3. Determination of the efficiency factors

Once the experimental laws among concrete compressive strength and w/c are available, a target value for the concrete compressive strength Rc may be selected and the correspondent efficiency factor k determined for any given compounds as it follows.

First, the w/c ratio needed to obtain the desired compressive strength is determined inverting the characteristic law: for instance, required w/c ratio to obtain Rc = 30 MPa at the age of 28 days from reference mixture (incorporating only plain cement) is w/c = 0.7. Considering mixtures incorporating compound PZ A, PZ B and PZ C, the following w/c values are found: 0.99, 0.94 and 1.19. Since characteristic laws of all mixtures were obtained varying the w/c ratios while keeping water dosage constant (195 lt/m^3), different cement dosages resulted among reference mixtures and those incorporating compounds. This differences in cement dosage compared to the amount on compound adopted (fixed to 100 kg for compounds PZ A and PZ B and to 150kg for compound PZ C) allows to evaluate efficiency factors. Going into details, 280 kg/m^3 of plain cement are needed to obtain Rc = 30 MPa at the age of 28 days from reference mixture (w/c= 0.7 , water = 195 kg/m^3, consequently c= 195/0.7=280 Kg/m^3); dosage of cement reduces to 197 kg/m^3 when concrete mixture incorporating 100 kg of compound PZ A is considered: saving of 82 kg/m^3 of cement results (280-197=82), and efficiency factor corresponding to compound PZ A for compressive strength of 30MPa at the age of 28days is evaluated as

$k_{PZ\,A,30,28} = 82/100 = 0.82$.

Computing k values for all the considered compounds, with respect of various target values for the concrete compressive strength (Rc = 20, 30 and 40 MPa respectively) and for various ages of the concrete (28, 60 and 90 days respectively), data

target compressive strength	age	K		
		Mixture including compound PZ A	Mixture including compound PZ B	Mixture including compound PZ C
20 MPa	28 days	0.78	0.7	0.69
	60 days	0.89	0.47	0.74
	90 days	0.81	0.52	0.8
30 MPa	28 days	0.82	0.72	0.77
	60 days	0.96	0.55	0.85
	90 days	0.89	0.58	0.91
40 MPa	28 days	0.79	0.68	0.81
	60 days	0.94	0.61	0.9
	90 days	0.92	0.62	0.98
average		**0.87**	**0.61**	**0.83**

Table 4: Efficiency factors corresponding to various compressive strength target and ages of the concrete

Francesco Surico at the 38th Conference on Our World in Concrete & Structures 2013

Table 5 Validating tests: cement and water dosages of the concrete mixtures and resulting compressive strength values.

Mixture #	Addition		Cement	Water			density	Air (%)	Slump UNI EN 12350-3 (mm after 7')	Compressive Strength (MPa) (at 20°C and 95%RU)	
	Type	Dosage Kg/m³	Kg/m³	lt/m³	w/binder	w/c	Kg/m³			7dd	28dd
RefMix	-	-	350	194	0.55	0.55	2340	2.3	220	37.3	44.6
MixPZ A	PZ A	100	260	194	0.54	0.75	2325	2.2	220	26.8	36.1
MixPZ B	PZ B	100	290	194	0.50	0.67	2325	2.2	220	31.4	41.3
MixPZ C	PZ C	100	270	194	0.52	0.72	2274	3.8	220	26.2	37.1

listed in Table 4 were obtained.

4. Results and discussion

To validate estimation of the efficiency factors, three new concrete mixtures been prepared and tested to compare compressive strength evolution and heat released during cement hydration. Details concerning concrete mixtures compositions are provided in Table 5. Cement type CEM II A-LL 42.5 was adopted and a superplasticiser (0.9% of the cement weight) was incorporated into mixtures.Concrete compressive strength experimentally measured at the ages of 7 and 28 days respectively have been reported in Table 5.

Figure 2 shows the graph of the temperature measured by an adiabatic calorimeter during the setting of the concrete mixtures listed in Table 5. As expected, mixtures incorporating any of the compounds in partial substitution of the original cement dosage of 350 Kg/m³ in RefMix, showed to reach lower temperature during setting

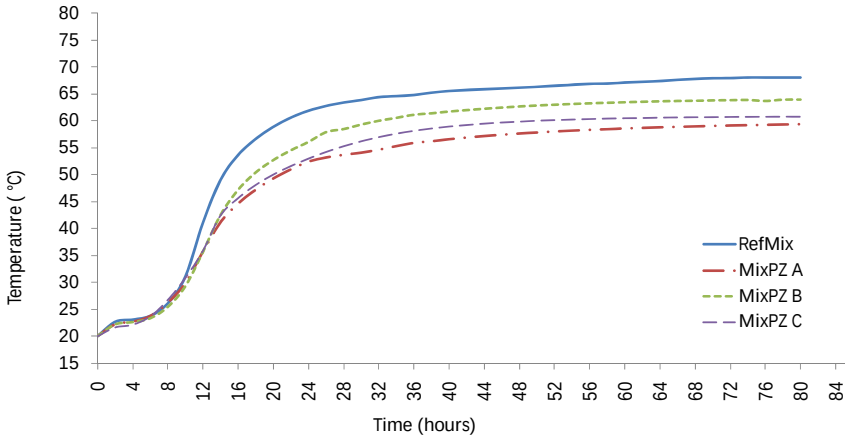

Fig. 2: Heat release in adiabatic calorimeter: temperature evolution during concrete setting

compared to RefMix (incorporating only cement).
Compared to compounds PZ B and PZ C respectively, curve corresponding to PZ A resulted to be the lowest in the graph so indicating it as the most effective in reducing heat release during concrete setting. However, experimental values of the 28 days concrete compressive strength corresponding to MixPZ A (36.1 MPa) resulted to be the lowest among all mixtures (last column in Tab 5), and difference of about 8.5MPa with reference value (44.6MPa for RefMix) may not be ignored. This would advice for a better calibration of the cement substitution when operating with compounds PZ A, although potential of this specific compound is believed to remain the most promising in comparison with other compounds PZ B and PZ C respectively.

5. Case study

The present case of study refers to the just built (2012) mat foundation of a new tower currently under construction in the CityLife district of Milan, to become the tallest skyscraper in Italy. The mat foundation bed, covers a rectangular area of about 63 m x 27 m and it is formed of a single, massive reinforced concrete block measuring about 2.5 m in thickness (somewhere up to 3.5 m) for a total volume of about 4200 m³. To speed up the construction process and due to the reinforcing bars congestion, building foundation was built in C32/40 SCC and accomplished in 30 hours of uninterrupted concrete pour. Due to the casting dimensions and to the usual cement content characterizing SCC mixtures, the project had to be regarded as a mass concrete case, thus taking precautions to prevent thermal cracking of the structure.

The main concerns with mass concrete placements were essentially two: the maximum temperature reached in the cast during the cement hydration and the maximum temperature difference among the interior volume and external surface.

In this case of study, designers prescribed the concrete maximum temperature difference not to exceed 20 °C. In addition, to regulate the rate of temperature drop and to reduce the stress differences due to steep temperature gradients between the concrete surface and the interior, formwork system were required to include pads of expanded polystyrene measuring 50 mm in thickness. On the free side of the cast, on top of fresh concrete surface, a sheet of polyethylene was prescribed before placing insulating blankets as well. While it may seem counter-intuitive to insulate mass concrete, it must be noted that insulation slows the escape of heat, which warms the concrete surface and reduces the temperature difference.

To realize the complex project and to speed up the construction process, both the concrete producer and the additions/chemicals supplier (Mapei) decided to use the pozzolanic addition PZ A (commercially available as Mapeplast PZ300) selected from the experimental work in the lab to prepare a tailor made low heat SCC mixture to be poured as a unique SCC massive cast to be accomplished in about 30 hours of uninterrupted work. This specific choice was taken in collaboration with the general contractor and the superintendent of works as well.

The following Table 6 summarizes the optimum SCC mixture composition selected for the project. Dosages refer to a meter cube of concrete. As mentioned before, the equivalent water/cementitious material ratio is calculated taking into account an equivalent cement dosage of 375 kg/m³ resulting from the sum of the cement and the pozzolanic addition respectively (the latter one considered with the relative efficiency factor k=0.7) in accordance with the fol-

Table 6 - Final SCC mix composition

Constituents	Weight
Cement type CEM III/A class 32.5	340 kg/m³
Mapeplast PZ300	50 kg/m³
Filler VG1 Nicem	120 kg/m³
Water	185 l/m³
Sieved sand 0-4 mm	589 kg/m³
Sieved sand 0-10 mm	455 kg/m³
Coarse aggregates 8-16 mm	327 kg/m³
Coarse Aggregate 11-22 mm	264 kg/m³
Superplasticizer Dynamon SR 914	4.08 lt/m³
Viscosity m.a. Viscostar 3k	0.50 lt/m³
Air content	11 l/m³
water /cement	0.54
Equivalent w/cementitious materials	0.49

lowing expression: 340+(0.7*50) = 375 kg. Concrete compression strength evolution and thermal performance of the mixture have been firstly evaluated during the qualification process of the mixture, then assessed during and after the construction process to monitor the proper execution of the work. Compressive strength data recorded at different concrete ages from qualification test are summarized in Table 7.

Table 7- SCC compressive strength evolution: mixture qualification test

Concrete age	Compressive strength (MPa)
3 days	20÷25
7 days	30÷35
28 days	45÷50
90 days	55÷60

Moving to the constructions field, fresh concrete properties were tested both at the mixing plant (by the concrete producer) and at the building site (by the Mapei Mobile laboratory). Test procedure included visual controls before any new concrete discharge, direct measurement of the slump flow with determination of T50, execution of the V-funnel and the J-ring test respectively (any 100 m^3 of new concrete). Monitoring of the concrete compressive strength gain was, instead, carried out at different ages on concrete samples taken during the concrete placement. A total number of 58 couples of concrete specimens were sampled during the first concrete placement (consisting of about 4150 m^3) and the foundation accomplishment (consisting of additional 1050 m^3) .

Average compressive strength vales recorded at different concrete ages have been reported in Table 8. Standard deviations values remained particularly low, clearly indicating the high homogeneity of the cast concrete.

Table 8 - SCC compressive strength evolution: results from field sampled concrete specimens

Concrete age	Average Compressive strength (MPa)	Standard deviation (MPa)
3 days	19.2	2.43
7 days	32.1	2.53
14 days	41.0	3.01
28 days	47.7	3.21
90 days	59.9	3.29

The temperature rise for the selected SCC mixture was predicted to be in the range of 29-30 °C. The result of the numerical calculation is discussed, comparing it with the experimental values recorded from a solid cubic meter of concrete cast as a test sample and instrumented with thermocouples. In this specific configuration, a maximum concrete temperature rise of 26 °C was measured at the age of 2 days from the cast, and minor temperature differences among the cube core and its external surface were recorded. Such a performance was considered satisfactory and in good compliance with the specifications.

Most significant results from thermocouples mounted along the vertical alignments located in the center of the placement have been reported in Figures 3 and 4 respectively. Graph in Figure 3 shows the temperature profiles recorded during the first two days after the concrete placement. In Figure 4 graph is extended up to 13 days after the pour accomplishment. Analysis of the temperature profiles suggest, in both cases, the following considerations:

- Blue line represents the temperature profile recorded at the maximum depth into the placement, at the foundation bottom, close to the ground (2.5 m below the final concrete top surface). These temperatures refers to the first layers of concrete placed into formwork.

- Red line indicates temperature profile recorded at the middle depth of the placement (about 1.5 m below the final concrete level into formwork). From this we can observe the maximum concrete temperature remained any time quite lower than the required limit of 70 °C. On the other hand, the reached peak of temperature of about 58 °C was found to exceed the maximum experimental value recorded in (semi) adiabatic condition on the concrete cube tested at the time of the concrete mixture qualification.

- Green line refers to temperature data

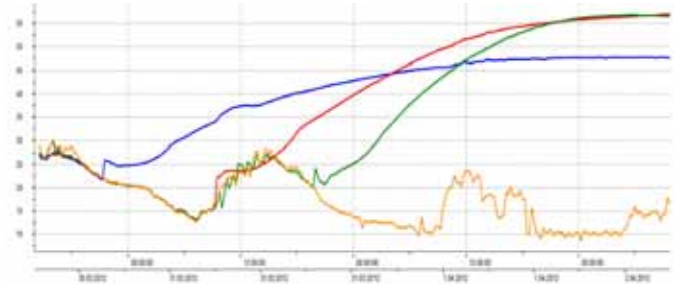

Figure 3 — Concrete temperatures recorded during the first 2 days at different depths at the geometric center of the rectangular foundation.

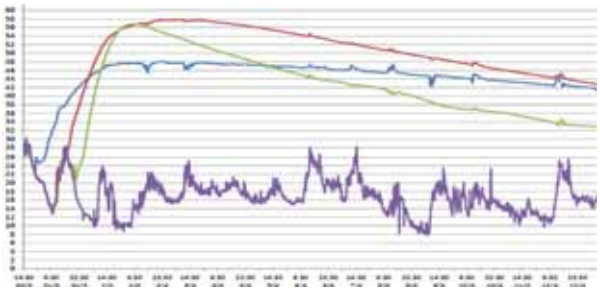

Figure 4 — Concrete temperatures recorded during the first 14 days at different depths at the geometric center of the rectangular foundation.

recorded at the cortical portions of the placement (at the depth of just few centimeters from the concrete free surface). The slope of the green profile is higher than in case of the red one, indicating that a faster temperature rise was experienced in this part of the mass concrete rather than in the middle thickness of the cast. This was considered to be a direct consequence of placing new layers of fresh concrete on top of already warm concrete represented by the previously cast part of the foundation. Actually, the same can be concluded also comparing temperature profile from the middle depth and the bottom side of the foundation respectively (red line in comparison with blue one).

- Orange line in Figure 3 and purple line in Figure 4 represent the environmental temperature profile.

From the last two graphs it is possible to note that maximum cortical and core concrete temperature values were found to be very close to each other, and both were recorded within the first 3 days after the start of the concrete pour. Thermal profiles in Figure 6 also show that heat dissipation in the concrete mass took place at a relatively slow rate. Data clearly prove that temperature difference from part to part of the mass concrete never exceeded the specified limit of 20° C. In particular, the concrete surface and the core mass cooled about at the same rate, so that temperature difference remained almost constant and in the range of 8-10° C.

6. Conclusion

High performance concretes are experiencing a fast growing demand on the market, and their application in becoming frequent in case of massive cast and in high rise of strategic structures. In all this application, improved mechanical properties are request to modern concretes in combination to other special requirements also concerning rheology and control of heat release during concrete setting.

The present work presents the result of a research aiming to demonstrate feasibility of substituting relevant amount of cement with combination of secondary cementitious materials with no effect on the final compressive strength of the concrete. In particular, experimental tests have been carried out partially replacing cement dosage in reference concretes with ternary combinations (compounds) of calcareous filler, silica fume and grounded blast furnace slag and correspondent efficiency factors have been determined. In situ and experimental measurements confirmed the effectiveness of the selected compound in reducing cement dosages in concrete and controlling temperature rise during concrete setting in a large pouring of mass SCC concrete mix.

The method of selecting a premixed combination of secondary cementitious materials in place of handling single ingredients separately has been presented as an interesting possibility given to ready mixed concrete producers to reduce the number of the storage tanks in their plants. And, last but not least, reuse in concrete of by-products such as silica fume and ground blast furnace slag is regarded as a positive example of green technology.

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Ascent Facilities Engineering Pte Ltd

Investigation/RepairAdvisoryServices/LifeCycleCosting/TechnicallyLedProjectManagement

Our Core Expertise

- Reinforced Concrete Corrosion
- Structural Steel Corrosion
- Building Materials Evaluation
- Performance Specification
- Evaluation of Mock-ups
- Material Durability Assessment

Areas of Application

- Structural Surveys
- Defect Assessment
- Remedial Recommendations
- Prediction of Time to Corrosion
- Life Cycle Costing
- Due Diligence Audits
- Project Management Services

Our Clients

Our Clients include Developers, Facility Owners, Contractors, Trusts Managers from the Building and Infrastructure, Pharmaceutical and Oil & Gas Industries

Introduction

Formed in 2004, Ascent Facilities Engineering Pte Ltd offers an integrated consultancy service in advising the performance of building materials, structures and facilities. Our capabilities stem from knowledge and experience covering 22 years of practical and professional experience uniquely from overseas and local projects. Both directors are ex-staff of Taywood Engineering Ltd, internationally recognized amongst UK consultants in providing engineering consultancy services related structural surveys, diagnosis and retrofitting

Services

We assess the current condition and future performance of commercial and residential buildings, civil structures and industrial facilities.

- **Durability Investigations for Concrete Structures:** The causes of reinforcement corrosion may be due to agents like chloride and carbonation. Reinforced concrete can also come under attack by chemicals having high acidity. It can breakdown due to the presence of reactive aggregates (Alkali-Aggregate-Reaction and Alkali-Silica-Reaction) and cracking of concrete can occur through high thermal differentials and restraints arising from casting of concrete.
- **Corrosion Investigations for Steel Structures:** We evaluate the causes of corrosion on steel structures due to exposure to harsh environmental condition during its service life. Many of these structures therefore start to corrode due to the breakdown of the protective paint layer resulting in galvanic corrosion taking place.
- **Building Facade Condition Audits and Investigations:** Curtain

Company Profile

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• www.ascentfe.com •Email: admin@ascentfe.com

wall and other façade systems deteriorate during their service life. We investigate the problems such as seepage, delaminations of finishes, loosening of façade components associated with the building facades and often find that such problems could be the result of expiring of service life, wrong detailing, poor workmanship, bi-metallic corrosion from two different metals.

- **Prediction of Time to Corrosion and Life Cycle Costing:** The data obtained from our field investigations are used in computer models to predict the time to corrosion. This information is useful for planning the maintenance schedule and allows the asset manager to set aside budgets for active maintenance of the structure, rather than wait for defects to surface. In many instances, when defects surface, the rate of deterioration often spiral exponentially. Repairs become costly at this stage. The prediction of time to corrosion therefore helps the asset manager to prepare a cost-effective life cycle cost for his structure.
- **Specification and Repair Proposals:** We determine the causes and recommend ways to prevent the problems from worsening. Many repair methods are available in the industry from structural strengthening to cathodic protection systems and we propose repair proposals based on the knowledge of the current condition and life expectancy required.

We have successfully completed many projects on the above and welcome you to visit our website at www.ascentfe.com where you may download a range of our project profiles for your information.

Ascent Facilities Engineering Pte Ltd have carried out projects in Singapore, Peoples' Republic of China and Seychelles Island.

Our Directors have participated in Conferences as speakers in:

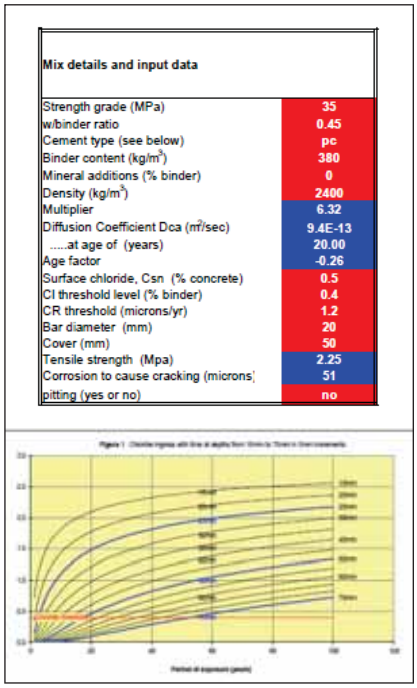
- 3rd Asian Concrete Federation (ACF) International Conference on Sustainable Construction, 2008 - Vietnam
- 10th Annual Conference on Inspection, Appraisal, Repairs and Maintenance of Structures, 2006 – Hong Kong (Recipient of Highly Commendable Paper AWARD 2006)

Collective Experience

Prediction of Time to Corrosion for Reinforced Concrete Structures

Modeling of the Time to Corrosion is done through the use of computer software programmes

Example of Application of Computer Models



Field data such as concrete strength, reinforcement cover, bar size, surface chloride content, chloride threshold level are used.

Durability investigation of Jetty and prepare Life Cycle Costs using different Remedial Methods

Evaluation of causes of spalling concrete problems, proposing remedial options and estimating of life-cycle-costs for maintenance for high value structures such as jetties and tunnels

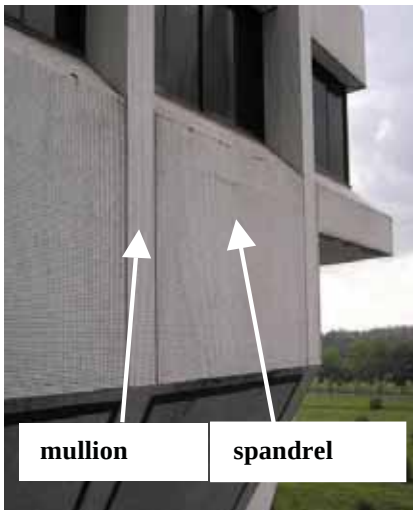
Half Cell Potential measurement and other tests can be used for the durability investigation. Using different options of repairs, the initial capital costs and subsequent cyclical costs over the service life can be estimated.

Life-Cycle-Cost studies allows the Client to choose between different remedial options vs costs. Some options may involve higher initial capital cost but the overall total cost may be lower over the service life of the structure

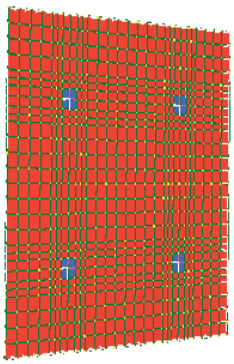
Repair Recommendations are validated Quantitatively using Finite Element Analysis Programme

Evaluation of a façade repair system using cementitious materials with anchor pins and fabric mesh

Material	Properties
Anchor with epoxy resin	Pull-out load for 30 mm embedment (when grouted with epoxy resin) : **2500 N** (before applying the recommended safety factor of 4) Tensile load for 30 mm embedment (when grouted with epoxy resin) : **1770 N** (before applying the recommended safety factor of 4) Spacing of anchors : **600 mm**
Fibreglass Mesh	Thickness : **2 mm** Density : **15.7 kN/m^3** Maximum Tensile Stress : **1.85 N/mm^2** Maximum Strain : **5%**
Cementitious Binder	Thickness : **3 mm** on either side of the mesh Density : **24.0 kN/m^3** Maximum Tensile Stress : **2.8 N/mm^2** Maximum Compressive Stress : **25.0 N/mm^2**



View of precast spandrel and mullion



Snapshot of model of repair system of repair system

The proposed façade repair system is checked for suction, shear and deflection against service loads such as wind and temperature

Based on the designed repair system of anchors, mesh and cementitious repairs, the proposed façade repair system (right) is checked for suction, shear and deflection against service loads such as self-weight, wind and temperature

Third Party Investigation on Problems affecting Concrete Structures

The effects of crack lines are often a cause of concern to all parties in a construction project. Investigation is called for an independent assessment on the cause and rectification.

Cracks on Newly Cast Concrete

Evaluation of the impact of crack lines on the strength of concrete and durability implications

Repair Proposals and Specifications

We have designed, specified and supervised numerous repair projects employing corrosion protection, injection and patch repair methods

Reinforcement Corrosion on Existing Concrete

The specification of corrosion repairs using sacrificial anodes for a reinforced concrete tunnel

Specialists Consultancy on Appraisals of Existing Building Facades

Increasingly, the importance of durability and safety in the maintenance of building facades are evident as many owners now include such appraisals as part of their maintenance programme

Inspection and retrofitting of existing curtain wall and stone/tile cladded facades

Typical defects noted including the loosening of aluminium finishes

Condition investigations and repair proposals of construction defects in concrete in Energy Power Station in Indonesia, pharmaceutical facilities and buildings in Singapore.

Inspection of steel pipe rack and platforms for corrosion and proposal of remediation measures

Inspection revealed corrosion treatment and replacement of some I beams required

Technical due diligence audits and life-cycle-costs study for various buildings prior to acquisition

Audits on buildings were carried to inform Clients on non-compliance issues, defects and actions for consideration. Life-Cycle-Cost Studies on the building, mechanical and electrical systems were carried out over a 25 year period.

Condition audits and compliance to building codes on facilities

Extent of audits cover the structural, architectural, fire, mechanical & electrical systems of the assets

proceq

silver schmidt 

For decades, Proceq's Original Schmidt Concrete Test Hammer has been the industry standard for a rapid assessment of the condition of a concrete structure. Test objects to which this method is applied may range from freshly prepared test cubes to historical wall segments. Now, Proceq has taken a significant step forward by launching a hammer that is even more accurate and user-friendly. Independent testing at the renowned Federal Institute for Materials Research and Testing, BAM Berlin (Bundesanstalt für Materialforschung und –prüfung, Germany) has confirmed that the SilverSchmidt has less dispersion than all of its predecessors over the entire compressive strength range.

Below is a summary of the benefits of the SilverSchmidt Concrete Test Hammer:
- **Ergonomics:** The SilverSchmidt body lies very comfortably in the hand. The display is highly readable under any conditions.
- **Robustness:** A two-layer seal prevents dust and dirt from penetrating to the interior of the instrument.
- **Impact direction independence:** The forward and the rebound velocity of the hammer mass are both measured in close proximity to the point of impact. The rebound value requires no angular correction.
- **Measurement accuracy and repeatability:** The new measurement principle and the redesign of the mechanics enable the SilverSchmidt to outperform its predecessors.
- **Objective evaluation:** A larger number of measurement points can be easily collected by the instrument and automatically evaluated according to statistical criteria.
- **PC connection:** The application "Hammerlink" allows all data to be uploaded via USB (PC version only). Firmware upgrades are also possible over this connection.

Proceq is confident that the SilverSchmidt hammers will become the new industry standard, just like their Original Schmidt Hammer has been for the last 50 years.

DY-2 FAMILY
PULL-OFF TESTING

Pull-off testing is one of the most widely used test methods in the construction industry. It is indispensable for the diagnosis of structural damage to buildings as well as for checking complete renovation work. Proceq announces an expansion to its existing Dyna pull-off tester portfolio with the DY-2 Family (DY-206, DY-216 and DY-225), a new generation of automated pull-off tester.

Complete range of applications covered
The three models of the DY-2 Family differentiate by a maximum pulling force. While DY-216 (15.5 kN, 3485 lbf) is covering most applications, DY-206 (6 kN, 1349 lbf) has an increased accuracy for low strength applications such as testing adhesive strength of mortars and renders. DY-225 (25 kN, 5620 lbf) can be used for very high strength applications such as testing of fibre reinforced polymers bonded to concrete structures or testing the bond strength of repair and overlay materials.

Constant load rate
One of the major influences on the result of a pull-off test is the operator influence in the application of a constant load rate. The newly introduced DY-2 models with their integrated, feedback controlled motors remove this variable completely, by providing a fully automated test at a constant load rate which can be verified.

Unique in parameter setting
The DY-2 is further unique in that it records every single test parameter required by the specification: Time and date of the test, test disc size, maximum load applied, automatic calculation of bond strength, applied load rate with graphical record, complete time of test as well as the failure mode.

For the very first time, the operator is able to provide a complete record of the pull-off test, proving that the test was carried out in accordance with the applicable standard.

CONSTRUCTION
made in switzerland

www.proceq.com

PanUnited

PAN-UNITED CORPORATION LTD

From the Founder's foresight in starting Hiap Soon to his bold expansionary moves in the marine sector and later the unprecedented venture to build a Chinese port, Pan-United Corporation is today a listed Asian giant. Its businesses now spread across five countries: Singapore (the Headquarters), Malaysia, Indonesia, Vietnam and China.

our businesses

The Group operates three core businesses:

- Basic Building Resources
- Port & Logistics management, and
- Shipping

basic building resources (BBR)

The Basic Building Resources (BBR) division was formed in 1994 to supply basic building resources to the Singapore construction industry.

The BBR division, one of Asia's top five companies, cemented its reputation as reliable and premier supplier of ready-mixed concrete (RMC) and cement, offering quality and innovative products to add value to the Group's core services. The division delivered more than 3.0 million cubic meters of RMC to public infrastructure projects, such as the Republic's MRT expansion project for the Downtown Line Phases 2 and 3, as well as the Tuas West extension, HDB housing, Marina Coastal Expressway, Ng Teng Fong Hospital and iconic residential projects, including The Interlace and d'Leedon.

Its overseas expansionary plans in Vietnam to manufacture and supply ready-mixed concrete, together with an aggregate quarry in Indonesia, have started operations in July 2011.

The BBR division provides materials and services through its subsidiaries:

- Cement from United Cement Pte Ltd
- Granite aggregate and sand from Pan-United Industries Pte Ltd
- Ready-mixed concrete from Pan-United Concrete Pte Ltd
- Refined petroleum products from Inter Terminal Services
- Trading from Pan-United Asphalt Pte Ltd

PAN-UNITED CONCRETE PTE LTD

Started in 1999, Pan-United Concrete Pte Ltd has grown to be Singapore's largest Ready-Mixed Concrete (RMC) supplier, providing unparalleled services and quality by customizing a full range of concrete mix designs for cost-efficient solutions to clients in the public and private sectors.

our resources

Our batching plants are strategically located in Singapore main land. They are all fully computerized, wet-mix batching plants. We have large fleet of concrete mixer trucks, comprising of 7m³ trucks, 8m³ trucks and 9m³ trucks to meet the demand of our customers.

innovation centre

The Innovation Centre provides research & development and quality assurance on the raw materials and finished concrete products. Our Innovation Centre is Singlas Accredited modern laboratory, fully equipped with the latest technology equipments and the test for raw materials and Ready-Mix Concrete products are conducted in accordance with SS EN specification.

Pan-United Concrete Pte. Ltd. is the first company in Singapore to be awarded certification production quality standards (SS EN 206) by the Building and Construction Authority. All concrete for buildings and civil engineering structures supplied from Ready-Mix Concrete plants in Singapore must be certified under the Singapore Accreditation Council's certification scheme.

CONCRETE PRODUCTS

We have handled mega-sized projects requiring special concrete

Hougang Parkview
SCC casting for HDB project

Self-Compacting Concrete (SCC)

We have supplied SCC to many projects such as MRT, private and commercial building and some HDB projects. SCC is a highly workable concrete that can flow through densely reinforced and complex structural elements under its own weight and adequately fills all voids without segregation and without the need for vibration. SCC increases the speed of construction, reduces labour demands and noise pollution.

PanUnited

Ultra High-Strength Concrete

Ultra high strength concrete (UHSC) with strength more than 150 MPa has been developed using locally available raw materials and high range water reducing admixture (HRWRA). The low water-to-cementitious materials ratio results in very low porosity and high durability, that encourages engineers to use it in many practical applications like nuclear waste containment structures, high rise structures, long span bridges etc.

Pan-U Green Concrete
Pan-U Eco-Concrete

Pan-United Concrete Pte. Ltd. is among the pioneers to introduce "green" concrete, which uses resource-saving and environmentally-friendly materials to produce performance-equivalent Ready-Mix Concrete. Our range of Pan-U Green Concrete and Pan-U Eco-Concrete products have been approved by Building & Construction Authority of Singapore; we offer Ready-Mix Concrete products with GreenLabel certification from the Singapore Environment Council.

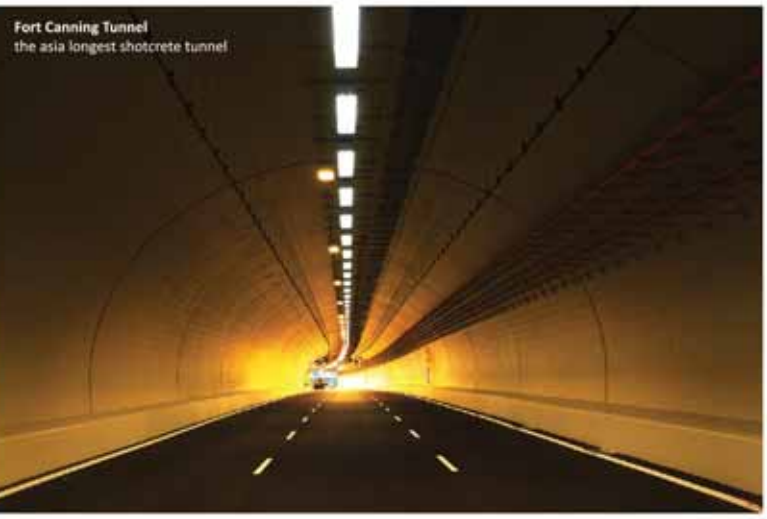
PanUnited

Temperature Controlled Concrete

Such concrete prevents thermal cracks and other temperature related defects to concrete. We provide Temperature Controlled Concrete for most of the thick foundation projects and underground projects. This is to control the maximum peak temperature and temperature differential between the interior and the surface of the concrete.

installing temperature monitor

Singapore LNG



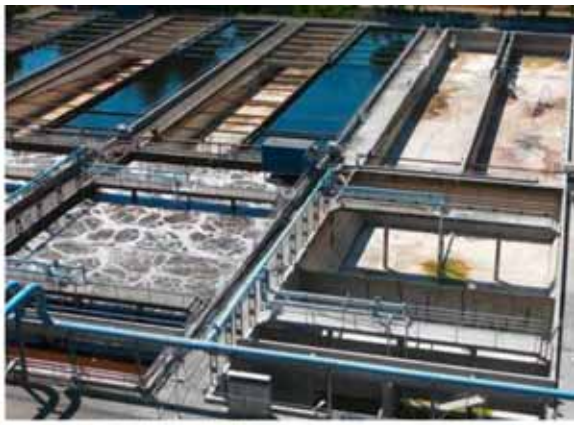
Fort Canning Tunnel
the asia longest shotcrete tunnel

Shotcrete

We have supplied Shotcrete to underground and tunneling projects such as the Jurong Rock Cavern (JRC) project, Mandai Ammunition Cavern, Fort Canning Tunnel and most of the MRT Projects.

Jurong Rock Caverns

MC Innovation



The revolution in protecting sewage treatment structures

For 25 years now, MC-RIM has enjoyed a market-leading position in the surface protection of concrete construction components found in sewage treatment facilities. Now with MC-RIM PROTECT PLUS, MC has developed a completely new all-in-one system. It meets the current state of the art for concrete technology and it is revolutionary in its simplification of the application as well as in providing extra-long protection for sewage structures exposed to particularly harsh conditions.

The concrete structures of sewage plants are exposed to mechanical, chemical, physical and biological effects each and every day. MC-RIM has been used for 25 years now in protecting these elements against damage. The new all-in-one system, MC-RIM PROTECT PLUS, is now even more efficient: it combines the latest concrete technology expertise with simpler and safer application and an even longer service lifetime. "With MC-RIM PROTECT PLUS, we have developed a perfectly coordinated high-tech all-in-one system for all concrete surfaces in sewage plants, which will delight applicators and planners," explains Werner Baumgart, concrete technologist and product manager with Protection Technologies at MC.

"Even covered construction elements, which are exposed to particularly aggressive environments in areas where air is present, can be given better and safer protection with our new product system." Numerous test certificates from Kiwa MPA Bautest GmbH are a testimony to the products' outstanding good resistance against the penetration of chloride, their excellent resistance to chloride diffusion, sulphate and acid attack, and their low porosity.

So simple and flexible

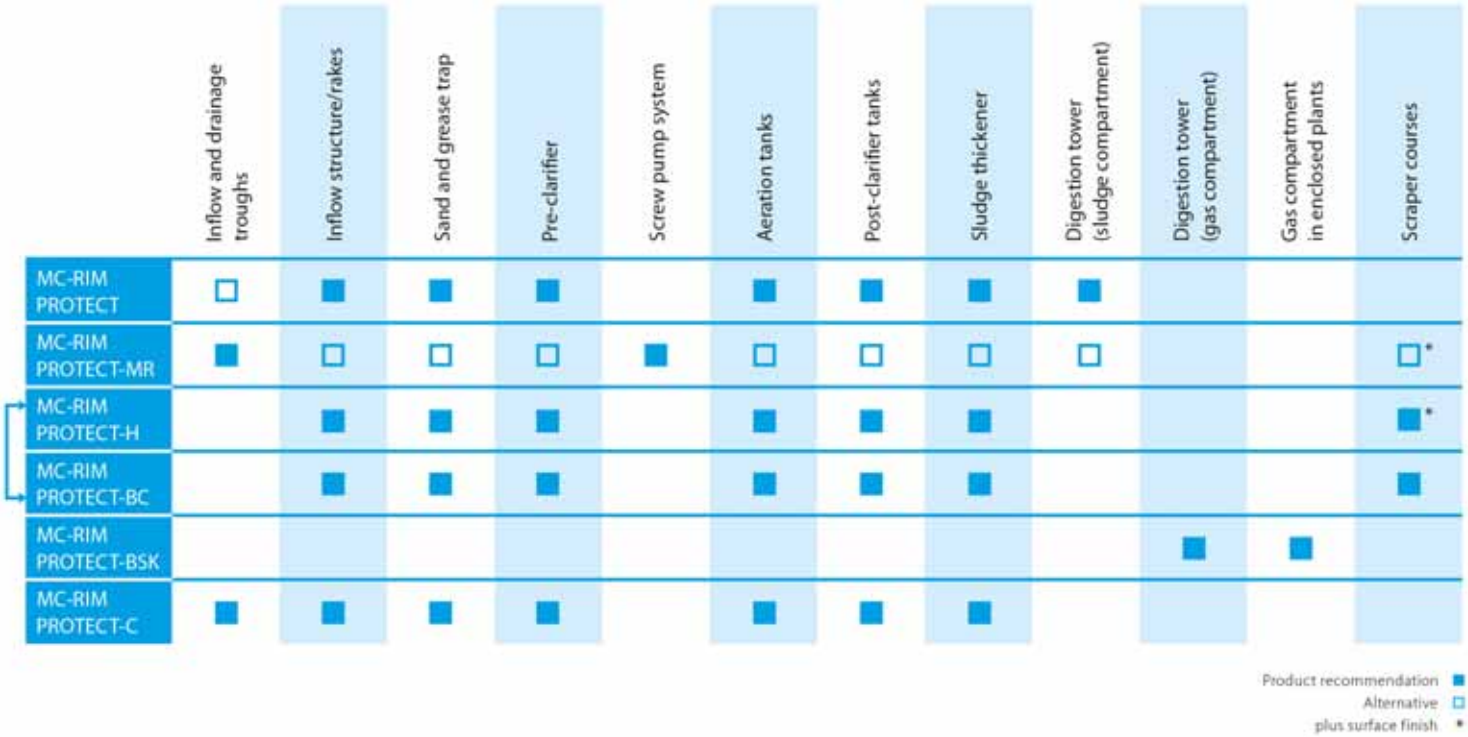
The system delivers many new benefits, particularly from the technical application perspective. The new products in the MC-RIM PROTECT PLUS range are mostly single-component – the only exception being MC-RIM PROTECT PLUS-BSK, which is used for areas exposed to biogenic sulphuric acid corrosion. This not only saves a tremendous amount of time but a great deal of expense too. It also greatly minimises the level of risk during application, and technical safety is enhanced. Plus, the fact that bonding courses are hardly needed anymore saves the applicator a whole step in the work process, reduces the working time and also simplifies the process.

MC-RIM PROTECT PLUS also delivers greater flexibility in relation to the application: apart from application by hand, it can also be applied using the wet and – this is new – the dry gunning process. Greater flexibility is also afforded by its workability to 35 degrees Celsius and the large available range in selecting the layer thickness, i.e. between 5 and 15 mm. Compared to MC-RIM, consumption is a full 10 percent less.

Better and safer

Specially inter-coordinated binder technology in combination with the DySc® technology means that a highly resistant cement matrix can be established, the like of which can be found nowhere else. "We have tested our technology in various research projects. In all of the tests the system scored extremely well against sulphates and acids, but also performed extraordinarily well against chloride diffusion, stunning even the experts of cement technology," says Product Manager Werner Baumgart.

MC-RIM PROTECT PLUS – at a glance



Long-life protection
MC-RIM PROTECT PLUS therefore fulfils the most important conditions for long-life concrete protection in sewage structures.

The all-in-one system delivers:
- A high resistance against chlorides and chloride diffusion
- Protection from sulphate attack
- High mechanical resistance
- Low porosity thanks to DySc® technology
- High acid resistance to pH values of between 3.5 and 14; MC-RIM PROTECT-BSK resists an even lower pH value range

MC-RIM PROTECT PLUS is also open to water vapour diffusion. There is no risk of osmosis. This then successfully combats the risk of losing bonding strength or stripping due to rising damp. All these properties deliver unique physical construction stability and a very long lifetime, which will be every bit the equal of the long-term experiences had with MC-RIM.

In the first few months of the year, Werner Baumgart, Rafael Sass and Moritz Koch presented the new product system through numerous workshops and training courses conducted both inside and outside the company. Customers and partners have already been able to test it for themselves and the feedback has been positive from all concerned.

Introducing the all-in-one system:

MC-RIM PROTECT is the lead product in the new MC-RIM family. It can be applied by hand or with a gun and it is highly resistant to sulphates. It possesses a fibre-reinforced surface coating and resists pH values of between 14 and 3.5.

MC-RIM PROTECT-MR is designed for surfaces exposed to high mechanical abrasion, but it also delivers the same level of protection against chemical, physical and biological attacks as MC-RIM PROTECT. It is similarly fibre-reinforced and can be applied by hand or by gun.

MC-RIM PROTECT-H is designed for application on horizontal surfaces. It can be applied by hand or by pump. MC-RIM PROTECT-BC provides a suitable bonding course for the application.

MC-RIM PROTECT-BC is a system component which can be used as a highly sulphate-resistant, mineral bonding course for MC-RIM PROTECT-H.

MC-RIM PROTECT-BSK is especially designed for application in particularly aggressive settings: when used in areas exposed to biogenic sulphuric acid corrosion, the product provides a highly acid-resistant surface.

MC-RIM PROTECT-C is a high-performance post-treatment agent with a wax dispersion base, and was developed for application in combination with MC-RIM PROTECT, MC-RIM PROTECT-MR and MC-RIM PROTECT-H.

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Email : enquirysingapore@mc-bauchemie.com

Dr. Claus-Michael Müller thanks Willie Kay (right) for the beneficial partnership over the past 15 years.

MC Bauchemie Singapore founded

In May 2013, the MC-Bauchemie Group expanded its operations in the South-East Asian region by buying WAK Technologies Pte. Ltd., which has been the distribution partner of MC in Singapore for more than 15 years now. The acquisition and renaming of the company to "MC-Bauchemie Singapore Pte. Ltd." sees the globally active family enterprise from Bottrop continue its strategy of growth. MC has been working the Asian-Pacific region for many years now, maintaining its own companies not just in Singapore but in India, Malaysia and Taiwan too.

"With the acquisition of our long-time distribution partner, we are taking the next step in the continued expansion of our presence and business activities in the South-East Asian region," said Dr.-Ing. Claus-Michael Müller, managing partner of MC-Bauchemie GmbH & Co. KG, adding, "For us Singapore has an important strategic role in this context. We want to be more intensively involved in a dynamically developing market and consider there to be great growth potential for our business in this part of the world."

Having successfully led WAK Technologies for the past 15 years, Willie Kay, who is retiring at the end of the year, will be handing over the management reins to his successor. However, he will still remain available to advise and assist MC-Bauchemie in special projects. Mr. Kay is an experienced businessman and has a thorough knowledge of the South-East Asian market. The Briton was responsible for developing the company into one of the leading suppliers of high-grade material systems for construction and repair work in Singapore and the surrounding region. "The work performed by Willie Kay has been ground-breaking, and he has played a crucial role in establishing and shaping the business in the Asian-Pacific region. We greatly appreciate his work in that respect and the extraordinarily good working partnership we enjoyed with him," said Dr. Müller in fulsome praise of Mr. Kay.

"A good product is only really good if it is properly applied. That is why we always work closely with our partners – construction planners, architects and application firms – and also train them in how to properly handle the MC's products," said Willie Kay. This approach has enabled numerous construction projects in Singapore and the surrounding region to be successfully implemented and promoted the application of product systems from MC-Bauchemie. Such works include the Changi water recycling plant in Singapore, the largest self-contained purification plant in the world. Over the past few decades the structural works performed here have included the application of special surface protection systems as well as injection systems and high-performance plasticisers. "We are delighted to now be a member of the MC family and are looking forward with optimism to our common future", said Willie Kay.

› willie.kay@mc-bauchemie.com

Dear all,

This is a press release explaining the acquisition of WAK Technologies by MC-Bauchemie to create MC-Bauchemie Singapore Pte Ltd.

This was an agreement I made with Dr Mueller in 1997, and we are satisfied.

I will leave MC Singapore in December with a new General Manager running the company and Holger Pohlmann will take over my regional duties. I will however assist next year in this transition to ensure the continual service to all our customers. This will be on an ad hoc basis covering a third of my time.

My other companies in the WAK Group will now be led by me through the existing managers and we will continue to be involved in all aspects of high performance concretes and specialist materials in Singapore, Malaysia and specific other countries.

We will also build a specialist repair and injection team including fissure grouting with existing applicators.

Our QA/QC division including training will continue to expand in both Singapore and Malaysia.

I thank you for all your past support and look forward to working with you in the future

Willie Kay
Group Managing Director

New Technology in sump excavation

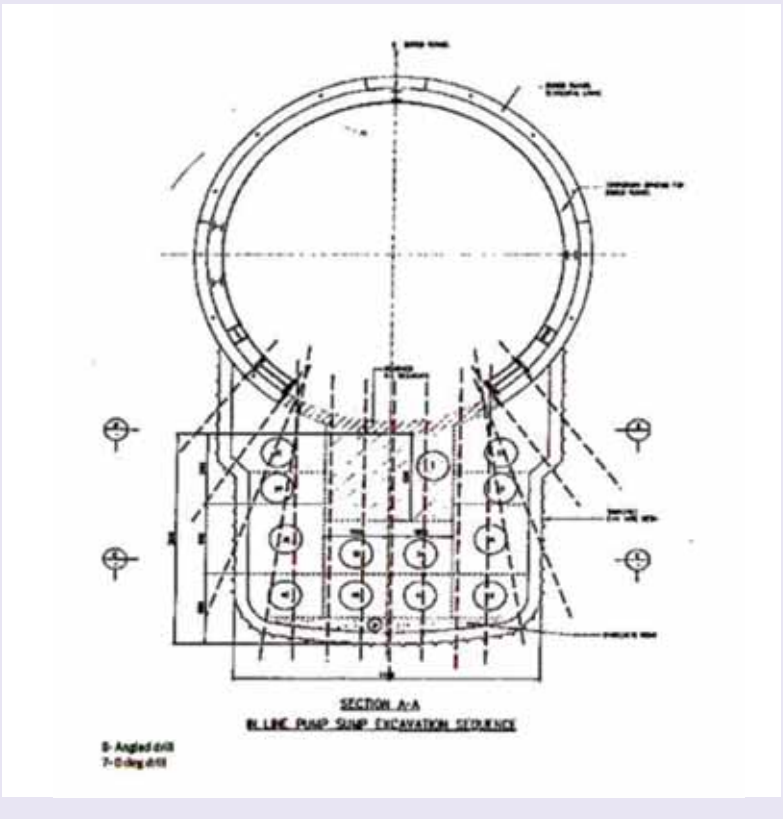
WAK

On a project in Singapore two sumps needed to be built inside a tunnel for future drainage. The ground varied from hard rock to running sand. Due to high water flow there was a danger of settlement and subsidence. The sumps 4.8 metre wide and 3.6 metres deep, and were hand excavated in stages. Initial methods to stabilise the ground included cement grouting but had little success.

WAK Consultants were called in to offer alternative solutions to control water flow which would allow safe excavation and then application of a stabilising layer of shotcrete.

Special Packer Note : Water Leakage

Figure I shows the general layout and concrete were raised of how to stabilise area underneath the existing tunnel segments.



The proposal submitted involved the use of special packers and injection resins from MC Bauchemie.

The method used was first to drill through the segments 1.2 metres and place special packers into these holes. Where there was soft ground and running water the packers were extended to 2 metre in length. Two materials were selected. For injection a water reactive foaming polyurethane which was subsequently re-injected with a non-toxin acrylate gel. The theory was to foam the water flow areas to produce a sponge like material to reduce the flow and then subsequently inject the gel using a twin line pump into this open cell sponge area. After a series of injection water flow was substantially reduced allowing the sumps to be excavated safely. They then had primary shotcrete lining followed by a shotcrete permanent lining.

NitCal™:
One product, a range of functional benefits with real business rewards

Are you looking for a solution to produce a more durable and faster-setting concrete?

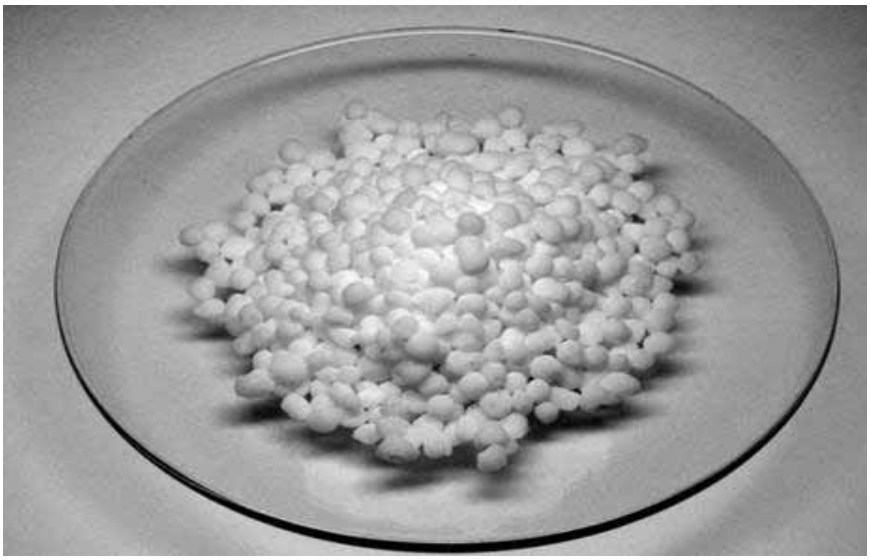
NitCal, Yara's multi-functional component of concrete admixture brings you both better performance and increased productivity across a broad temperature range. Building on a century of expertise from a nitrogen chemistry pioneer, NitCal is a specialty nitrate developed to answer the needs of the concrete construction industry in terms of setting acceleration, corrosion inhibition, cold weather concreting and overall durability.

One product, multiple applications

Based on research at the Yara Technology Center in Norway, as well as at several leading universities around the world, NitCal delivers multiple benefits to concrete construction. Originally developed in Norway for cold weather concreting, continuing R&D work is yielding new important applications. NitCal is a purified, specialty nitrate based, chloride free, accelerating admixture for concrete, presenting the following characteristics:

- Shorter setting time, and thereby, shorter construction time
- Ammonia-free, so no lingering odors
- Alkali-free, no worries about alkali-silica reaction
- Corrosion inhibition
- Cold weather concreting
- Counterbalance to plasticizers' retardation process
- Long-term strength enhancement

Ammonia-free NitCal-K: all the benefits, none of the smell



NitCal –K is a special ammonia-free grade developed to avoid the challenges often encountered by other setting accelerators in terms of unpleasant lingering ammonia odors.

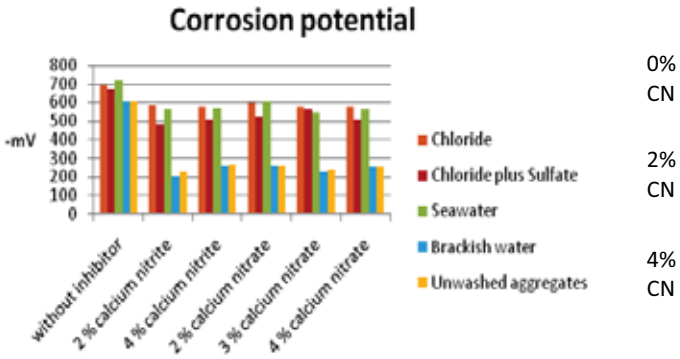
Cold weather concreting made easy

NitCal offsets the impact of low temperatures by accelerating the setting time. Using NitCal allows you to continue to produce quality concrete in sub-zero ambient temperatures. NitCal harnesses hydration heat to prevent freezing, it does not shift the freezing point of water.

Suppressing Corrosion, a the major structural threat to concrete constructions

Concrete reinforcement corrodes in two ways.

NitCal™:
One product, a range of functional benefits with real business rewards



• Rebar iron gets corroded when it is in contact with water or humid air. The rate of corrosion is very low within concrete as water diffuses very slowly into the concrete.

• Concrete reacts with carbon dioxide (CO2). CO2 diffuses into the concrete where it reacts with Ca(OH)2 to create CaCO3 – lime stone. This reduces the pH-value. This is a problem for steel reinforcement, as steel is dissoluted by acids, and CO2 itself delivers a weak acid, H2CO3.

NitCal works on both issues
• Oxidation of Iron and stabilizing it (Justnes (2006).
• Reduction of pore volume (Justnes (2003). The reduction of pore volume seems to be the result of increased CSH phase formation.

NitCal improves the durability of reinforced concrete both at the level of the concrete and of the rebar. NitCal –based admixtures provide corrosion inhibition for reinforcements by forming protective hydroxide layers around the reinforcements and enhancing chloride fixation. The protective effect is comparable to that of nitrite, but is a achieved in a more environmentally friendly way.

Why choose NitCal?

High quality product that is easy to handle

NitCal is a purified, specialty nitrate which is chloride free. It is available in granules or liquid solutions and can be dosed very efficiently. The International Maritime Dangerous Goods Code (IMDG) does not apply to this product (re: Special Provision 208), therefore, it is easy to handle.

Available worldwide where you need it

Yara is the world's leading nitrates producer, maintaining a global production base and logistics platform so that NitCal
is available to you where and when you need it. Yara delivers NitCal to most countries around the world.

Major construction projects across the globe used NitCal

• The world's tallest moveable concrete object ("Troll A", situated in the North Sea) could only be built, within a reasonable time and considering the harsh sea condition which it will be exposed to, with the use of NitCal.

• Incheon International Airport: NitCal was used for its setting accelerator benefits (partly due to cold conditions) and the long term strength benefit. Incheon is the largest airport in South Korea: since 2005, the airport has been

consecutively rated as the best airport in the world by the Airports Council International.

For more information visit www.yara.com

They all have *One thing* in common

They have all used Grace Solutions for High Strength Concrete.

Yoho Mid-Town, Hong Kong	Stonecutters Bridge, Hong Kong	International Finance Centre II, Hong Kong	International Commerce Centre, Hong Kong	Q1 Tower, Gold Coast, Australia	Keppel Bay Bridge, Singapore	The Sail, Singapore

Grace has a proven track record in the customised development of solutions for ultra high strength and high strength concrete. We do not just deliver concrete admixtures, but partner with you to understand how the constituent ingredients of cement, aggregates, sand and water all work together to affect performance.

Consult Grace today to develop a high strength concrete mix for your next project: 6265 3033 or asia.enq@grace.com.

www.graceconstruction.com

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▪ Australia ▪ China ▪ Hong Kong ▪ Indonesia ▪ Japan ▪ Korea ▪ Malaysia
▪ New Zealand ▪ Philippines ▪ Singapore ▪ Thailand ▪ Vietnam

Many concrete producers have chosen to work with Grace. And their reasons are:

- **Expertise and Knowledge**
  Grace specialist knowledge goes beyond developing the mix to include understanding of customer raw materials, project requirements, pre-construction planning, and advising contractor on job site conditions.

- **Technical Competence**
  Pro-active and reliable technical support, both in the lab and on site, through all phases of the project, to meet concrete property, pumpability, and site requirements.

- **Proven Track Record**
  Proven performance in delivering countless ultra high strength concrete projects all over Asia Pacific.

To push the threshold of performance, contact Grace today: 6265 3033 or asia.enq@grace.com.

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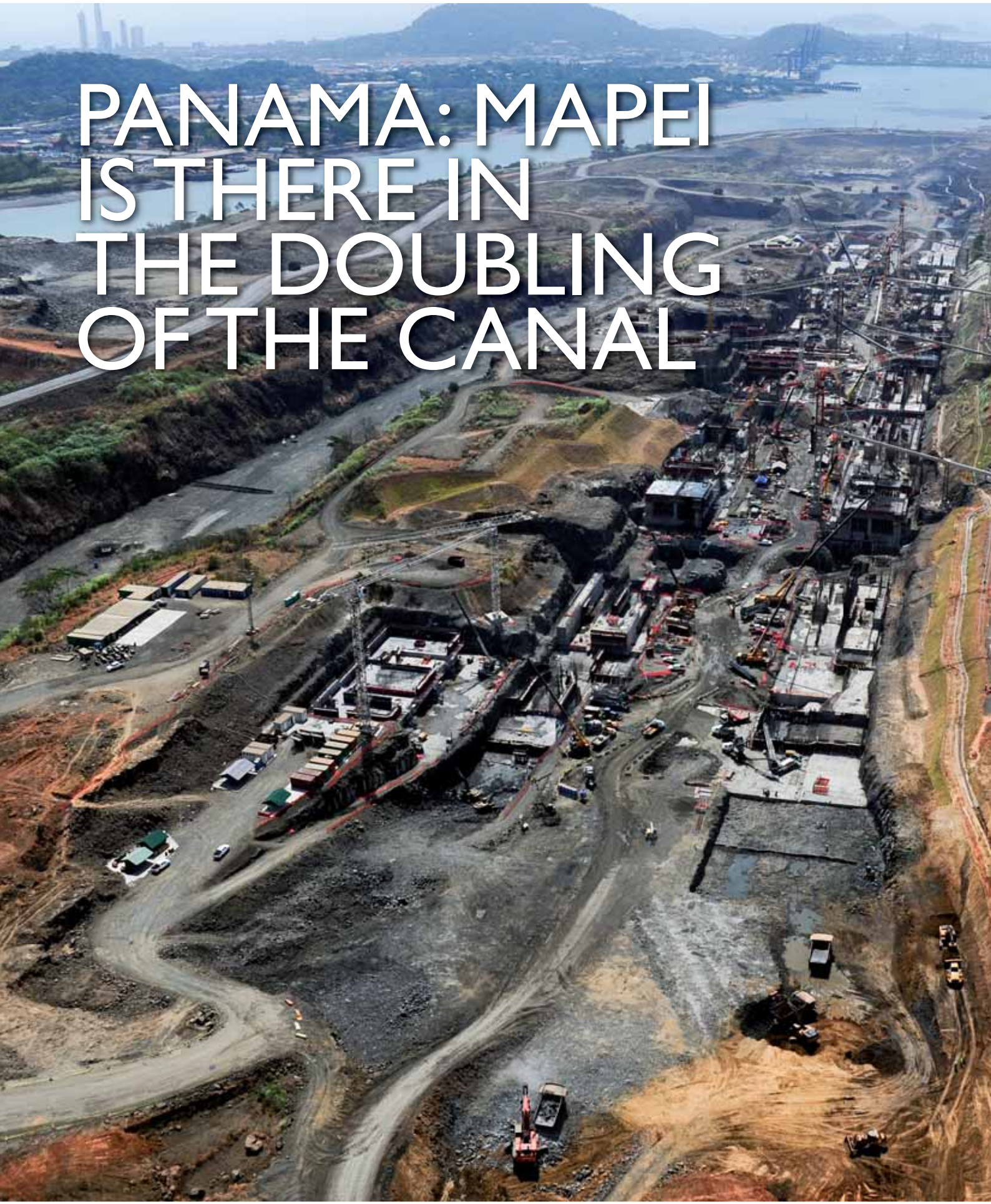
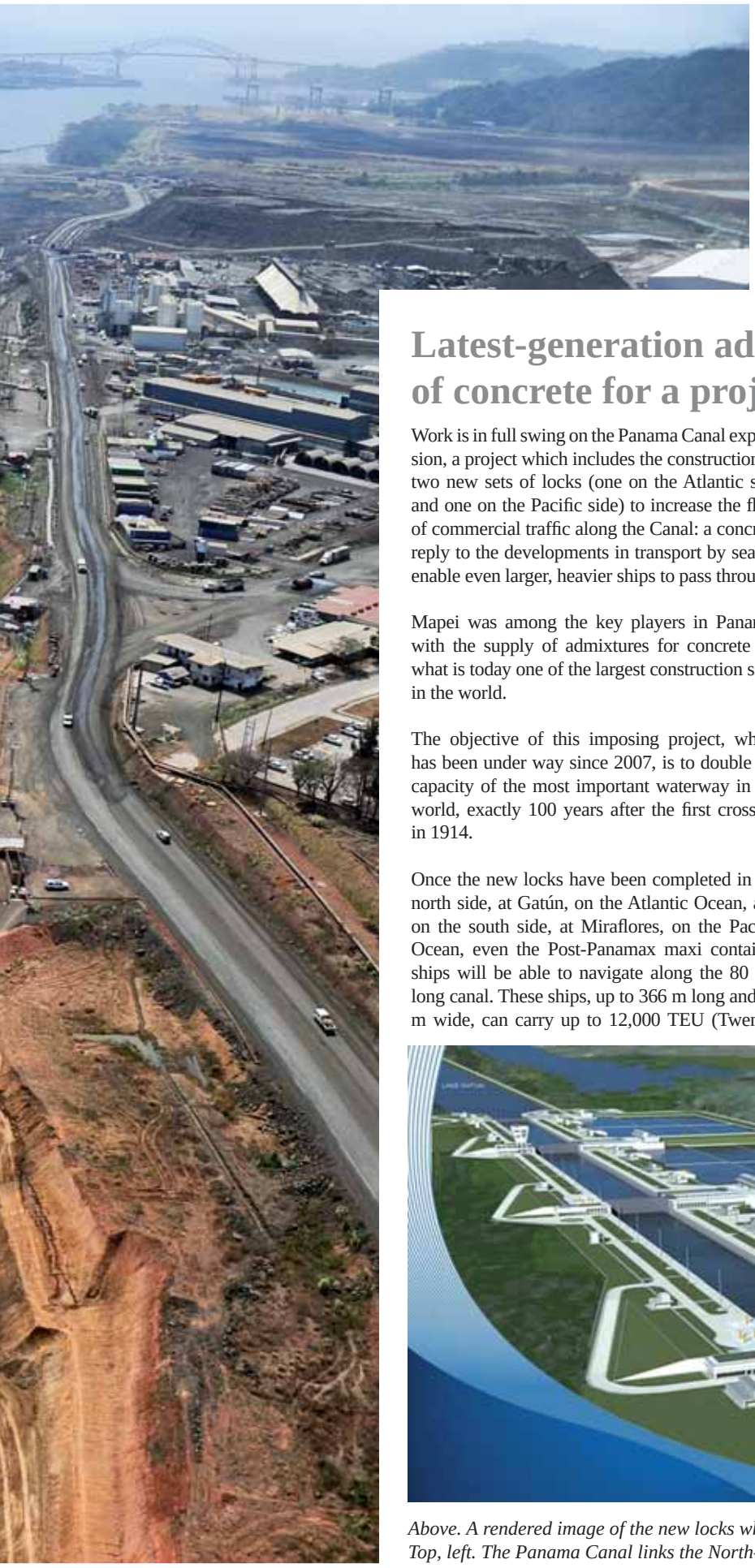
▪ New Zealand ▪ Philippines ▪ Singapore ▪ Thailand ▪ Vietnam

PROJECTS

PANAMA: MAPEI IS THERE IN THE DOUBLING OF THE CANAL





Latest-generation admixtures for 5,500,000 m^3 of concrete for a project in progress

Work is in full swing on the Panama Canal expansion, a project which includes the construction of two new sets of locks (one on the Atlantic side and one on the Pacific side) to increase the flow of commercial traffic along the Canal: a concrete reply to the developments in transport by sea, to enable even larger, heavier ships to pass through.

Mapei was among the key players in Panama, with the supply of admixtures for concrete for what is today one of the largest construction sites in the world.

The objective of this imposing project, which has been under way since 2007, is to double the capacity of the most important waterway in the world, exactly 100 years after the first crossing in 1914.

Once the new locks have been completed in the north side, at Gatún, on the Atlantic Ocean, and on the south side, at Miraflores, on the Pacific Ocean, even the Post-Panamax maxi container ships will be able to navigate along the 80 km long canal. These ships, up to 366 m long and 49 m wide, can carry up to 12,000 TEU (Twenty-Food Equivalent Units, the standard international volume for ISO container transport), compared with the 4,400 TEU currently allowed for the so-called Panamax ships.

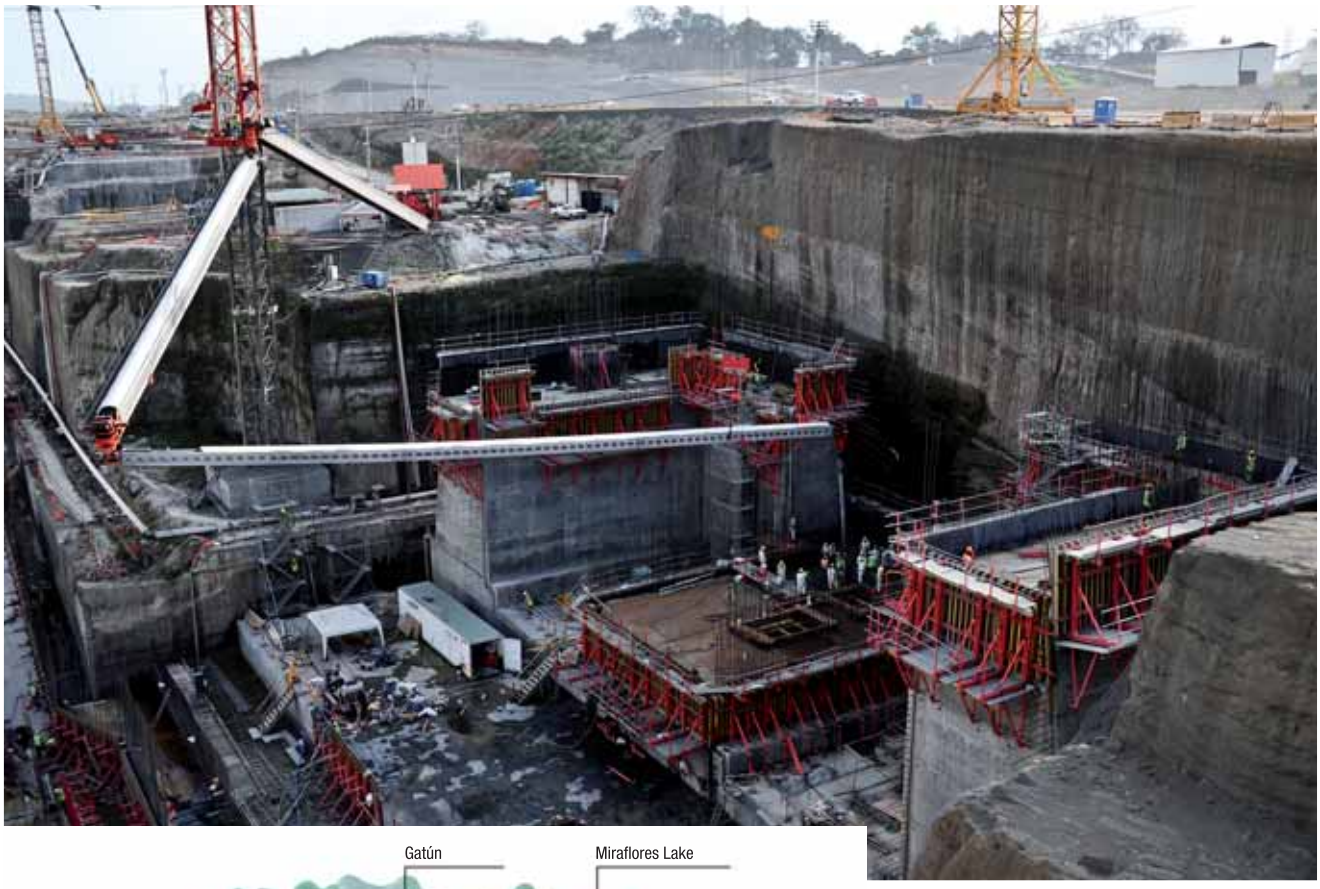
Today, the Panama Canal is an artificial channel that crosses the Panama isthmus for an overall length of 81.1 km, joining the Atlantic and Pacific Oceans.

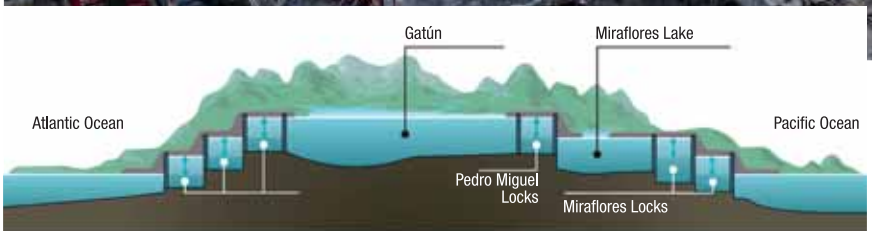
The new waterway is scheduled to be completed in 2014, the centenary of the inauguration of the existing canal.

The Canal expansion project is the result of an agreement between the Panama Canal Authority (ACP), a Panama Government body delegated to running the infrastructure, and the Grupo Unido por el Canal (GUPC) consortium, comprising of Sacyr Vallehermoso (Spain), Impregilo (Italy), Jan de Nul (Belgium) and Constructora Urbana (Panama) companies, with an overall value of 3.22 billion US dollars.

The total cost of the project is 5.25 billion dollars, and will be financed by the government by

Above. A rendered image of the new locks which are currently being built at Panama Canal. Top, left. The Panama Canal links the North-American and the South-American continents.





THE CANAL IN NUMBERS

Inauguration of the Canal: 15th of August 1914
First Official Crossing: the Ancon ships in 9 hours 40 minutes
Length of the Canal: 80 km
Dimensions: maximum depth 12 meters, variable width from 240 to 300 m in Lake Gatún and 90-150 m in correspondence with the so-called Culebra Cut
Canal Operating Mechanism: through a system of locks divided into compartments, with entry and exit gates to lift the ships, which then navigate to Lake Gatún to be lowered down to sea level
Dimensions of Chambers in the Locks: 33.53 m wide, 304.8 m long
Number of Workers During Construction of the Canal from 1904 to 1913: 56,307 from every part of the world
Number of Employees in September 2010: 9759
Average Time Required to Navigate the Canal: 8-10 hours for average size ships
Number of Ships Navigating the Canal from 1914 to 2010: 1,004,037

increasing toll charges by 3.5% for the next twenty years.

Restructuring the Original Canal

The project also includes restructuring work on the original canal.

And in this case too, Mapei offered a contribution for renovation and consolidation work for the Gatún Lock, located approximately 30m below ground and considered to be the most imposing reinforced concrete structure ever constructed. This project uses a special type of concrete and Mapei has supplied admixtures to make it: PLANITOP 15, an inorganic powder product added to the concrete cast into formwork, and the liquid admixture MAPECURE SRA, specially formulated to reduce the formation of cracks caused by hygrometric shrinkage in normal and self-compacting concrete.

Two Enormous Locks

The key elements of this project are the two enormous locks, one on the Atlantic coast and the other on the Pacific coast.

Work includes excavating and dredging the canal access on both sides for a total length of 11.2 km and a total width of 218 m.

The Canal today has two lock lanes. The new project consists of adding a third lane through the construction of two lock facilities. Every new lock facility will have three consecutive chambers named lower, medium and upper chamber regulated by four sliding gates, designed to move the vessels from the sea level to the level of Gatún lake (27 m) and back down again.

Each chamber will have three lateral water reutilization basins for a total of 9 basins per lock and 18 basins in total. Like in the existing locks the new locks will be filled and emptied by gravity, without the use of pumps (200 million liters for each crossing).

The new lock chambers will be 427 m long, 55 m wide and 18 m deep for a total length of 1.5 km. The two enormous reinforced concrete structures will be completed with a new canal access on the Pacific side. It will be the Italian company Cimolai, from Pordenone (Northern Italy), that will supply the new gates. Work will involve constructing 16 aluminium plate sliding gates, each one measuring 28 m in height, 58 m in length and 16 m in width.

The locks will be transported to Panama by sea and then installed on site between July 2013 and January 2014.

Above. For this building project Mapei developed a new tailor-made admixture: DYNAMON XP2 EVOLUTION 1. The concrete made with it features excellent workability and ease of application.

Cutting-edge Admixtures for Durable, Long-lasting Concrete

Mapei admixtures were selected to build all concrete structures including mass concrete as well as marine concrete, to be used to make the external sides and internal sides of the concrete locks, respectively.

The latest generation in admixture technology was introduced, and will be used to make 5,500,000 m^3 of concrete designed specifically for this grand structure.

The aim is to ensure, through special tests on concrete, that the building will last 100 years.

The first tests, carried out at the GUPC consortium site laboratory, started in Panama in September 2010.

Cement paste samples were tested to verify the compatibility and to find the best plasticising capacity of various samples of admixture in combination with the types of cement scheduled to be used on the structure (CEMEX cement, type II ASTM and Panama cement, type II ASTM).

In the first phase of testing, to overcome problems which arise when using complex raw materials (basaltic aggregates and basaltic pozzolan), admixtures from many other competitors on the international market were also tested. After numerous checks, carried out in the purpose-built Mapei laboratory in Panama, and then by cross-referencing the results with the GUPC laboratory, in mid December the admixture DYNAMON XP2 was judged to be the only solution suitable for use with the materials which had been actually chosen and which will be used in future on both the Atlantic side, where they are using Panama cement,

A BRIEF HISTORY OF THE CANAL

The Panama Canal is one of the most important feats of engineering in the world, and is a must for anyone visiting the city. It was dug out in one of the tightest points and in the lowest part of the Central Cordillera of the isthmus, which links the North American and South American continents. It takes a ship from 6 to 10 hours to navigate the Canal, which is made up of various elements: Gatún Lake, the Culebra Cut and the system of locks (Miraflores and Pedro Miguel on the Pacific side and Gatún on the Atlantic side). Gatún Lake, whose waters are fundamental for the functioning of the inter-oceanic waterway, was the largest artificial lake in the world for a number of decades. The locks system, which allows ships to carry out a change in level of 26 metres and so avoid having to circumnavigate South America, used to be the most imposing reinforced concrete structure ever built. Constructed by the United States between 1904 and 1914, it is 81 km long and is still a symbol of the strategic importance that the isthmus has maintained since the 16th century, and today is still one of the most important communications routes in the world.

Above. The two locks are currently being built, one is on the Atlantic Ocean and the other is on the Pacific Ocean. They are 1.5 km long and feature huge size. The sketches show a comparison between the existing locks and the new ones.

and on the Pacific side, where they are using CEMEX cement. This led to Mapei's winning the Short Term Supply Contract.

In early 2011, after starting production of the concrete and aggregates, several serious problems concerning a considerable loss of mechanical strength and durability in the concrete were solved thanks to the contribution of Mapei. In this phase, Mapei's support was concentrated on various activities: a study and new chemical and mineralogical characterisation of the raw materials used (fine sand, pozzolan and cement); technical suggestions and advice to help make a correct choice for the flocculating and coagulating materials used to treat the water for cleaning the aggregates; a chemical and petrographic analysis and control of the pozzolanic activity of the fine basalt sand to reduce or optimise its content of natural pozzolan.

Following a request from the client, Mapei then started to develop a new product which could work well with the new mix designs being verified at the GUPC laboratory. After an arduous competition, which included participants from our competitors, Mapei technicians managed to design a new, highly-evolved admixture called DYNAMON XP2 EVOLUTION 1, with the name chosen to give a sense of continuity to the enormous amount of work previously carried out on the old admixture. This product featured better maintenance of workability and application properties, in dosages even lower compared with the competitors.

The 21st of December 2011 is the date of the final contract for the New Panama Canal project. Formalised with the signatures of Giorgio Squinzi, CEO of the Mapei Group, and Bernardo Gonzales, Project Manager for GUPC, it represents a success story for Mapei. A victory which is the fruit of perfect team work and a consolidated modus operandi which included constant technical assistance on site to solve both large and small problems, and the decisive support of the Mapei Research & Development laboratories which investigated every material to find the most advanced technological solutions to make the best products.

TECHNICAL DATA

Panama Canal, Panama City and Colon (Panama)
Period of Construction: 1910-1914
Period of the Mapei Intervention: 2010-2014
Intervention by Mapei: supplying admixtures for the concrete used for building the new canal's locks and renovating the existing ones
Project: Mike Newberry (CICP, Panama), Bernardo González (Grupo Unido Panama Canal, Panama)
Client: Administración Canal de Panamá
Contractor: GUPC (Grupo Unido Panama Canal), including Impregilo (Italy), Sacyr Vallehermoso (Spain), Jan de Nul (Belgium) and Constuctora Urbana (Panama)
Works Director: eng. Bernardo Gonzales (GUPC)
Mapei Distributor: Mapei Construction Chemicals Panama S.A.
Mapei Coordinator: Roberto Saccone, Mapei SpA (Italy); Thomas Lundgren, Mapei Corp. (USA)

MAPEI PRODUCTS

Preparing the concrete mix for the renovation of existing locks: Planitop 15 (only distributed on the America contents by the Mapei Americas subsidiaries) and Mapecure SRA
Preparing the concrete mix for the construction of the new locks: Dynamon XP2 and Dynamon XP2 Evolution 1 (specially developed by Mapei for this project)
For further information see www.mapei.com.

The article courtesy of Realta Mapei International no.40

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epretech@easternpretech.com.sg
www.easternpretech.com.sg

Precast Concrete Projects References:

ITE Hub at Ang Mo Kio

JCube at Jurong East

Office at Tampines Grandes

Mapletree Business City at Alexandra

Skyline Condo at Angullia Road

Ardmore 7 Condo at Ardmore Park

PBU for Oceanfront Condo

PBU & Precast for N V Residence

Think Precast ...Think Eastern Pretech
Your Precast Concrete Partner & Supplier

EXCEL PRECAST PTE LTD
WE DELIVER PROMISES

Precast concrete is a construction product produced by casting concrete in a casting yard with reusable mould which is then demoulded, stored, transported to the construction site and installed into the designated position. This prefabrication method will speed up the total site construction with high quality and consistent products and less labours on site that will increase the productivity and higher cost savings.

The growth of Excel Precast

As a young company that started in 1999, Excel saw this period of low demand as a blessing in disguise. Reputation is of utmost importance in the construction industry. Few customers would have used the services of a precaster without a track record for fear of potential inferior products. This was a perfect time for Excel to carve out a name as a committed solutions provider that delivers its quality products.

It worked. Excel began to gain the trust of clients and won projects for factories and the Housing Development Board's (HDB) upgrading programmes. When construction demand finally picked-up towards the end of 2007, Excel was well-placed to secure more HDB Built-to-Order projects.

At the same time, not wanting to become over-dependent on public housing projects, Excel started to expand its portfolio by diversifying into private residential properties, institutions, industrial properties, commercial buildings and military buildings.

To increase Excel's production capacity, a decisive move was made to trade in its two-hectare land in Tuas for a three-hectare property in Tampines, where it is now located. The Tampines factory is equipped with six production lines and lifting machinery alongside a computerised concrete batching plant of the latest standards.

Soon after, a bold decision was made to set up a production facility in Johor Malaysia, to further boost Excel's output. This factory was subsequently expanded to four hectares as Excel foresaw an upsurge in the Singapore construction market.

The Johor precast plant played an instrumental role in many of Excel's large scale

projects. In 2008, Excel managed to secure its then biggest HDB project for a site in Punggol East with a concrete volume of about 18,350 cubic metres. This contract was a significant milestone for Excel - not only because of its size, but also because it underscored the client's belief in Excel's capabilities.

The Punggol East project also made Excel the pioneer in supplying precast for HDB projects from Malaysia. Above all. it has proven hard to sustain competitive advantages in the precast industry. For instance, expansion into Johor gave Excel access to lower land costs and relatively cheap labour. Once the venture proved to be successful however, competitors started to rush in.

An award-winning company

Today, Excel has a solid reputation for delivering quality products, and offering innovative and practical solutions through its design capabilities. The company has received numerous certifications and awards such as ISO 9001:2008, IS014001:2004 and OHSAS18001:2007, bizSAFE Star, bizSAFE Partner.

Moreover, Excel had been awarded the 2011 Successful Entrepreneur Platinum Award, the Circle of Excellence COEIREI 2011 /2012 Singapore's Top 10 Building Material Firms Award, Singapore SME 1000 Award 2011 for highest turnover growth, the 2011 and 2013 Enterprise-50 Awards.

Excel's value proposition

Despite the constraints and challenges, Excel has managed to emerge as one of the best precasters in the field. A lot of things are not within our control but those that are; we will make sure we do them well.

This philosophy has not only brought Excel far in the on-going upturn, it can also be counted on to shelter the company from any upcoming downturns.

One of Excel's key success factors is its client-centric mentality. "We make it a point to be personally involved in our customer's meetings," Mr Tan, the CEO of Excel Precast, said. Excel works closely with its clients to break down an architectural design into replicable segments suitable for precasting. But Excel does not stop here. Through its "design-and-build capabilities", it goes one step further to suggest modifications, to make the design more precast-friendly. This maximises the utilisation of every precast mould and

helps customers get the most out of every-cent.

Quality is important

By getting involved in the planning process, Excel ensures that whatever it produces meet customer requirements, hence minimising re-work costs. But more importantly, Excel's belief in maintaining close touch with its clients in all projects has enabled the company to build a loyal customer base.

"Excel is not just a manufacturer. We are committed and that means doing the best job with the least errors. It is ensuring quality, not quantity. One of our key performance indicators is mistakes-reduction. We want to do better," said Mr Tan. This is the corporate spirit that underlies Excel's drive to produce only the best all these years.

Building Information Modeling (BIM)

Excel Precast is one of the pioneers in Singapore as a precaster that implement BIM Software. From the Design and Shopdrawing Submission the BIM Software helps to present quality with high integrity and accuracy of drawings. Not only 3D-drawings produced by BIM for better visualization but also to check the workability and clash detection. The Production has the system to check and maintain the quantity and quality of our products.

Green Products

Excel Precast is one of the pioneers for green concrete precast products.

One of the projects using green concrete is the IES Annex Building at Bukit Tinggi Road. The structural components like columns were being introduced.

Research and development

Closely associated with Excel's commitment to quality is its research and development (R&D) methodology. R&D in Excel takes two forms: first, technical R&D such as the use of new production planning software and second, the simple motivation to find better ways to do something.

In particular, the computerised concrete batching plant in Excel's Tampines factory plays an integral part in its R&D efforts. The facility makes it possible for Excel to produce its own special concrete mixes, rather than being limited to ready-mix concrete. This is important as different mixes have different characteristics and applications. R&D in the area of concrete opens up new opportunities for Excel. For instance, Excel can now take on projects with special technical requirements.

Solutions identified via R&D can also lead to large savings. One example is Excel's experience with concrete pinholes. When cement reacts with water, gas is produced and small cavities known as pinholes form in the concrete. Pinholes are undesirable and require additional surface touch-up. Through extensive knowledge sharing and brainstorming, Excel's staff managed to find a way to reduce the number of pinholes. The amount of touch-up required decreased and Excel enjoyed savings in time, material and labour as a result.

Commitment

As a growing company with proven prestigious awards, Excel Precast always delivers promises and will strive as a key player in the precast concrete construction industry and is established with one of the most advanced infrastructure to answer the needs for quality precast construction, effectively, efficiently and speedily.

Excel
Precast
Pte Ltd

PRODUCT QUALITY & SERVICE EXCELLENCE

- Quality product assurance
- Fast & accurate product deliveries
- Cost-effective designs & solutions
- Handle projects with full commitment
- Engage new technology (BIM) for shopdrawings
- Improve production process and innovative new products
- Produce 'Green Concrete' precast products

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10% COST SAVINGS ON SINGAPORE'S BIGGEST TUNNEL

HOW WE'RE ADDING VALUE

Our innovations on Singapore's Marina Coastal Expressway have enabled faster, more efficient construction while meeting the state's famously tough safety requirements.

Singapore's Marina Coastal Expressway (MCE) is a game changing project. Built mainly in tunnel, the 5.1km long, dual five lane highway will link existing expressways in east and west Singapore with the New Downtown area in Marina Bay. The city state has become famous for mammoth cut and cover tunnels in the soft ground close to its reclaimed shoreline. But with a width of 60m, this project is "considerably bigger and more challenging than anything that's been done here before," says Mott MacDonald geotechnical manager Dr Nick Mace.

We have worked closely with two contractors to review conventional construction methods and develop more efficient alternatives that have enabled nearly 3km of tunnel to be delivered safely, with cost and time savings. Our successfully proven approach is likely to become standard practice on future tunnelling projects in similar conditions.

SOFT GROUND TUNNELLING CHALLENGE

Cut and cover excavation involves installing temporary longitudinal retaining walls and then excavating the ground between them. A reinforced concrete base slab, permanent side walls and a roof are then cast in the excavation before ground is reinstated over the top. The method can become complicated in soft ground.

MCE traverses an area of man-made land consisting of 30-40m of marine clay, underlain by firm Old Alluvium and capped with 15m of fill. To ensure safety in such conditions, client body the Land Transport Authority (LTA) has set stringent requirements for temporary works, including geotechnical parameters, retaining wall sizes and ground improvement.

BETTER VALUE FOR THE PUBLIC PURSE

When design and build contracts for MCE were put out to tender in 2008 the indicative design required that lateral deflection of the retaining walls would be no greater than 75mm. To achieve the target, the LTA required two layers of ground improvement underlying the formation level, founded on bored reinforced concrete piles. Sheet pile retaining walls were to be supported from in front by I-section soldier piles toed into the Old Alluvium.

In addition, the retaining walls were to be propped as excavation advanced with five layers of struts at depth intervals of 3m.

We teamed with contractors Samsung and Ssangyong to bid for four of the six MCE packages. A combination of innovations pared more than 10% off the client's cost estimates for contract 482 won by Ssangyong and contracts 483 and 486 won by Samsung.

40% SAVING ON PILES

A stiff layer was created at the base of the excavation using a ground improvement technique known as deep cement mixing (DCM). Underlying this layer are bored reinforced concrete piles. On most previous cut and cover projects in Singapore, engineering solutions have considered the performance of piles in compression only. "But the piles work in tension too," Nick notes. "Analysis showed that uplift exerted by earth pressure on the DCM layer would cause it to heave and bend. But we found that this was reduced by the action of the piles in tension. This is something that's usually ignored – but by making the piles stiffer, we were able to anchor down the DCM layer."

Stiffening the piles required additional reinforcement. To avoid unnecessary use of steel and resulting cost, we analysed the forces acting on every one of the 2500 piles across all three contracts. Normally, reinforcement would be designed to cope with the maximum load and applied to each and every pile. Instead, "we assumed a minimum and worked up from there," Nick states. This delivered a 40% saving on steel reinforcement across the project.

US$70M SAVING ON STRUTS

In another departure from convention the contractors proposed constructing retaining walls using 1.2m to 1.5m diameter pipe piles instead of the common sheet and soldier pile combination. "Pipe piles are far stiffer, making it easier to comply with the LTA's very tight wall deflection criteria," Nick explains. "Their structural strength would in theory have allowed us to eliminate all but one layer of struts from the temporary works. In the context of the prevailing industry culture, we elected not to push for this option, but strongly argued against using the four to five strut levels specified in the indicative design. Two levels were more than adequate."

With the first strut level just below ground level, the second was installed at mid-height, 7m down, with deep level restraint provided by the massively strong DCM ground improvement layer. On each contract, the elimination of every strut layer has saved almost US$24 million, yielding a US$70 million combined benefit. Reducing the number of struts from five to two layers has offered a huge time saving and dramatically improved worker safety, with lifting and manual handling operations cut by 60%.

Productivity has been improved by creating more working room. Construction equipment can move freely within the excavation. And concreting operations have been simplified: "Normally the lowest layer of struts would be just above the final formation level so you'd be laying reinforcement and pouring concrete for the base slab around a grid of temporary steelwork," explains Nick. "On MCE, there was 7m clearance between the base slab and the nearest struts." The reinforced base slab of the highway tunnel effectively acts as an additional strut and we showed that the second level of steel struts could be safely removed once it had been created. This allowed the tunnel's permanent reinforced concrete side and central walls to be created in single full-height pours. "Normally you'd be creating the walls in 3m lifts, each advance being restricted by the next layer of struts," Nick explains. "This has enabled us to advance faster and reduce the number of cold joints, which benefits the strength and durability of the finished tunnel."

34th SCI Anniversary Gala Dinner
Theme: "Sustainable Concrete Innovation"

Held on 16 November 2012 and more than 350 professionals attended the dinner at the Swissotel Merchant Court Singapore.

Highlights of the event:

Presenting the plaque to main sponsors


SINGAPORE
CONCRETE
INSTITUTE

The world's first Multi-Storey Aircraft Carousel Storage & Parking System

Developer Mr. Beng Keat Khoo, MAJ Aviation Pte Ltd.
Lead Design Consultant: Mr Florian Schaetz, Assistant Prof NUS, Schaetz Design & Construction GmbH (Germany)
Structural Engineer: Mr Uli Schaetz, Schaetz Design & Construction GmbH
Mr. Adrian Huang, JHA Partnership
Project Architect: Mr. Bernard Hon Wui Khong, Principal Architect, H.Mill Design + Architecture LLP
Carousel Contractor: Mr Isaac Yeo, Chong Fong Engineering Pte Ltd.
Main Contractor: Ms Pauline Chan , Executive Director CCM Industrial Pte Ltd
Contact: www.aircraft-carousel.com

INTRODUCTION

Innovation: The world's first vertical aircraft parking system has been in operation since February 2012 at MAJ General Aviation Center located at Seletar Airport in Singapore. Measuring only 22 m in diameter, the carousel's footprint covers an area of only 500 m2 and allows parking of up to fourteen aircraft on two decks. It works like a large 'Lazy Susan', allowing any aircraft parked to be extracted when required within 1min 26sec only. Parking the aircraft on two stories of independent rotating discs, allows a reduction from 100 m^2 per aircraft in the conventional parking space to 35 m^2 per aircraft. Through this world's first vertical storage system, the parking capacity is tripled over the same land area. Due to its innovation, compactness and light weight filigree concrete structure, there is sufficient saving in costs, labor and energy.

THE CHALLENGES

One of the key criteria that JTC & EDB decides for Direct Land Allocation (DLA) of land in SAP (Seletar Aerospace Park) is for MAJ Aviation's Facility Plan to demonstrate a substantial intensification of land usage; in especially so where MAJ is not an existing incumbent in Seletar, and neither is it directly bringing in major foreign investments to Singapore.
Problem: Create a value proposition to maximize the aircraft parking facilities at the Seletar Airport with a limited plot of land available. For wanting to demonstrate the land intensification, MAJ decided to go beyond the norms of compact parking adopted elsewhere in the world. It places a challenge on itself to triple the number of aircraft it could accommodate in a given footprint. This leads to a structural design challenge to build the most ecological, economical and feasible concrete filigree structure that can hold the maximum of vertical loads and transfer its rotation moments within the structure.

SOLUTIONS

MAJ appointed Schaetz Design and Construction GmbH to design a very innovative, functional and cost saving solution to increase the parking capacity through a 2 level vertical stacking of aircraft.

The final design is a pre-stressed concrete filigree framework capable of carrying 54 tons. With a see-through metal mesh rotary disc, it becomes a fully mechanized parking system for light general aviation aircraft, helicopters and small business jets up to 14.5m wingspan and 3.5 tons take-off weight. Aircraft can be easily parked, relocated and safely handled on two levels at any position within 2 minutes. Aircraft can also be assessed by the hydraulically operated vertical scissor lift, which fetches the aircraft 7m vertically to and fro between the mezzanine level and the ground level.

Requiring only 1min 26sec per complete rotation, the handling time to park one of 14 aircraft is vastly reduced to optimize efficiency, whilst conventional parking system would require up to 4 to 5hr hour. The

carousel is easily operated by a switchboard and is CCTV monitored. It allows the operator to move the carousel precisely to the centre of the hangar opening.

Advantages of Proposed Solutions: The innovative design not only helps to increase the storage space for aircrafts by 300%, it also allows for a 95% decrease in time spent for parking and retrieval of aircraft. The removal of an aircraft from its parking space also quickens by five-folds in this new system. The land occupation by the hangar is brought down from 1200 m2 to 450 m2 (267% savings) as compared to conventional hangar parking.

Construction: The total weight of only 54 tons is distributed over 18 self-lubricating load-bearing rollers on each level, which are anchored by Halfen-Tracks into a pre-stressed concrete ring of only 45/60cm x 90cm dimension and a 25cm diameter central column. The ball bearing rollers allows the light weight carousel to rotate effortlessly.

The rotating discs which are mounted on each level's column and pile cap, bears the weight of the steel platform. The portal doorframe in only a 5mm pre-stressed concrete beam that spans just over a regular wing span of 14m, and allows the lower aircraft to ingress and egress into the lower carousel. Besides the weight of the upper carousel, the construction also takes into consideration, the vertical rotation moments of the system when the only 3KW motor is running. Only nine supporting pillars are placed around the upper ring beam to bear the weight of the upper ring beam, the upper steel deck as well as weight of the seven aircraft. The upper ring beam and the supporting pillars act as a weight-bearing structure without additional bracing. Three steel tie-rods help to keep the central 25cm concrete column in place. The system works as a wheel spoke with a central spine. The supporting pillars are not placed around the doorframe to allow for free movement of aircraft into the storage device or movement of aircraft out of the storage device. Here the "doorframe" takes the place of the omitted support pillars to bear the weight of the upper ring beam as well.

Structurally, the exposed steel members and the concrete ring beam are pre-tensioned and curved slightly upwards to carry loads of up to 54 tons. The turntable is powered by two single phase electrical motors, each on one level. Furthermore, besides the dead weight of 40 tons of steel, the design team had to cater for different weight distributions across the disc to accommodate the different types of aircraft parked on the same plane. Despite the reduced weight of the carousel, the turning system has been engineered to keep friction to a minimal, such that in manual reversion mode, it can be operated by less than five people, even with full load.

FerroLite partition wall

Leader : Heru Santoso Soedarsono
Members : Ms Angelina Ngen
Email : an15@hdb.gov.sg

INTRODUCTION

Faced with the challenge of continually meeting the housing needs of the nation's rising population, HDB has embarked on the construction of taller buildings to deliver more homes faster in land scarce Singapore. With over three decades of experience in precast concrete technology, HDB has succeeded in developing and refining its own concoction of semi-precast system to achieve high quality and construction productivity in the development of these high-rise buildings.

THE CHALLENGES

In order to increase construction productivity and reduce our reliance on raw materials like cement, sand and aggregates, there is an urgent need for HDB to continuously enhance the design and construction of prefabricated housing. One of the precast components identified is the internal partition walls within the dwelling units. The current partition wall systems implemented at HDB sites comprises concrete based normal weight concrete partition wall system and hollow blockwall/ brickwall.

These non-structural load bearing partition walls make up to about 10% of the total precast components per dwelling unit and the amount is substantial when considered in the whole building contract. Furthermore, coordination between the suppliers and the contractors is also crucial as some of these precast elements are in the critical path of the construction schedule. Therefore, timely production and delivery of precast components, sufficient site storage and erection works on site must be closely monitored. Other than the main focus of improving construction productivity when sourcing for an alternative partition wall system, there are other key factors to be considered, e.g. eco-friendly, lightweight, ease of production and installation, flexibility in terms of application, etc.

There are many types of partition wall systems available in the market and each has different levels of performance standards. However, these types of partition wall system are not suitable to be used in HDB contracts. Some known limitations are:
1) Costly (proprietary product)

2) Hollow sound

3) Not fire rated

4) Not water resistant

5) Durability

6) Difficulty in handling

Most proprietary partition wall systems are manufactured overseas and special orders or modifications need to be made to suit HDB's requirements. For over two years, the project team has been working on an R&D project to develop an alternative partition wall system since 2005. Exhaustive performance tests have been carried out on the proposed system to ensure that it can meet the design criteria and performance requirement. The main performance criteria set when developing the new partition wall system are as follows:

a) Incorporation of precast technology.

b) Cost effective and ease of prefabrication locally.

c) Able to accommodate concealed services.

d) Enable easy installation on site with minimum supervision required.

e) Lightweight and at the same time able to achieve the required performance strength.

f) High quality finished surface.

g) Non-critical component in terms of activities specified in the construction schedule.

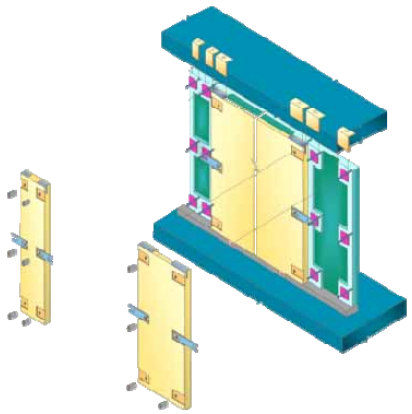
h) Flexibility in the application of the system.

i) Reduction in the use of raw materials.



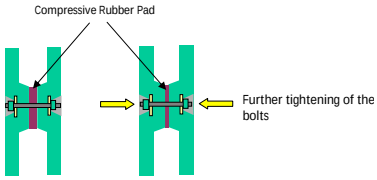
SOLUTIONS

The FerroLite partition wall system is invented by HDB to provide a sustainable and economical solution for internal partition walls in HDB buildings. It was designed and developed at the onset to improve construction productivity and reduce our reliance on raw materials.



FerroLite is a partition wall system made of precast ferroconcrete panels. The panels have an overall thickness of either 75mm or 90mm and can be set side by side to form up a whole partition wall. Ferroconcrete was selected due to its resilient property to achieve precast panels with thin sections without compromising overall compressive strength. Notably, unlike conventional concrete, large coarse aggregates are not required in the mix design. With thinner section, steel reinforcements required are also reduced. Each FerroLite modular wall panel is made up of two individual components (20mm thick each) bolted together to form a wall with a 30mm hollow core to reduce weight and raw materials. The hollow core also has other functional purposes, for example, improved airborne sound resistance and concealment of services. In terms of its acoustic performance, 75mm thick and 90mm thick FerroLite provides a Sound Transmission Class of 41dBA and 44 dBA respectively.

The wall's main unique feature is the ability for fine adjustments of overall wall thickness through varying of the torque of the bolts. This is to facilitate "on-the-fly" adjustments during installation works for improved alignment with adjacent wall panels erected, thus achieving better flatness of the partition wall.



Adjustment of wall thickness by varying the torque applied to the connecting bolts

With the introduction of standardized modular sizes, the walls can be easily produced in a factory using steel moulds which can be reused for at least 1000 times when manufacturing the wall panels.

Extensive R&D studies have been carried out and vigorous performance tests conducted on the "FerroLite Partition Wall System" at accredited labs in accordance to relevant Test Standards. This is to ensure that it meets the high performance standard required for HDB buildings. The FerroLite has been tested to be in full compliance with SS492 and BS5234 Part 2:1992 standards to ascertain its capability in resisting heavy impact forces and fixtures loading e.g. cabinet and cupboard loads. Other performance tests such as fire resistance, water tightness and joints performance were also conducted to ensure robustness of the wall system.

The FerroLite wall has bee adopted in HDB residential projects as internal partition walls, mainly at bedroom/ living room/ dining and also wet areas and corridor partitions.

Factory Production of FerroLite Wall System

Design and build a SRC Seawater Intake Relocation Project for Singapore Refining Co Pte Ltd.

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INTRODUCTION

Our Client proposed to construct a new seawater intake facility in its refinery complex located at 1 Merlimau Road, Jurong Island, Singapore 628260.

The facilities include a 4 compartment seawater intake pit with 3 seawater pumps and 5 firewater pumps. The deep seawater pit will be constructed as an intake point to convey seawater to the various process units for operational use as well as for fire-fighting purpose.

The size of the onshore portion of the pit is 17m X 17m with a depth of 8.5m. The design features an intake channel in the form of a 28m offshore extension.

Each compartment of the pit is fitted with stoplog gates, a bar screen and a travelling screen.

THE CHALLENGES

To deliver the project in an effective and efficient approach with consideration of safety, quality and environmental concern.

- Interface - complex activities with interface of various work sequence
- Schedule - tight schedule requires close monitoring and control
- Offshore coffer dam - hazardous working conditions
- Formwork – conventional timber formwork requires huge amount of material and labor.
- Quality – high wall concrete casting will affects quality and finishing
- Communication within project stakeholders for any document updates, revisions and announcement

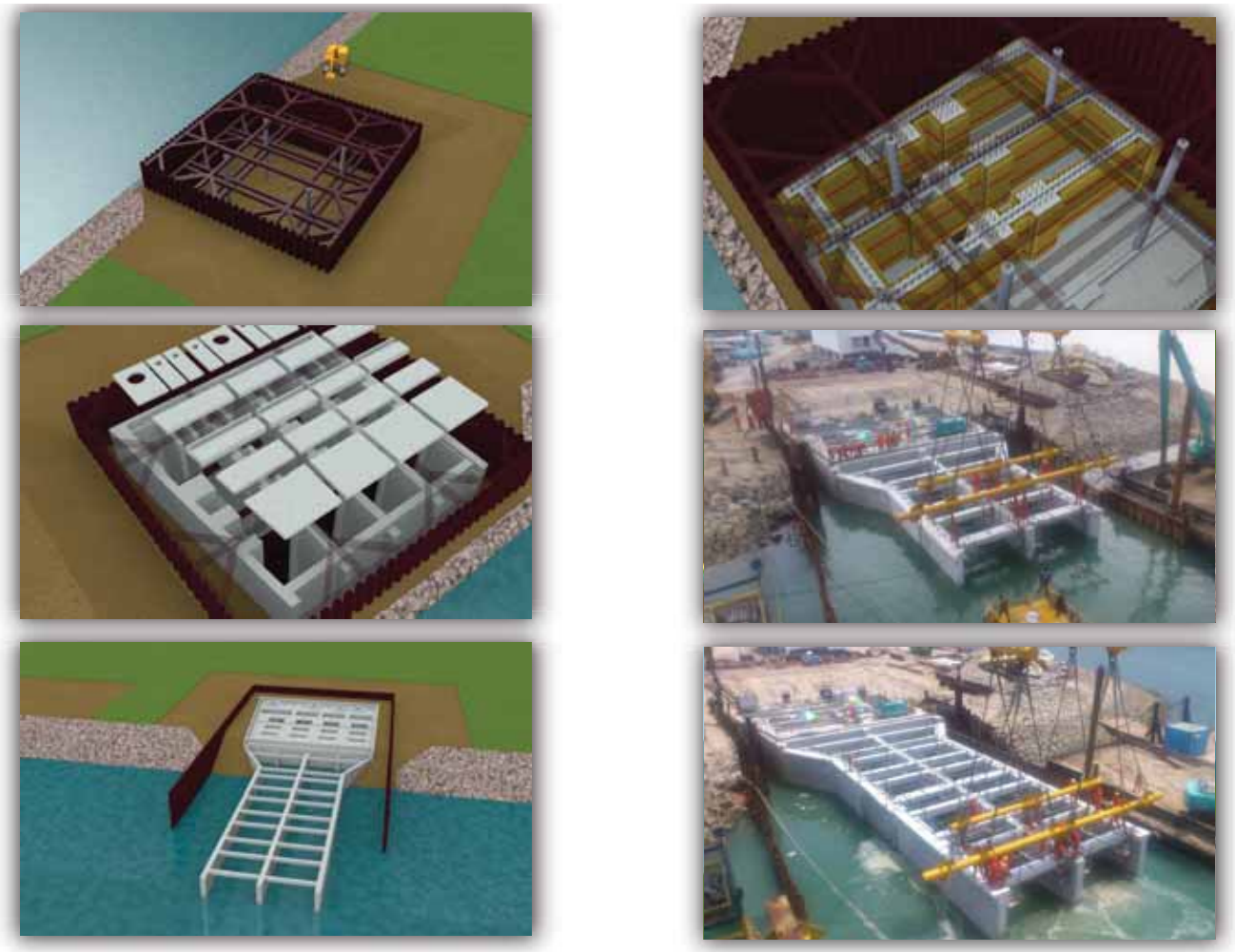
SOLUTIONS

HSL Team SRC PNSIP brainstormed on the various challenges and worked on thefollowing solutions and mitigation measures to ensure project execution efficiency, safety and ensuring successful completion.

- Interface – Due to complexity of the work interface, the project team developed a 3D animation of the complete construction work sequence and share with all project stakeholders, including clients, consultant, vendors, contractors and workers. This had greatly helped improving the clarity of the intended work sequence and anticipating the various interfacing and execution challenges. (Appendix 3)
- Schedule – HSL combines the use of the Primevera scheduling tool and 3D construction sequence animation to develop a 4D concept. The 4D animation will display the work sequence with a schedule component. The program can detect any delay in the baseline vs actual in the schedule. (Appendix 4)
- Offshore structure – Use of precast structure each weighing 240 ton (5 pcs) instead of casting in-situ will allow both onshore and offshore works to be carried out concurrently.
- Formwork – Use of system formwork (PERI) to enable speedy formwork set-up ensures better finishing and formwork material wastage.

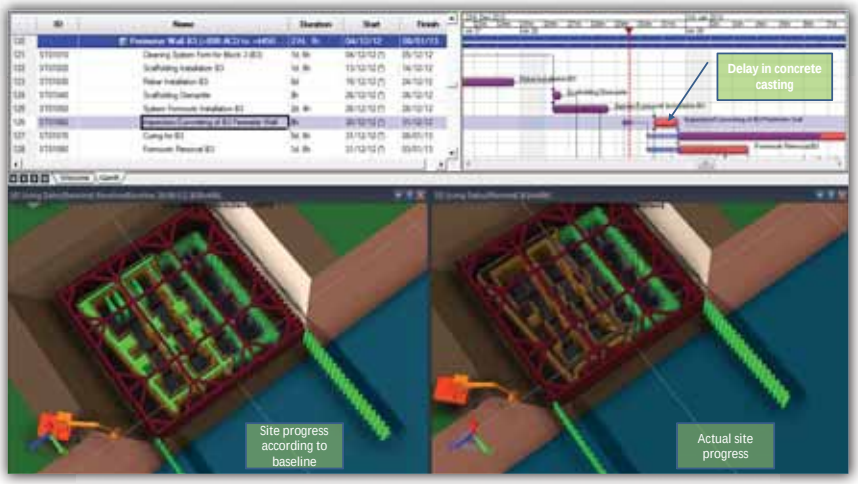
HSL – SRC Process North Seawater Intake Project

Stills from 3D animated construction work sequence



Quality - Self-compacting concrete needs no help in spreading, leveling and compacting, as it flows like a liquid during concrete placement. This improves productivity and quality.

Communication – Microsoft Sharepoint Online for project portal. Document transfers are paperless, fast, and efficient. All comments and revisions are handled via the project portal.



GMR Energy 2X400 Mw CCP Project – Offshore Civil Package

Team Leader: Ye Genjin
Designation: Project Manager

INTRODUCTION

As part of the newly developing Combined Cycle Power Plant at Jurong Island in between Oil Tanking and Power Seraya Power Plant, HSL is constructing the following;

1. Circulating Water Intake Structure

Size: 61m x 14.9 m x 14 m
Structure Details:
- 73 nos of 900mm Soft Primary Secant Bored Pile
- 73 nos of 1500mm Hard Secondary Secant Bored Pile

2. Discharge Outfall Structure

Size: 32.4m x 17.5 m x 11.7 m

3. Underground Concrete Box Culvert – Single and Double

Single Box Culvert
Size: 63.2m x 2.9 m x 3.15 m

Double Box Culvert
Size: 83.2m x 5.35 m x 3.15 m

4. Marine Offshore construction of Intake Pipe Header – 2 nos

Size: 10.5 m x 10.5 m x 8.45 m with a maximum weight of 116 tonne/piece

5. Onshore and Offshore GRP pipe Installation

Onshore GRP:
- Diameter: 2m
- Total Length: 186m
Offshore GRP:
- Diameter: 3m
- Total Length: 370m

6. Seabed Dredging Works

Total dredging Quantity is around 38,000m^3.

7. ERSS for Offshore, Onshore Works as the excavation depth is more than 5m.

THE CHALLENGES

To deliver the project in effective and efficient approach with consideration of safety, quality, environmentally in a most cost effective manner and on time.

Intake Header
- Concrete structure to be constructed in the sea
- Correct fitting of different pieces
- Heavy Lifting of the precast pieces
- Installation of the Intake Header Base out in the sea at the correct coordinates
- Hard soil at the intake header location (SPT >100)

Box Culvert
- High Ground Water Table

Onshore 2m Diameter GRP Pipeline
- Installation of Pipe with Earth Retaining or Stabilising Structure (ERSS)

Offshore 3m Diameter GRP Pipeline
- Largest Glass Reinforced Pipe (GRP) to be installed in South East Asia.
- Low visibility during pipe installation both within sheet piling area and the open cut trench.
- The pipeline is buried at depth of up to 25m below the sea level and this greatly reduces the dive time for the divers for installation of pipe.
- Installation of Pipe within ERSS
- Tight schedule with regards to ERSS works
- Installation of pipe in the sea according to coordinates
- Buoyancy of pipe during backfilling
- Installation of Chlorination pipe inside the pipeline

Intake Structure
- High water table poses challenge for excavation and dewatering
- Excavation of pit consisting of sand, marine clay and water causing a mixture of

sludge
- Construction of 500 mm thick Skin Wall 14 m high
- Installation of Connection Pipe within ERSS

Outfall Structure
- Dewatering as the structure sits on both the land and sea side
- Construction of Concrete Structure in Offshore
- Protection/prevention of water pollution (of silt) during the work
- Close proximity to the existing PUB pipeline.

SOLUTIONS

Intake Header
- The individual pieces will be precast and installed separately.
- Metal formwork will be used to cast the fitting of the individual pieces.
- Metal steel plate with frame which is similar with the precast base slab was used to help divers to survey the evenness of sea bed before the heavy lifting;
- Detailed planning utilizing heavy crane on both the land and sea side.
- A metal structure will be constructed to be used for the tie-in between the offshore GRP pipe and the intake header base with buoys attached to this metal structure to identify the coordinates for installation.
- Buoys are used as guide piles instead of driving I-beams due to the hard layer encountered.

Box Culvert
- Creating a drainage system within the trench and installing suitable pumps to direct all the water out of the trench.

Onshore 2m Diameter GRP Pipeline
- The ERSS with strutting is designed to accommodate and allow ease of installation of the pipe.

Offshore 3m Diameter GRP Pipeline
- The ERSS with strutting is designed to accommodate and allow ease of installation of the pipe.The first piece of GRP pipe elbow is tie back to I-beams installed which allows the pipe to be fixed to the coordinates. Concrete blocks with buoys are installed along the pipe line with sufficient offset using a crane barge with GPS. Buoys are installed along the pipeline concurrently with pipeline installation which becomes surveying points or markers to identify the exact coordinates.
- Divers are equipped with camera as part of their diving gear which allows the dive master on the barge to gain control of the operations in the sea.
- Diving operation is planned according to daily activities so that the divers achieve the maximum productivity and efficiency during the short period of time in the sea. Divers usually work in pair and their dive may sometimes be staggered at different timing so ensure continuous work progress and proper handover to the next pair of divers.
- 2 nos. of 1 ton sand bag were laid cross over along the GRP Pipe line every 8 meters to prevent the buoyancy movement during the SC1 material backfilling.
- Excavator with vibro is mounted on the flat top barge is used to drive offshore sheet piles.

Intake Structure
- Use of DOKA System Formwork
- Engineering calculation done to use suitable pumps for removal of high volume of water
- Construction of a layer of hardcore at the depth of the intake structure where the sludge mixture is present
- Sump pit constructed to install large capacity pumps to remove the high volume of ground water and sea water.

Outfall Structure
- The outfall structure will be cast using Self-Compacting Concrete (SCC)
- Silt curtain will be installed
- Markers piles and guides beams are installed to identify the boundaries between the structure and the PUB line.

Microsoft Online Share Points
- Helps all parties of the project to get the update through their account so that no information is missed out or preventing usage of obsolete drawings.

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SINGAPORE CONCRETE INSTITUTE

Using Nondestructive Testing as an Inspection Tool in Structural Evaluation

Keynotes by recognized Industry Experts

Thursday, June 27, 2013

Supporting Organisations:

BCA

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SP School of Architecture & the Built Environment

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SETSCO

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AGENDA & SPEAKERS

08:15 - 08:45	Registration, Guests to be seated
08:45 - 09:00	Welcome Note
09:00 - 10:30	Presentations Part I
10:30 - 10:45	Tea Break
10:45 - 12:00	Presentations Part II
12:00 onwards	Lunch

Mr. Malcolm Lim is the General Manager of Proceq Technical Services, USA, providing the highest quality of nondestructive testing consulting and engineering services. Mr. Lim has over 25 years of experience with nondestructive testing and evaluation. His expertise includes Strength Testing, Impulse Radar, Impulse Response, Impact Echo, Optical Fiber-scope, Infrared Thermography, Ultrasonic Thickness measurement of metals, Ultrasonic Testing of concrete as well as state-of-the-art techniques, such as corrosion measuring devices and other electrochemical methods.

Mr. Ong John Wei has been with Setsco since 1989. He is currently the head of department for Structural & Integrity Testing Department. His expertise is in the use of various basic and advance NDT tests in structural investigation on building and civil structures. He has been involved in investigation works such as building audit, bridges, marine structures, fire damaged building, concrete repair projects, concrete failures, etc. locally and overseas.

Mr. Ng Kam Leong Senior Manager, joined Building & Construction Authority in 1990. He is presently involved in quality development such as ISO certification and construction quality assessments. He is a qualified ISO 9001, ISO 14001, OHSAS 18001 auditor and CONQUAS assessor. He is also in-charge of the SCI's precaster accreditation scheme.

Dr. Sabet is senior structural engineer at Precast Design Consultants Pte Ltd. As a concrete specialist, Dr. Sabet has extensive background in concrete related research and designing concrete mixes to provide ultimate strength and long-term durability for various structures. Dr. Sabet has been involved in the design of concrete mixes for various challenging onshore and offshore projects where long-term performance and durability of the concrete structures are critical. Previously, Dr. Sabet served as a Research Fellow in the School of Civil & Environmental Engineering at the Nanyang Technological University. Dr Sabet is currently serving as 2nd Vice President of Singapore Concrete Institute.

Mr. Fong Weng Khiong is a Director of a consultancy firm, Ascent Facilities Engineering Pte Ltd, specialising in inspection, evaluation and remedial measures of structures. Prior to setting up the company in 2004, he worked as a graduate engineer from 1991 to become the Singapore office manager of Taywood Engineering Ltd (UK) in 2000. He was Head of Department, Building Performance, at SETSCO Services Pte Ltd, from 2000 to 2004. He has inspected more than 100 projects to date, dealing with problems in new construction as well as existing structures affected by deterioration. His expertise is in assessment of deteriorated concrete structures, mitigating and providing repair proposals.

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PRESENTATIONS

How to define a crack, void or honeycombing in concrete structures with UPV (Malcolm Lim)
Ultrasonic Pulse Velocity testing is a useful tool used in the evaluation industry to determine anomalies in concrete structures. Understanding the basics theory of UPV and how to apply the testing principals of the method is critical in the evaluation process. Once the testing is complete, analyzing the data and presentation the results in a easily understood format is another key element that will be discussed. The presentation will also include a case study where known anomalies were missed by misreading the data.

Basic and Advance Non-Destructive Tests on Concrete Structures (Ong John Wei)
Non Destructive Testing (NDT) are techniques in obtaining information on the properties of the concrete structure, in particular the in-situ concrete strength, layout of steel reinforcement and pre-stressed tendon, uniformity/ integrity of concrete, etc. The use of NDT is popular and economical as it cause no or minimum damage to the tested concrete structure. It is important to understand the various test methods available, their limitations and knowledge of the relevant standards and specifications in the selection of the appropriate NDT for the specific application such as in quality control tools during/after construction and in the assessment of old structures that are to be modified or have been damaged.

NDT in the CONQUAS Concrete Structural Assessment (Ng Kam Leong)
Two NDT assessments on the finished concrete, concrete cover and concrete consistency, are assessed under the BCA CONQUAS structural assessment to determine the workmanship quality of the concrete works. This presentation will cover the NDT sample selection, sample assessment size and assessment criteria.

Understanding pore structure of concrete in relation to durability testing (Dr. Sabet)
Pore structure of concrete is one of the most important parameters affecting the strength and durability of concrete. Various test methods such as Rapid Chloride Permeability Test (RCPT), Rapid Chloride Migration Test (RCMT), Direct electrical resistivity test and 4-point Wenner Probe were used to indirectly correlate the movement of ions and electrical charge in concrete with pore structure of the concrete. It is very important to understand the basic principal of these techniques to benefit from their potentials and to avoid mistakes in measurements.

Field and Laboratory Testing and Durability Investigation of a Pier Structure (Fong Weng Khiong)
A durability investigation of a 30 year old barge pier structure located in a tropical marine environment was carried out. The principal problems reported were spalling and cracking of concrete on the reinforced concrete under-deck and pitting corrosion on the steel piles. Various field and laboratory tests including extraction of concrete core samples, impact echo test, measurement of concrete cover, electrical potential measurement, chloride measurement and petrographic examination of concrete samples were carried out. Using the measured profile of the chloride concentration levels, a service life prediction of the time to initiation of corrosion and cracking was carried out in order to provide a predictive indication of the stage to which the deterioration of concrete had reached. Different rehabilitation options including conventional patch repairs and cathodic protection were then considered. Tradeoffs between costs and frequency of repairs were examined for the different remedial options through a life cycle cost analysis to determine the most cost effective option.

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In appreciation of

Mr Malcolm Lim

for conducting a Technical Talk on Using Non-destructive Testing as an Inspection Tool in Structural Evaluation

27th June 2013
Singapore Polytechnic

Vijeyasingam, Managing Director, Proceq Asia Pte Ltd
Koh Beng Thong, President, Singapore Concrete Institute

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Dr Sabet Divsholi Bahador

for conducting a Technical Talk on Using Non-destructive Testing as an Inspection Tool in Structural Evaluation

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Koh Beng Thong, President, Singapore Concrete Institute

35th SCI Annual General Meeting 26 April 2013

SCI Annual General Meeting is organized once a year to select new board of directors. The 35th Annual General Meeting was organized on 26th April 2013 at NUSS Kent Ridge Guild House.

SCI Supports The Institutions Of Higher Learning For Academic Excellence

Singapore Polytechnic : SCI Gold Medal S$700
****Paid from the proceeds of the S$15,000 Non-Endowment Fund donated by SCI in 2010.**

Nanyang Technological University : Singapore Concrete Institute Book Prize S$200

National University of Singapore : Gold Medal S$100 Book Prize
****Paid from the proceeds of a capital sum of S$15,000 donated by SCI in 1997.**

SCI Social Networking Night at Penny Black, 28 Boat Quay 15th August 2013

The networking night for 2013 was organized on 15th August 2013. This event was sponsored by BASF South East Asia Pte Ltd and 60 participants attended the event with lots of camaraderie spirit and socializing mood.

SCI was Supporting Association for BEX ASIA 2013 11-13 September 2013

SCI Accreditation Schemes

Waterproofing Accreditation Scheme

Singapore Concrete Institute's Accreditation Scheme for Waterproofing Specialist Contractors was launched in September 2004. The aim of this scheme is to ensure minimum competency and raise the capability of waterproofing specialist contractors serving the construction industry in the longer term. It also provides recognition to contractors who are committed to deliver quality works. This scheme is managed by the Singapore Concrete Institute (SCI) as part of the effort to promote greater self-regulation by the industry.

The accreditation criteria were developed jointly by the SCI and Building and Construction Authority (BCA) with inputs from Waterproofing specialists and the Waterproofing Trade Association. Real Estate Developers' Association of Singapore (REDAS) had given their support on the scheme and would encourage its members to specify the use of accredited contractors for their projects.

Accreditation Grading And Accreditation Process

There are three categories of grading under the accreditation; they are W1, W2 and W3. Waterproofing specialist contractors will be assessed using the accreditation criteria during the accreditation audit. Subsequently, the accredited contractors will be assessed annually for compliance in order to retain their grading.

Accreditation Criteria

The accreditation criteria are based on three main areas. They are:

- Financial & Track Records
- Human Resources
- In-house Quality Management System

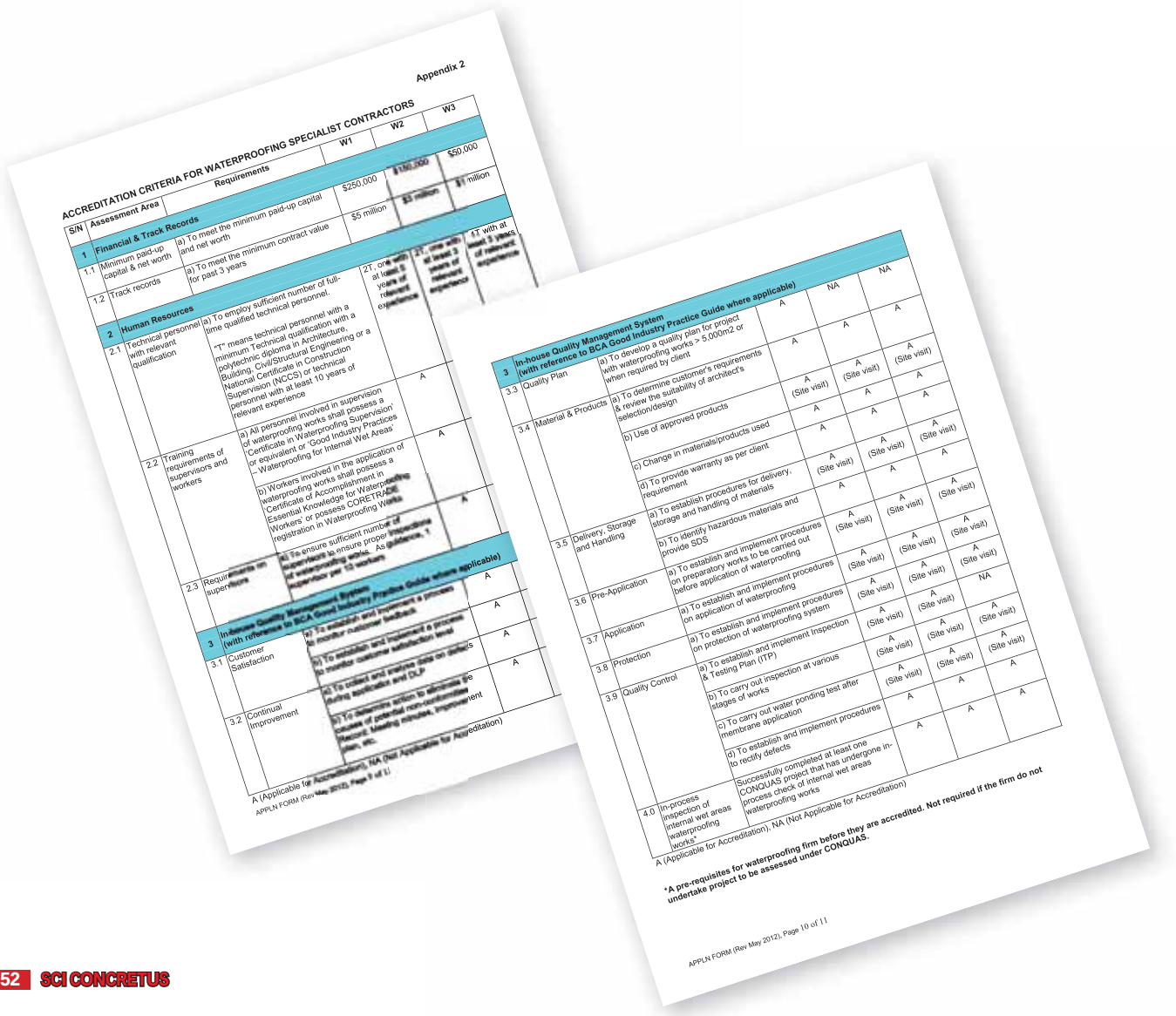
Benefits of Accreditation

The benefits of the scheme include:

- To recognise contractors who are committed to deliver quality waterproofing works, the Building and Construction Authority (BCA) has agreed to award full points for the in-process check of internal wet area waterproofing for projects assessed under CONQUAS, if the waterproofing work is carried out by a SCI waterproofing accredited firm. On-site verification is not required.
- This will certainly add value to the SCI Accreditation Scheme as main contractors will be encouraged to engage accredited firms to carry out waterproofing works for their projects.
- Improved marketability and competitiveness
- Supported by REDAS
- Enhanced public image of firms

Enquiry

For more information, please contact Ms Edina Koh (Tel: 6552 0674).



Appendix 2

ACCREDITATION CRITERIA FOR WATERPROOFING SPECIALIST CONTRACTORS

S/N	Assessment Area	Requirements	W1	W2	W3
1	**Financial & Track Records**				
1.1	Minimum paid-up capital & net worth	a) To meet the minimum paid-up capital and net worth	$250,000	$100,000	$50,000
1.2	Track records	a) To meet the minimum contract value for past 3 years	$5 million	$3 million	$1 million
2	**Human Resources**				
2.1	Technical personnel with relevant qualification	a) To employ sufficient number of full-time qualified technical personnel. "T" means technical personnel with a minimum Technical qualification with a polytechnic diploma in Architecture, Building, Civil/Structural Engineering or a National Certificate in Construction Supervision (NCCS) or technical personnel with at least 10 years of relevant experience	2T, one with at least 5 years of relevant experience	2T, one with at least 3 years of relevant experience	1T with at least 3 years of relevant experience
2.2	Training requirements of supervisors and workers	a) All personnel involved in supervision of waterproofing works shall possess a 'Certificate in Waterproofing Supervision' or equivalent or 'Good Industry Practices – Waterproofing for Internal Wet Areas' b) Workers involved in the application of waterproofing works shall possess a 'Certificate of Accomplishment in Essential Knowledge for Waterproofing Workers' or possess CORETRADE registration in Waterproofing Works	A A		
2.3	Requirements on supervision	a) To ensure sufficient number of supervisors to ensure proper supervision of waterproofing works. As guidance, 1 supervisor per 10 workers	A		
3	**In-house Quality Management System (with reference to BCA Good Industry Practice Guide where applicable)**				
3.1	Customer Satisfaction	a) To establish and implement a process to monitor customer feedback b) To establish and implement a process to monitor customer satisfaction level	A A		
3.2	Continual Improvement	a) To collect and analyse data on defects during application and DLP b) To establish action to eliminate causes of potential non-conformities (Records: Meeting minutes, improvement plan, etc.	A A		

A (Applicable for Accreditation), NA (Not Applicable for Accreditation)

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S/N	Assessment Area	Requirements	W1	W2	W3
3	**In-house Quality Management System (with reference to BCA Good Industry Practice Guide where applicable)**				
3.3	Quality Plan	a) To develop a quality plan for project with waterproofing works > 3,000m2 or when required by client	A	NA	A
3.4	Material & Products	a) To determine customer's requirements & review the suitability of architect's selection/design	A (Site visit)	A (Site visit)	A (Site visit)
		b) Use of approved products	A	A	A
		c) Change in materials/products used	A	A	A
		d) To provide warranty as per client requirement	A (Site visit)	A (Site visit)	A (Site visit)
3.5	Delivery, Storage and Handling	a) To establish procedures for delivery, storage and handling of materials	A	A	A
		b) To identify hazardous materials and provide SDS	A (Site visit)	A (Site visit)	A (Site visit)
3.6	Pre-Application	a) To establish and implement procedures on preparatory works to be carried out before application of waterproofing	A (Site visit)	A (Site visit)	A (Site visit)
3.7	Application	a) To establish and implement procedures on application of waterproofing	A (Site visit)	A (Site visit)	A (Site visit)
3.8	Protection	a) To establish and implement procedures on protection of waterproofing system	A (Site visit)	A (Site visit)	NA
3.9	Quality Control	a) To establish and implement Inspection & Testing Plan (ITP)	A (Site visit)	A (Site visit)	A (Site visit)
		b) To carry out inspection at various stages of works	A (Site visit)	A (Site visit)	A (Site visit)
		c) To carry out water ponding test after membrane application	A (Site visit)	A (Site visit)	A (Site visit)
		d) To establish and implement procedures to rectify defects	A	A	A
4.0	In-process inspection of internal wet areas waterproofing works*	Successfully completed at least one CONQUAS project that has undergone in-process check of internal wet areas waterproofing works	A	A	A

A (Applicable for Accreditation), NA (Not Applicable for Accreditation)

***A pre-requisites for waterproofing firm before they are accredited. Not required if the firm do not undertake project to be assessed under CONQUAS.**

APPLN FORM (Rev May 2012), Page 10 of 11

Accredited Waterproofing Firms

Asiabuild Enterprises Pte Ltd
80 Playfair Road #07-11 Kapo Factory Building Blk B S367998
Tel: 6285 4988 Fax: 6284 3677
project@asiabld.com

BCS-PROKON CONTRACTORS (PTE.) LTD.
No. 53 Ubi Avenue 1
#03-28 Paya Ubi Industrial Park
Singapore 408934
Tel: 6744 5841 Fax: 6841 0632
bcswp@singnet.com.sg

BESTCOAT CONTRACT SERVICES PTE. LTD.
10 Admiralty Street
#06-29 North Link Building
Singapore 757695
Tel: 67523005 Fax: 67533208
enquiry@bestcoat.com.sg
www.bestcoat.com.sg

CHIN LEONG CONSTRUCTION SYSTEMS PTE LTD
2 Tanjong Penjuru, Singapore 609017
Tel: (65) 6265 2788 Fax: (65) 6266 0081
chinleong@clp.com.sg

CRG CONTRACTORS PTE. LTD.
30 Toh Guan Road
#07-01 ODC Districentre
Singapore 608840
Tel: 68633977 Fax: 68634552
crg88@singnet.com.sg

HENG BOON SENG CONSTRUCTION PTE. LTD.
3 Pemimpin Drive
#07-05 Lip Hing Industrial Building
Singapore 576147
Tel: 62590988 Fax: 62593822
hbscs@singnet.com.sg
www.hbsc.com.sg

LEE CONSTRUCTION PTE. LTD.
50 Kallang Avenue
#01-01 Noel Corporate Building
Singapore 339505
Tel: 68422345 Fax: 68424812
dick@leeconstruction.com.sg
www.leeconstruction.com.sg

MAXBOND SINGAPORE PTE. LTD.
10C Jalan Ampas, #01-01
Ho Seng Lee Flatted Warehouse
Singapore 329513
Tel: 62511471 Fax: 62511473
enquiry@maxbond.sg

UNISEAL SINGAPORE PTE. LTD.
31 Mandai Estate, Innovation Place
IMMEDIA, #06-04
Singapore 729933.
Tel : 67550055 Fax : 67531398
info@uniseal.com.sg

CEMENTAID (SEA) PTE LTD
12 Neythal Road,
Singapore 628578
Tel: 6896 9801
caseasales@cementaid.com
www.cementaid.com

GOLDFIELD CONSTRUCTION PTE. LTD.
48 Toh Guan Road East
#06-132 Enterprise Hub
Singapore 608586
Tel: 68586151
admin@goldfield.com.sg
www.goldfield.com.sg

LH WATERPROOFING SPECIALISTS PTE. LTD.
27 Mandai Estate Tower 2
#05-05 Innovation Place
Singapore 729931
Tel: 63142322
Fax: 63142022
lhwps@singnet.com.sg

ENG SENG TECH PTE LTD
24 Woodlands Industrial Park E5
Singapore 757801
Tel: 63687737
Fax: 63657477
marcus@engsengtech.com.sg

PRO-WERKZE (S) PTE LTD
39 Opal Crescent Singapore 328427
Tel: 62940018
Fax: 62940017
prowerkze@singnet.com.sg

ACP BUILDING SERVICES PTE LTD
63 Hillview Avenue #07-03
Lam Soon Industrial Building
Singapore 669569
Tel: 67695190
Fax: 67695928
kim@acp-bldgsvc.com

CAPSTONE ENGINEERING PTE LTD
No. 48 Toh Guan Road East, #05-149,
S608586
Tel: 6469 8983
Fax: 6468 8831
wahheng.ng@gmail.com

HOE KIM TILING & BUILDING PTE LTD
50 East Coast Road, #02-33
Roxy Square Shopping Centre,
Singapore 428769.
Tel : 63460585 Fax : 63460653
hoekim@pacific.net.sg

KHIAN HENG CONSTRUCTION PTE LTD
294 Lavender Street,
Singapore 338807
Tel : 62557355 Fax : 62537696
patricksoo@khianheng.com.sg

MAXISEAL PTE. LTD.
7030 Ang Mo Kio Ave 5, #05-19, North Star@AMK, Singapore 569880
Tel: 68942393
Fax: 62970481
kelvin@maxiseal.com.sg

QIN JIN BUILDING SERVICES PTE LTD
Blk 644 Hougang Ave 8 #01-277
S530644
Tel: 638 53572 Fax: 6385 1076
qinjinbuilding@hotmail.com

RENESCO INJECTION (WATERPROOFING) PTE. LTD.
30 Toh Guan Road
#07-01 ODC Districentre
Singapore 608840
Tel: 68633677
Fax: 68634240
crg88@singnet.com.sg

SOURCE WATERPROOFING PTE LTD
7 Kaki Bukit Road 1, #01-05, Eunos Technolink, Singapore 415937
Tel: 67444693
Fax: 67444367
source46@singnet.com.sg

YJ WATERPROOFING PTE. LTD.
51 Jalan Pemimpin #04-03 Mayfair Industrial Building Singapore 577206
Tel: 62556880
Fax: 62556881
enquiry@yjwp.com.sg

WATERPROOFING EXCELLENCE AWARD

The inaugural Waterproofing Excellence Award is launched on 15 November 2013 at the SCI 35th Anniversary Gala Dinner at the Swissotel Merchant Court, Singapore. This distinction award recognises SCI accredited waterproofing specialists for their commitment and achievement in delivering high quality waterproofing workmanship. It promotes leading SCI accredited waterproofing firms who have consistently excel in their waterproofing workmanship, setting high quality standards for their workmanship and improve the waterproofing process.

The award winners are selected base on the criteria below and the acceptance of the award is voluntarily. There is no need for nomination and application. SCI have implemented this special award for their accredited waterproofing firms to enhance the industry professionalism and increase their quality workmanship of waterproofing performance. In appreciation of the SCI accredited waterproofing specialists, SCI would like to raise the waterproofing performance even higher through the continuous audit of these firms by their participation in the Waterproofing Accreditation Scheme.

EVALUATION CRITERIA

1.The waterproofing firm must be accredited under the SCI Waterproofing Accreditation Scheme.

2.The SCI accredited waterproofing firm have completed at least 5 CONQUAS/QM projects within a period of 3 years.

3. All completed CONQUAS/QM projects within the last 3 years must achieved 100% pass in the internal wet area water-tightness tests.

BENEFITS OF THE AWARD

- The Waterproofing Excellence Award is given to the firm as a distinction of excellence in quality waterproofing workmanship and for their support of the SCI Waterproofing Accreditation Scheme.
- For CONQUAS project engaging SCI accredited waterproofing firm with Waterproofing Excellence Award, an extra provisional Bonus Point will be considered for the Architectural Score.
- The award-winning firm is given an award certificate and issued with the Waterproofing Excellence Mark.

Precaster Accreditation Scheme

Background

The Singapore Concrete Institute's Precaster Accreditation Scheme was launched on 1st January 2007. The scheme aims to improve the quality and productivity of precasters serving the construction industry. It also provides recognition to precasters who are committed to quality and safety of the production plant and products. The scheme is open to local and overseas precasters which have their fabrication yard located outside Singapore. This scheme is managed by the Singapore Concrete Institute (SCI) as part of the effort to promote greater self-regulation by the industry. The accreditation criteria were developed jointly by the SCI and the Building and Construction Authority (BCA) with inputs from the precasters.

Accreditation Categories & Criteria

There will be three Categories of Accreditation:

Category PC1

Precaster that has the financial, human resources, plant and design capabilities to fabricate Structural Building and Structural Civil Engineering Elements of more than or equal to $30 million in contract value for the past 3 years.

Category PC2

Precaster that has the financial, human resources, plant and design capabilities to fabricate Structural Building and Structural Civil Engineering Elements of more than or equal to $5 million but less than $30 million in contract value for the past 3 years.

Category PC3

Precaster that has the financial, human resources, plant and design capabilities to fabricate Non-Structural Building and Non-Structural Civil Engineering Elements.

Definition

1. Structural Building and Structural Civil Engineering Elements shall include but not limited to column, beam, double-T beam, hollow core slab, prestressed plank, household shelter, structural faade with built-in beams, staircase, balcony, parapet wall, gable end wall, faade (without beam), water tank, prefabricated bathroom, road viaduct components, MRT and LRT viaduct components, pedestrian overhead bridge components, deep sewerage tunnel components, MRT tunnel components, RC pile, spun pile, box culvert, sewerage tunnel, drainage tunnel.
2. Non-Structural Building and Non-Structural Civil Engineering Elements shall include but not limited to internal partition wall, cladding, sun breaker, refuse chute, roofing slab, interlocking block/paver, manhole chamber ring, RC cover for sewer manhole, U-drain.

The accreditation criteria are based on two main areas. They are:

- Management and Facilities
- Track Record and Design Capability

Precaster Accreditation Process

Precasters will be assessed using the accreditation criteria during the accreditation audit. Subsequently, the precaster will be assessed annually for compliance in order to retain its grading.

The benefits of the scheme include the following:

- Accredited Precasters can pride themselves to be recognised as among the best in the industry, having achieved the required standards in its class of accreditation
- The Accreditation Register will be a good source for selection of reliable precasters.
- The scheme will encourage continual improvement and professionalism as Accredited Precasters aspire to upgrade to higher categories.

Precaster Accredited Firms

SUNWAY CONCRETE PRODUCTS (S) PTE LTD
4 Tampines Industrial Street 62
Spore 528817
Tel: 6582 8089
Fax: 65810482
precast@sunway.com.sg

C.L. PILE SDN BHD
No 8-01 Jln Sri Perkasa 1/3 Taman Tampoi Utama 81200 Johor Bahru, Johor
Tel: 607-2413715
Fax: 607-2413717
khloh@chuanluck.com

QINGJIAN PRECAST PTE LTD
58 Seletar North Link,
Singapore 797613.
Tel : 64845857
Fax : 64846405
email : ngkokkeong@cnqc.com.sg

K L PILE SDN BHD
No. 39A, Jalan Impian Emas 5/2,
Taman Impian Emas, 81300 Skudai,
Johor.
Tel: 607-5576509
Fax: 607-5576463
enquiry@klpile.com

SUNWAY SPUN PILE (ZHUHAI) CO. LTD
Xingang Zone (Baijiao Village),Baijiao Science Technology Industrial Park,
Doumen District, Zhuhai City,
Guangdong Province, China
Tel : (86)756-5232299
Fax :(86)756-5232883
email : sunway.smm@gmail.com

UNIBASE PRECAST SDN BHD
PTD 1232925 Taman Nusa Cemerlang,
81550 Gelang Patah, Mukim Pulai,
Johor.
Tel : 607-5563588
Fax : 607-5562598
email : jackpoh@uci-gp.com

CHIP ENG SENG CONTRACTORS (1988) PTE LTD
69 Ubi Crescent, #06-01, CES Building,
Singapore 408561.
Tel : 68480848
Fax : 68480838
email : enquiry@chipengseng.com.sg

Enquiry

For more information, please contact Ms Edina Koh (Tel: 6552 0674).

The 39th Conference on OUR WORLD IN CONCRETE & STRUCTURES

Singapore, 20-22 August 2014

Secretariat: CI-Premier Pte Ltd, 150 Orchard Road #07-14, Orchard Plaza, Singapore 238841

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TOPICS

01- Concrete design & analysis for buildings & structures
02- Concrete mix design, quality control and production
03- Concrete technology, ready-mix, SCC, RCC
04- Concrete plant, equipment and machinery
05- Concrete repairs and rehabilitation
06- Concrete materials, composites
07- Concrete construction and safety
08- Concrete application in roads, bridges, tall buildings, tunnels, underwater, underground, etc

SPECIAL SESSIONS on selected and special topics –Organisers are invited.

IMPORTANT DATES

- Abstracts deadline (in one A-4 page) 30 Mar '14
- Notification of acceptance 30 Apr '14
- Full text in required format to be received by 30 Jun '14
- Conference Dates 20-22 Aug '14

PUBLICATION POLICY

Please note that it is part of the requirements of submission of abstract that the author or one of the co-authors will attend the Conference and present the paper.
Papers accepted for inclusion in the Conference Proceedings will have to be registered, with a text-inclusion fee (SGD400 for each accepted paper). All registered participants would be issued with a copy of the proceedings. It is also an understanding that the Organisers hold the copyrights of the papers published in the Proceedings, which will carry an ISBN reference. The proceedings would be submitted to the relevant indexed organisation after the conference.

CONCRETE AWARDS

All accepted papers (except keynote and invited papers) will automatically be reviewed and assessed for consideration in the Concrete Awards Scheme (non-competitive) for its originality and level of excellence, provided the text is received before 30 June 2014.
More than 10 such awards are available.
In the memory of a dear friend, the LIMHOEPENG Award will be created and added to the scheme.

CO-SPONSORING ORGANISATIONS

The American Concrete Institute, USA

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-Mr Casey Teo, W R Grace (Singapore) Pte Ltd
-Dr Ramanathan Krishna, former Secretary General of the Indian Concrete Institute

Footnote! BRIEF REPORT of the 2013 Conference

About 300 participants from 21 countries were in attendance at the OW13 conferencer held on 21-23 Augfust 2013 at the Goodwood Park Hotel, Singapore
The OW13 conference celebrated the GOLDEN JUBILEE of "STUP Consultants Pvt Ltd", India and the Conference Lecture was delivered by its Chairman: Shri C R Alimchandani on
"FIVE DECADES OF INNOVATION FOR CREATING SUSTAINABLE CONCRETE STRUCTURES"
Two AWARD papers :
The STUP Golden Jubilee Award went to:
Mr Naoki Nagamoto, Sumitomo-Mitui Construction Company Ltd., Japan
"An expressway bridge having prestressed butterfly-shaped web" by Kenichiro Ashizuka, Naoki Maehara, Kenichi Kata and Naoki Nagamoto,
and
The Japan Concrete Institute Award went to:
Padmaja Krishnan, NationalUnmiversity of Singapore, Singapore
"Multi-functional building materials for photocatalytic degradation of particulate pollutants and self-cleaning of building surfaces" by Padmaja Krishnan, M-H Zhang, Liya E Yu and H J Feng
(Proceedigs of the OW13 conference and all the previous 27 conferences are available at the Secretariat)
Issued by Er John S Y Tan
Conference Director

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MEMBERSHIP APPLICATION FORM

Type of Membership applying (please tick) :

☐ Corporate ☐ Ordinary ☐ Associate

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Nominee 2	Prof/Dr/Mr/Mrs/Miss	Designation	
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	Nominee 1	Nominee 2	

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Name in full	Prof/Dr/Mr/Mrs/Miss				
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Employment Records

Employer's Name				Designation	
Address					
				Postal Code	
Tel. No.		DID/Ext. no.		Mobile No.	
Working Experience	Please state number of years in construction industry				

Qualifications: Academic (please attach photocopy of certificates):

Year of Graduation	University/College Attended	Highest Qualifications Obtained

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Year	Type of Award / Publications	Awarding Bodies / Publisher

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Associate Members shall be persons who are concerned with concrete technology and are acceptable to the Board of Directors.	** Subscription of members admitted in November & December of a year will cover the following year as well.*

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Name	Joined Date
1) Jiang Shan	5 Dec 2012
2) Subramaniam Kalaimahan	18 Jan 2013
3) Tharmaraj Ramesh Pandian	7 Feb 2013
4) Teoh Kok Hean	7 Feb 2013
5) Ariel Duhaylongsod Cabatbat	26 March 2013

Name	Joined Date
6) Souradeep Gupta	26 April 2013
7) Mohamed Shafik Bin Noordin	26 April 2013
8) Au Jia Li Anthony	16 May 2013
9) Thirugnanasambandam Kumanan	16 May 2013

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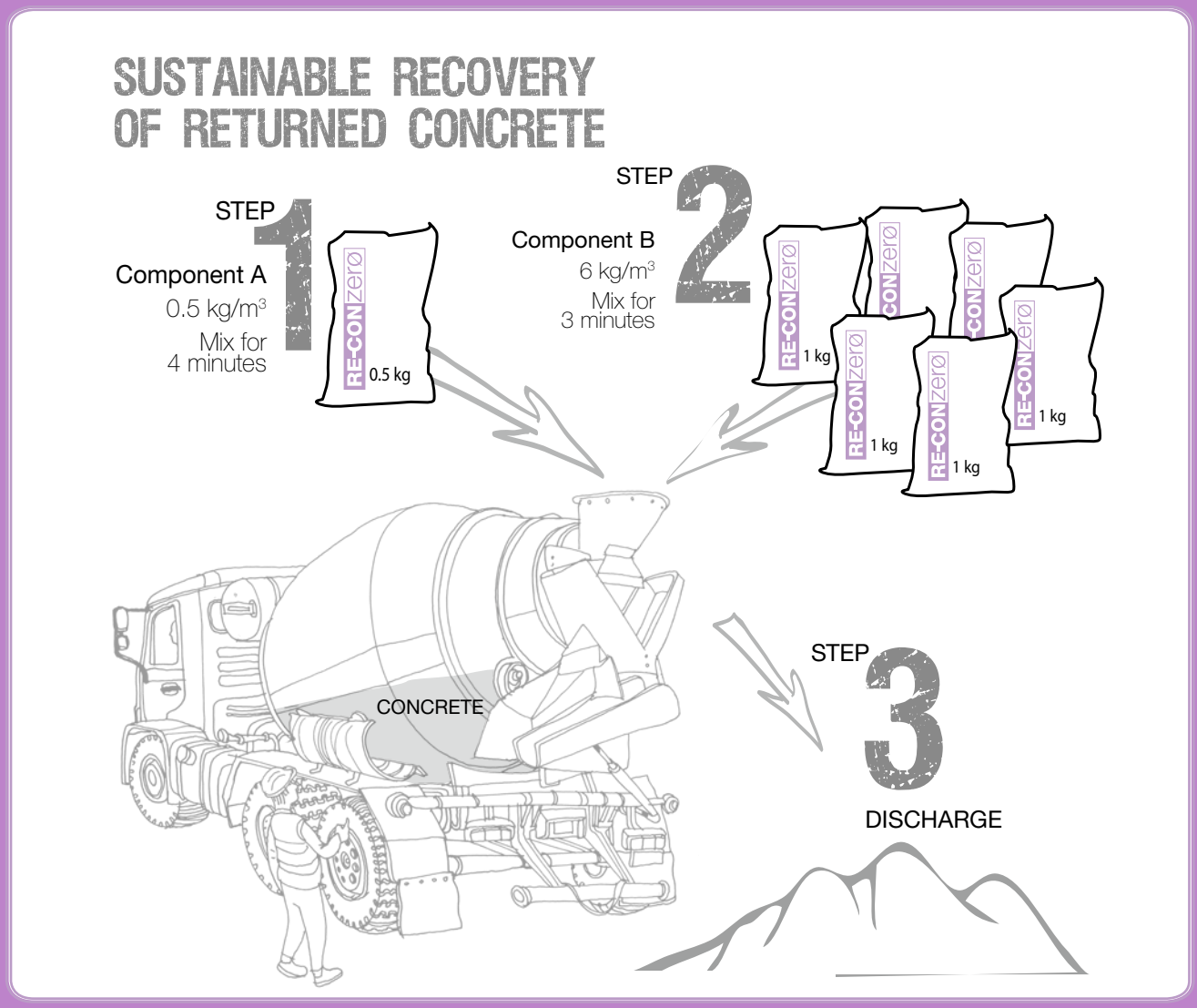

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