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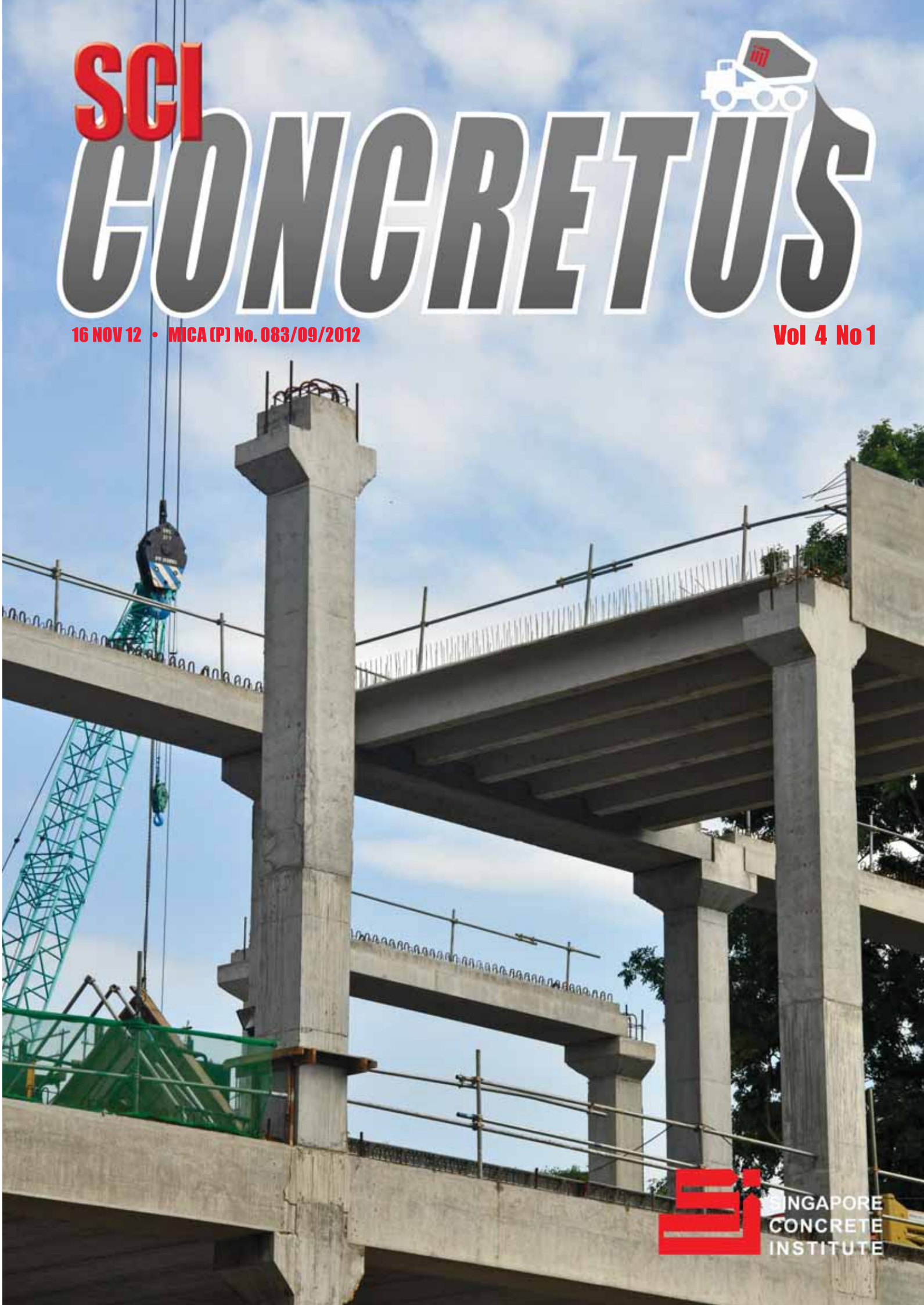

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President's Message

In conjunction with our 34th Anniversary Celebration of Singapore Concrete Institute this year, the publication of the fifth issue of the Concretus carries a special tribute to our immediate Past President and a staunch supporter of SCI, Mr Willie Kay. The recently held 37th Conference on Our World in Concrete and Structures of which SCI was a co-sponsor since 1984, was specially dedicated to Mr Willie Kay for his unrelenting support of the OWICS Conference Series since it started in 1976. The theme of this year's celebration, "Sustainable Concrete Innovation" is to reinforce the importance of sustainable development and the use of limited resources for our built environment. The submissions for this year's SCI Excellence Awards 2012 reflected the theme appropriately and well demonstrated the concern of all stakeholders in the construction industry on the subject of sustainability.

The concern over sustainability also comes forth in this issue of the Concretus with several articles focused on the issue of limited material resources for the production of concrete. Our readers should find these articles a timely update on the various positive developments to address the need for sustainable construction for the sake of saving the environment.

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 thus far in providing generous financial contributions and technical knowledge towards the publication of Concretus. We look forward to your sustainable support in making the Concretus a useful resource for the benefits of all our esteemed readers.

Thank you.

Oh Lock Soon Er.
President

Singapore Concrete Institute
16 November 2012

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USE OF 100 % VSI PROCESSED COARSE AND FINE AGGREGATES IN CONCRETE

By Ikegami Akio
General Manager (Technical), YTL Cement Marketing Singapore Pte Ltd

The use of manufactured sand (M-sand) has been encouraged to replace "natural sand" world-wide. The exhaustion of major sources of natural sand, compounded with environmental and ecological considerations, has motivated the use of alternative resources for sustainable construction. Especially in Singapore, where most construction materials have to be imported, alternative measures have been strongly encouraged by the authorities through the implementation of new measures. The new Singapore standard, SS EN 12620: 2008 Aggregates for concrete, is one such measure which encourages the use of more M-sand to substitute "natural sand" in concrete production.

Recently many research works on the utilization of manufactured sand in concrete have been conducted world-wide using many rock types of manufactured sand together with the VSI processed samples, several types of concrete admixtures and cementitious materials. Standards of aggregates for concrete have been reviewed according to findings from such research works, especially for Grading and Fines Content.

Table 2: Test Results of Grading of VSI 20 mm Coarse Aggregate (4/20 graded: by SS EN 12620: 2008)

Sieve Size (mm)	Quarry A Passing (%)				Quarry B: Passing (%)				SS EN 12620: 2008 (Passing: %)	
	Av.	S.D.	Max.	Min.	Av.	S.D.	Max.	Min.	Min.	Max.
40.00	100.0	0.00	100.0	100.0	100.0	0.00	100.0	100.0	100.0	100.0
31.50	100.0	0.00	100.0	100.0	100.0	0.00	100.0	100.0	98.0	100.0
20.00	94.2	0.76	95.3	91.0	94.1	1.39	95.4	86.0	90.0	99.0
10.00	41.2	2.79	48.1	35.5	40.4	2.79	45.8	30.0	25.0	70.0
4.00	8.9	1.25	11.4	6.8	7.8	1.60	11.1	3.7	0.0	15.0
2.00	3.0	0.44	4.0	2.2	3.0	0.47	4.4	1.7	0.0	5.0
1.00										
0.063	0.7	0.11	0.9	0.4	0.6	0.20	1.5	0.3	-	4.0

Quarry A: Test results from April 2011 to May 2012 (N = 46), Quarry B: Test results from April 2011 to May 2012 (N = 43)
Sampled in Singapore upon un-loading from barges/ lorries, and Tested by an accredited laboratory in Singapore

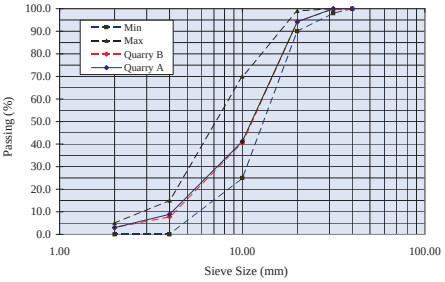


Figure 2: Grading Chart of VSI 20 mm Coarse Aggregate (by SS EN 12620: 2008)

Manufactured Sand is defined as "A purposeful made crushed fine aggregate produced from a source material designed for use in concrete or for other specific products". Manufactured sand is a further development in the use of crushed fine aggregate to compare with Crushed dusts (Quarry dusts), which is mainly obtained as a by-product of crushing rock to produce coarse aggregate (refer to Ref. 12).

Table 1: Test Results of Grading of VSI M-sand (0/4 MP: by SS EN 12620: 2008)

Sieve Size (mm)	Quarry A: Passing (%)				Quarry B: Passing (%)				SS EN 12620: 2008 (Passing: %)		
	Av.	S.D.	Max.	Min.	Av.	S.D.	Max.	Min.	Min.	Max.	Range
8.00	100.0	0.00	100.0	100.0	100.0	0.00	100.0	100.0	100.0	100.0	
6.30	99.8	0.43	100.0	99.0	99.9	0.37	100.0	99.0	95.0	100.0	
4.00	92.6	1.01	95.0	91.0	92.3	0.98	94.0	91.0	85.0	99.0	85 to 99
2.00	76.3	1.91	81.0	73.0	75.7	2.08	79.0	70.0	**60.0**	**90.0**	
1.00	59.2	2.14	63.0	54.4	58.2	2.51	62.8	51.3	**37.0**	**77.0**	**57 +/- 20**
0.50	42.8	2.34	47.1	38.5	42.1	3.13	46.8	32.5	30.0	70.0	
0.250	30.2	2.13	33.6	25.4	30.1	2.01	33.7	26.0	**8.5**	**48.5**	**28.5 +/- 20**
0.125	19.4	1.90	23.6	15.3	19.9	1.88	22.7	16.0	5.0	30.0	
0.063	9.6	0.92	11.4	5.8	9.4	0.72	10.9	8.0	**7.0**	**13.0**	**10 +/- 3**
FM	2.79	0.10	2.99	2.64	2.82	0.11	3.08	2.63	(for MDM: 2.80)		

Quarry A: Test results from April 2011 to May 2012 (N = 50), Quarry B: Test results from April 2011 to April 2012 (N = 20)
Sampled in Singapore upon un-loading the products from barges/ lorries, Tested by an accredited laboratory in Singapore,
Min & Max Limits for sieve sizes of 2.00 mm, 1.00 mm, 0.250 mm,0.125 mm and 0.063 mm are provided by YTLCMS (supplier).

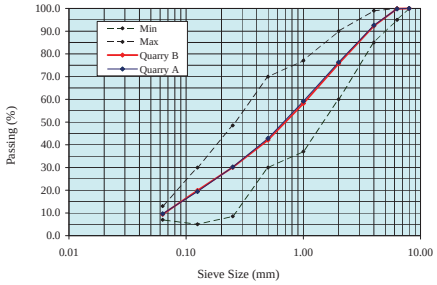


Figure 1: Grading Chart of VSI M-sand (by SS EN 12620: 2008)

Crushing technology for aggregates has also advanced; upgraded granite crushing technology using crushers such as the Vertical Shaft Impact Crusher (VSI) are currently been utilized in some countries in the region, to produce both crushed coarse aggregates and M-sand, with improved particle shape and consistent grading for use in concrete production.

Since 2007, YTL Concrete (S), the ready-mixed concrete division of YTL in Singapore has successfully produced ready-mixed concrete using both coarse aggregates and 100 % M-sand processed by VSI.

This report informs on the performance of VSI processed coarse aggregate and M-sand, and their effect on the concrete performance.

1. Performance of VSI Processed Coarse and Fine Aggregates Used in Singapore

1.1 Grading and Fines Content of VSI processed Coarse and Fine Aggregates

• Regular quality check on the imported

Table 3: Range of Fineness Modulus (FM) by Type of Fine Aggregate (by SS 31: 1998)

Type of Sand	Source of Sand (nos.)	Test (Nos.)	FM (Av.)	FM (Max.)	FM (Min.)	Range of FM (Max - Min)
VSI M- sand	2	28	2.76	2.86	2.62	0.24
Natural- sand	4	39	2.67	3.16	2.08	1.08
Quarry Dust	4	190	3.37	3.99	2.95	1.04

Test Periods: VSI M- sand: Jan. 2011 to Apr. 2011, Natural Sand: Oct. 2010 to Mar. 2011, Quarry Dust: Feb. 2011 to Sep. 2011

VSI processed aggregates; tested at accredited testing laboratories in Singapore for more than one year, proved that Grading and Fines Content (% passing 0.063 mm sieve) of both VSI processed 20 mm coarse aggregate and M-sand are quite consistent and well controlled within the required/ target limits of each sieve size for SS EN 12620: 2008. Grading charts of 20 mm aggregate and M-sand from Quarries A and B are quite close: almost overlapped (refer to Tables 1 and 2, Figures 1 and 2).

• Grading and Fineness Modulus (FM) of other types of Fine Aggregate fluctuate depending on the type and source; Fineness Modulus (FM) is quite different depending on the type of Fine aggregate (refer to Table 3). Grading test results of three types of fine aggregate indicates that: 1) Natural Sand has less particle size passing 0.250 mm, 2) Quarry Dust has less particle size passing 0.125 mm to compare with VSI M-sand (refer to Table 4 and Figure 3).

1.2 Limit of Fines Content of Crushed Fine Aggregate in the Aggregate Standards

• In SS EN 12620: 2008, limit of Fines Content (%: passing 0.063 mm) of M-sand is specified to 16 % (f16 for Crushed rock sand: PD 6682-1: 2009 Table 4).

• In USA, International Center for Aggregates Research (ICAR) proposed in 2009 amendment of the standard: maximum amount of fines content to 20 % (passing 0.075 mm sieve for the existing limit of 7 % in ASTM C 33-08) through extensive research works (refer to Ref. 11).

• Fine particles of M-sand from crushed rock through the crushing process and further processed by crushers like VSI has minimum risk of clay, soil or silt unlike N-sand.

• Many test results world-wide prove that high content of fine particles in this type of M-sand benefits concrete performance as to: improve work-ability of fresh concrete, increase concrete strength and enhance durability of hardened concrete by denser concrete mix with good particle size distribution and improved shape of M-sand.

1.3 Particle Shape of VSI processed Crushed Aggregates

• Other test results and pictures indicate that VSI processed aggregates (20 mm and M-sand) improve their shape to compare with other crushed aggregates (refer to Annex A, Tables A.1 and A.2, Figures 4, 5, 6, 7 and 8).

1.4 Other Properties of VSI processed Crushed Aggregates

• VSI processed aggregates comply with the BCA Test Requirements for Imported Coarse and Fine Aggregates (Tests on the Alkali-silica reactivity, Water-soluble Chloride Content and Acid Soluble Sulfate Content).

Table 4: Grading of Fine Aggregate from Different Type and Source (by SS EN12620: 2008)

Sieve Size (mm)	NS 4	NS 5	VSI MS A	VSI MS B	Quarry Dust 2	Quarry Dust 3	MDM
6.3	100.0	100.0	99.8	99.9	99.0	100.0	97.5
4	99.9	99.9	92.6	92.3	90.0	93.0	92.0
2	98.4	98.3	76.3	75.7	61.0	63.0	75.0
1	83.2	83.4	59.2	58.2	45.0	38.0	57.0
0.5	50.2	47.5	42.8	42.1	31.0	20.0	50.0
0.25	7.2	7.2	30.2	30.1	21.0	10.0	28.5
0.125	0.8	1.4	19.4	19.9	15.0	6.0	17.5
0.063	0.8	0.7	9.6	9.4	9.8	2.5	10.0
FM	2.60	2.62	2.79	2.82	3.37	3.70	2.80
Range of FM	2.41/ 2.83	2.27/ 2.91	2.64/ 2.99	2.63/ 3.08	-	-	-
Test Number: N	10	15	50	20	1	1	-

NS 4 and 5 (N-sand): Tested from Feb. 2011 to Jul. 2011, VSI MS A: tested from Apr. 2011 to May 2012,:
VSI MS B: Tested from Apr. 2011 to Apr. 2012, Quarry Dusr 2 and 3: Test results by typical sample tests in 2011
MDM (Mean Distribution Model): Grading of medium point of each sieve size of Max./Min. limits (tentatively provided by the supplier: YTL Cement Marketing Singapore Pte Ltd)

• Test results on the particle shape of VSI processed 20 mm indicate better results of Flakiness Index and Shape index than other crusher type 20 mm, which means that particle shape is improved by VSI process (refer to Annex A, Table A.2: tested by BS EN 933-3 and 4)

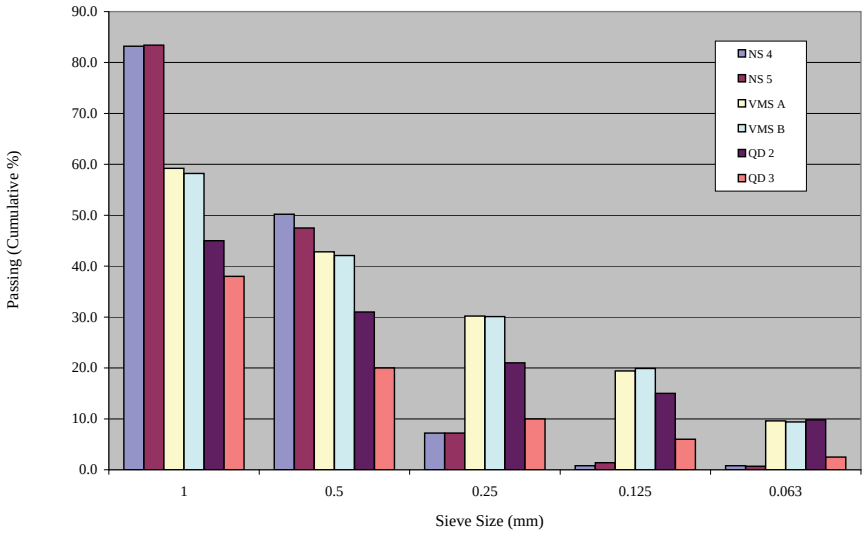


Figure 3: Grading of Fine Aggregate from Different Type and Source (by SS EN 12620: 2008, Sieve Size 1.00 mm and below)

Figure 4: Picture of Particle Shape of VSI 20 mm Aggregate

Figure 5: Picture of 20 mm Aggregate produced by Other Type of Crusher

2. Effect of VSI Crushing Process on the Performance of Aggregates

• VSI Crushing Process is able to produce an improved shape and a consistent grading of coarse and fine aggregates (M-sand), by controlling in-put aggregate quantity and rotating speed. Adjusting the machine structure according to the type of rocks also contributes improvement of production and quality of crushed aggregates.

• VSI has been introduced in the granite quarry industry in the region in the recent 10 years.

Figure 6: Particle Shape of VSI M-sand (Microscopic picture of Particle size: 1.18 mm to 0.60 mm)

Figure 7: Particle Shape of Non-VSI M-sand (Microscopic picture of Particle size: 1.18 mm to 0.60 mm)

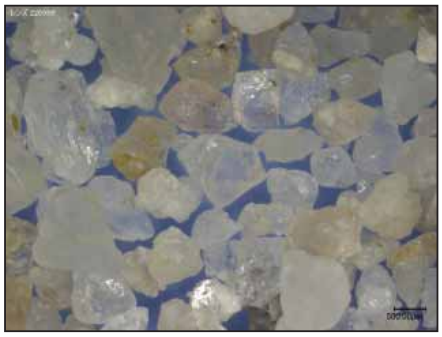


Figure 8: Particle Shape of Natural Sand (Microscopic picture of Particle size: 1.18 mm to 0.60 mm)

3. Laboratory Concrete Tests on the Use of VSI Processed Aggregates

Two series of laboratory tests on the use of VSI processed aggregates and several types of admixtures in concrete were conducted jointly by YTL Concrete (S) Pte Ltd and BASF South East Asia Pte Ltd in 2008. The laboratory tests are: 1) Test on the Use of 100 % M- Sand in Concrete, and 2) Test on the Bleeding of Fresh Concrete.

Both tests were carried out at BASF Concrete Laboratory under the ambient room temperature and humidity conditions. Tested concrete mix conditions and test results are summarized in Tables 5 and 6. Materials used for the tests and test method for the Bleeding of Fresh concrete are as follows:

• Aggregates: VSI processed graded 20 mm, Manufactured Sand (imported from Batu Tiga Quarry, Malaysia) and Natural Sand (available in Singapore)

• Fineness Modulus (FM) of Fine Aggregate: M-sand (FM: 2.85), N-sand (FM: 2.83)

• Admixtures: Set Retarding and water reducing admixture (RT), Super-plasticizing admixture (SP) and New generation super-plasticizing admixture for extended slump retention (HPSP), provided by BASF South East Asia

• Cement: Ordinary Portland cement (OPC): imported from Japan

• Bleeding test method: based on the ASTM C232-07: Standard Test Methods for Bleeding of Concrete (however tested under ambient room temperature and humidity environment, and plastic pales (242 mm D and 250 mm H) were used for the Bleeding Test.)

3.1 Summary of the Test on the Use of 100 % Manufactured Sand in Concrete

• Same unit water content of concrete mix was achieved for the target slump by adjusting admixture dosage.

• Admixture dosage of concrete mixes increased according to increase in M-sand ratio (refer to Figure 11).

Figure 9: External View of Vertical Shaft Impact Crusher System (VSI)

• Work-ability and slump retention performance were improved tremendously with the use of HPSP including 100 % VSI M-sand mix.

• Proper dosage of HPSP would be 500 to 900 ml (per 100 kg cement). Less dosage of HPSP for N-sand 100 % mix (200 ml) resulted in the poor slump retention performance (refer to Figure 12).

• Slump of fresh concrete dropped to 60 mm within 60 minutes after mixing concrete in all the RS mix conditions.

• Slightly higher initial compressive strength gain was observed up to 7 days in the HP type concrete mixes with the use of M-sand.

• Almost the same level of 28 days compressive strength was achieved for all the tested mixes.

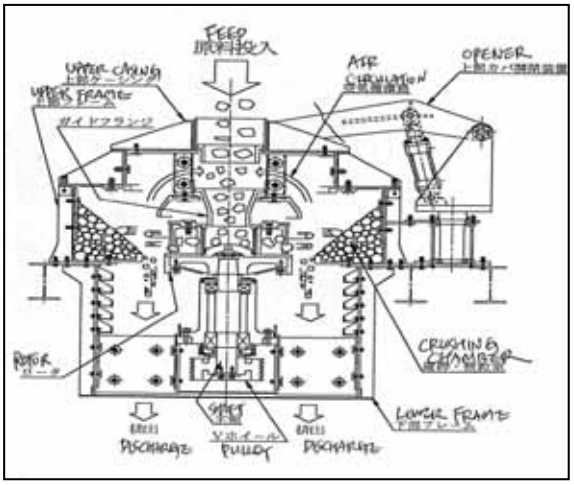


Figure 10: Crushing and Re-shaping Mechanism of VSI

3.2 Summary of the Test on the Bleeding of Fresh Concrete

• Bleeding Rate of fresh concrete decreased according to increase in M-sand ratio.

• Bleeding Rate of fresh concrete of RS type concrete mixes (using combination of RT/SP admixtures) indicated higher rate than mixes with HPSP.

• Higher Bleeding Rates were observed in the concrete mixes with higher unit water content of 181 (kg/m3) than mixes with water content of 168 (kg/m3).

3.2.1 Avoiding the Risk of Plastic Shrinkage Cracking of Concrete due to the rapid evaporation of water from a concrete surface.

• Test results suggest that under the hot weather conditions where the rapid evaporation rate of water from a surface of cast concrete is expected, proper preventive measures are necessary at initial curing stage to prevent risk of plastic shrinkage

Table 5: Laboratory Test on the Replacement Ratio of M-sand in Concrete

Mix Type	Mix Proportion (kg)				Ratio		Admixture (ml/100 kg C)			Slump Retention (mm)			Compressive Strength (N/mm2)			
	C	W	S	G	W/C (%)	MS (%)	RT	SP	HPSP	0 min.	60 min.	120 min.	1 day	3 days	7 days	28 days
M100RS	390	180	780	1010	0.462	100	500	900	0	135	60	-	16.6	37.5	47.7	52.2
M70RS			775			70		800		135	60	-	15.3	36.3	48.2	54.9
M50RS			775			50		700		140	60	-	15.4	34.9	47.3	55.6
N100RS			765			0		600		135	60	-	15.2	37.6	47.3	54.4
M100HP	390	180	780	1010	0.462	100	0	0	700	125	115	110	20.3	39.3	48.9	56.4
M70HP			775			70			500	125	120	115	20.5	39.0	47.3	52.7
M50HP			775			50			450	120	95	75	20.7	35.3	44.3	53.8
N100HP			765			0			200	105	65	-	20.6	36.2	43.4	50.9

Table 6: Laboratory Test on the Bleeding of Fresh Concrete: Effect of M-sand Replacement Ratio

Mix Type	Mix Proportion (kg)		Ratio		Admixtures (ml/100 kg C)			Bleeding (hrs)	Bleeding (%)	Bleeding (kg/m2)	Bleeding Rate: kg/m2/hr		
	C	W	W/C	MS (%)	RT	SP	HPSP				at 190 min	after190	total
M100HP	390	168	0.431	100	0	0	700	6.167	2.01	0.73	0.126	0.110	0.118
M50HP				50			600	6.167	3.18	1.09	0.212	0.140	0.177
N100HP				0			450	5.667	5.93	1.93	0.474	0.172	0.341
M100RS				100	400	750	0	10.167	6.31	2.07	0.189	0.210	0.203
M50RS				50		650	0	9.167	8.56	2.89	0.350	0.297	0.315
N100RS				0		500	0	11.167	14.95	4.93	0.638	0.364	0.441
M100HP	420	181	0.431	100	0	0	600	6.667	2.61	1.03	0.196	0.117	0.155
M100RS				100	400	700	0	9.667	7.26	2.82	0.319	0.278	0.291

cracking of concrete at construction sites, depending on the weather conditions, materials used for concrete mix and their proportions, and cast conditions (refer to Figures 13).

• For example, estimated Evaporation Rate of 0.50 kg/m2/hr is obtained from the monograph where: Ambient Temperature: 33 deg C, Relative Humidity: 70 %, Concrete Temperature: 34 deg C, and Wind Speed: 10 km/hr (2.8 m/sec.), refer to Ref. 15). (Above conditions are different from those at the actual conditions on the bleeding test at BASF laboratory; however we estimate the risk based on the conditions.)

• All the mix conditions (from100 % use of M-sand to 100 % use of Natural sand) resulted in the lower Bleeding Rates than the estimated Evaporation Rate of 0.50 kg/m2/hr.

4. Conclusion

• Regular quality check on the imported aggregates from several quarries for the period of more than a year, proved that VSI processed Coarse and Fine aggregates (M-Sand) have improved particle shape, consistent grading and fines content. Other properties of them also comply with the standards requirements and BCA requirements (including tests on the Alkali-silica reactivity) for the imported Coarse and Fine Aggregates

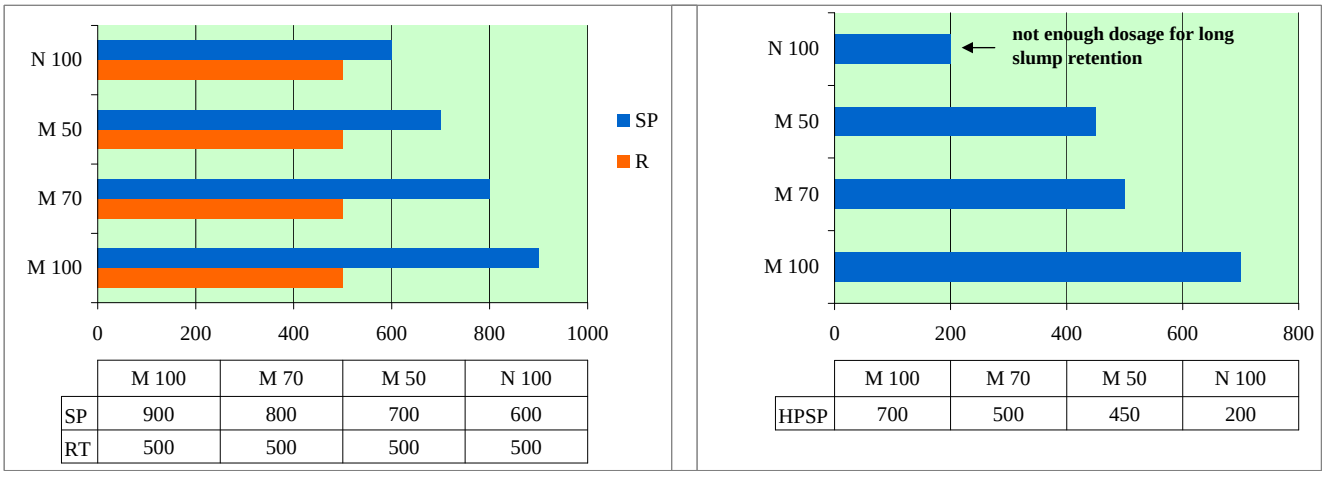
• Consistent VSI processed aggregates grading and low moisture content of M-sand both contribute to lower variability in concrete production, particularly for high performance concrete, such as high strength concrete above C50/60 and SCC (Self Compacting Concrete).

• Many research works indicate importance: effect of aggregate characteristics on the performance of concrete, and explain especially that VSI processed manufactured sand provides improved particle shape and texture, and grading, which contribute improvement of concrete performance.

• YTL Concrete (S) has been supplying its concrete to all the construction projects with the use of VSI processed aggregates: 100 % M-sand and coarse aggregates since the start of its operation in mid-2007.

• Manufactured-Sand is expected to be used more in Singapore as a replacement of Natural- Sand for sustainable construction, provided the product meets the requirements of SS EN 12620 and specific needs of construction projects.

• Proper Concrete Mix Designs shall be determined for the desired fresh and hardened concrete properties based on the properties of Manufactured- sand used,



	M 100	M 70	M 50	N 100
SP	900	800	700	600
RT	500	500	500	500

	M 100	M 70	M 50	N 100
HPSP	700	500	450	200

Figure 11: Admixture Dosage (ml per 100 kg of cement) by M-sand Replacement Ratio (%)mm to 0.60 mm)

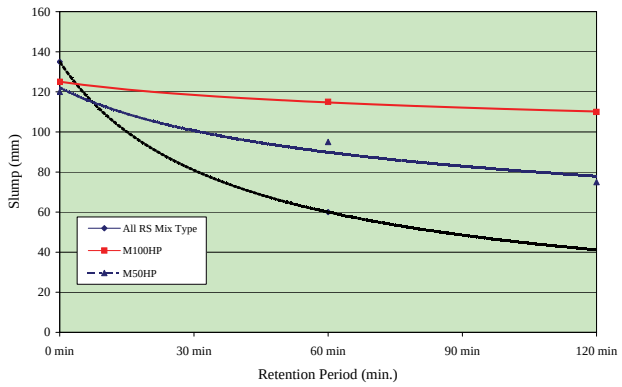


Figure 12: Slump Retention Test Results

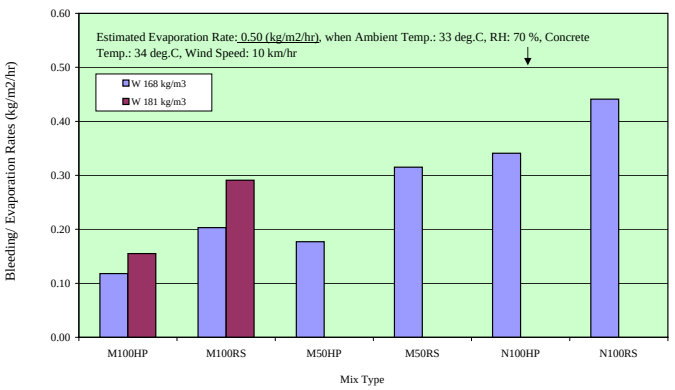


Figure 13: Bleeding/ Estimated Evaporation Rates of Fresh Concrete by VSI Msand replacement Ratio/ Admixture Type

together with the use of suitable type and dosage of concrete admixtures.

Acknowledgement

I express my appreciation to all who contributed to the content of this paper, especially to colleagues and staff from YTL Concrete (S) Pte Ltd, BASF South East Asia Pte Ltd, Batu Tiga Quarry Sdn Bhd, and Nakayama Iron Works Ltd, Japan.

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Annex A: Other Properties of VSI Processed Coarse and Fine Aggregates

1. Table A.1: Other Properties of VSI M-sand (Typical Test Results at Accredited Testing Laboratories)
2. Table A.2: Other Properties of VSI 20 mm Coarse Aggregate (Typical Test Results at Accredited Testing Laboratories)

Table A.1: Other Properties of VSI M-sand (Typical Test Results at Accredited Testing Laboratories)

Property	Unit	Test Method	Test Result	Specification requirement	Standard
Particle Density (SSD base) &	(Mg/m^3)	BS EN 1097-6: 2000	2.63	-	SS EN 12620: 2008
Water Absoprtion	(%)	BS EN 1097-6: 2000	0.4	-	SS EN 12620: 2008
Fines Content (under 0.063 mm Sieve)Decantation Method)	(%)	BS EN 933-1: 1997	9.6	max 16 (f_{16}: crushed rock sand)	BS EN 12620: 2002+A1
Organic substances	-	BS EN 1744-1: 1998, 15.1	negative	lighter than Organic Plate No.3	SS EN 12620: 2008
Loss on Ignition (at 900 deg.C by Furnace)	(%)	BS EN 1744-1: 1998,17	0.77	-	
Magnesium Sulphate Soundness	(%)	BS EN 1367-2: 1998	4	max 18 (MS 18)	
Water Soluble Chloride Content	(%)	BS EN 1744-1: 1998,7	< 0.01	max 0.01 (by mass in combined aggregates)	BCA Test requirements for Imported Carse and Fine Aggregates
Acid Soluble Sulfate Content (as SO_4)	(%)	BS EN 1744-1: 1998,12	< 0.1	max 0.8 (AS $_{0.8}$: Aggregates other than air-cooled blast-furnace slag)	
Alkali Silica Reactivity (Chemical Method)	Sc: (mmol/l)	ASTM C289: 2007	2	the sample tested can be considered innocuous	ASTM C289: 2007
	Rc: (mmol/l)		82		

Table A.2: Other Properties of VSI 20 mm Coarse Aggregate (Typical Test Results at Accredited Testing Laboratories)

Property	Unit	Test Method	Test Result	Specification requirement	Standard
Aggregate Flakiness Index (tested for VSI 20 mm)	(%)	BS EN 933-3: 1997	8	FI_{35} : for clushed rock or crushed gravel FI_{20} ,FI_{15} : for special circumstances	BS EN 12620: 2002+A1
Aggregate Flakiness Index (tested for other 20 mm)	(%)	BS EN 933-3: 1997	17		
Aggregate Flakiness Index	(%)	SS 73 Part 5.1: 1992	12	shall not exceed 40	SS31:1998
Shape Index (tested for VSI 20 mm)	(%)	BS EN 933-4: 1999	10	Limits are not specified yet.	SS EN 12620: 2008
Shape Index (tested for other 20 mm)	(%)	BS EN 933-4: 1999	12		SS EN 12620: 2008
10% Fines Value	(kN)	SS 73: 1974	240	min 150 (Heavy duty concrete floor finish)	SS31:1998
Aggregate Impact Value	(%)	SS 73: 1974	19	max 25 (Heavy duty concrete floor finish)	SS31:1998
Los Angels Abrasion (Smaller than 37.5 mm)	(%)	SS 73: 1974	30	shall not exceed 50	SS31:1998
Particle Density (SSD base) &	(Mg/m^3)	BS EN 1097-6: 2000	2.63	-	SS EN 12620: 2008
Water Absoprtion	(%)	BS EN 1097-6: 2000	0.4	-	SS EN 12620: 2008
Fines Content (under 0.063 mm Sieve)	(%)	BS EN 933-1: 1997	0.7	max 4 (f_4 : crushed rock coarse aggregate)	BS EN 12620: 2002+A1
Aggregate Shell Content	(%)	SS 73: 1974	0	max 8 (Aggregate coarser than 10 mm)	SS31:1998
Aggregate Crushing Values	(%)	SS 73: 1974	18	max 45 (Other than wearingsurfaces)	SS31:1998
Organic Impurities	-	SS 73: 1974	lighter	lighter than the reference standard solution	SS31:1998
Water Soluble Chloride Content	(%)	SS 73 Part 17: 1992	< 0.01	max 0.01 (by mass in combined aggregates)	BCA Test requirements for Imported Carse and Fine Aggregates
Acid Soluble Sulfate Content (as SO_4)	(%)	BS EN 1744-1: 1998,12	0.09	max 0.8 (AS $_{0.8}$: Aggregates other than air-cooled blast-furnace slag)	
Alkali Silica Reactivity (Mortar -Bar Method) Method: at 16 days after	(%)	ASTM C1260: 2007	0.09	not greater than 0.20	
Alkali Silica Reactivity (Chemical Method)	Sc: (mmol/l)	ASTM C289: 2007	14	the sample tested can be considered innocuous	ASTM C289: 2007
	Rc: (mmol/l)		60		

IBB RHEOLOGY PROBE

1. Introduction

A concrete producer need to have feedback as fast as possible from newly made concrete. At the moment, some sensor in the batching plant mixer (usually a Watt-meter measuring the electric power consumption to operate the mixer) can help to estimate the slump providing that the produced concrete quantity is constant from batch to batch. This is not always the case and do not give any information on concrete temperature.

To get more precise feedback, many suppliers sample and measure, on a regular or as required basis, the fresh properties after batching. This takes time and effort, creates waste and takes away concrete from their clients.

IBB has developed a Rheological probe that can help to measure the concrete fresh properties in continuous and automatic way and in respect of the environment by not creating any waste material.

This document has been produced to describe how to use the IBB probe. It contains three sections:

1- Historical background
2- Description of probe system
3- Basic Operation

This document is complemented by four other documents explain some specific aspect of the probe. They are:

• The Installation Manual that explains how to install the device on the truck.
• The Configuration Manual that explains how to communicate with the probe and receiver. This also explains how to retrieve data from the receiver.
• The Slump Calibration Manual that explains how to calibrate the slump for a particular mixture.
• The Volume Calibration Manual that explains how to calibrate a particular installation in order to read the volume of concrete inside the drum.

All of these documents are continuously updated and the latest version is available on IBB Rheology website at www.ibbrheology.com.

2. Historical Background

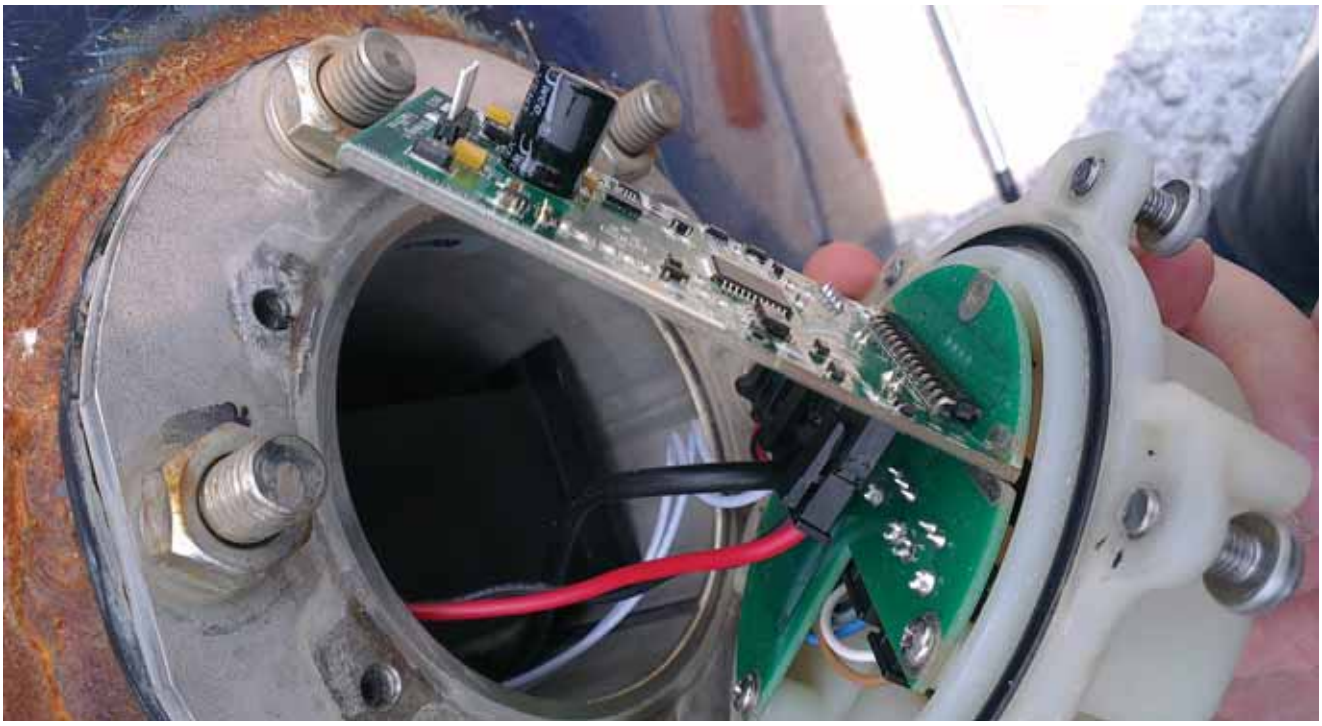
Historically concrete workability has been measured using different tests among which the slump test is still the most popular. More recently, rheometer have been used to measures more fundamental properties such as yield stress and viscosity.

In short, viscosity is a properties of fresh concrete that affect the speed at which the concrete will flow under certain stress, this is particularly important for pumping operation. The yield stress is like some internal friction that must be overcome before the concrete starts to flow, it will affect directly the slump in an inverse manner: the lower the yield, the higher the slump. The viscosity is not related to the slump. For more details on rheology, please look into our web site (ibbrheology.com).

Rheological properties have been measured on concrete for at least 35 years but the lack of standard method and the cost, availability and size of rheometer have keep the industry from using these properties to describe the fresh concrete behavior. Up to now, rheology has been a science used in laboratory with little use in the field.

IBB rheology, a company that was making the IBB rheometer, has recently completed the development of a probe that can be mounted inside the drum of a ready-mix truck and therefore do not require any sampling. The device called, rheological probe, measures much more than the

Figure 1: IBB Rheological Probe and Receiver



rheological properties as it gives, all the following parameters:

- Slump
- Viscosity
- Yield stress
- Temperature
- Speed & direction of drum

- Volume of concrete inside the drum

These parameters are displayed and stored on a receiver without wasting any concrete. This is one reason the rheological probe can be seen as a green technology and has helped a producer in the Middle East to get a Silver certification for sustainability by the NRMCA.

3. System description

The IBB Probe system has two main components with two main options:
1- A Stainless steel probe; installed inside the drum of the ready-mix truck (See installation manual for details),
2- A Receiver that is fixed on the truck,
3- A Solar Panel (optional but strongly recommended); fixed outside the drum and connected to the probe,
4- A System Manager, that enable two way communication and data transfer between the plant operator and the probe to improve the system performance.

The Probes works using a variety of sensor (accelerometer, thermistor and load cell) and electronic component that are powered by rechargeable batteries. Collected data from many sensors are processed, stored and send to a Receiver using radio signal to be displayed, stored and further made available for an alternate communication system, such as GPS (not provided by IBB Rheology), for real time monitoring. Figure 1 show a picture of the IBB Rheological Probe.

The Receiver displays the information shown in Figure 1. It has memory to store data for up to approximately 2 days of normal utilization. The Receiver can be connected to a computer, on temporary basis, to collect the stored information. The Receiver can also be connected to a GPS communication system (not provided by IBB) to transfer that data on real time basis or for further processing. The receiver is powered by the truck main batteries. The receiver has also a cable that can be used to recharged the batteries when the truck is not working.

The Solar Panel is normally connected to the probe to keep the battery pack charged. The power of 4 Watts is sufficient to power the probe even in cloudy condition.

The System Manager is a two way communication system between the plant operator and the probe to transfer useful information that improve the plant performance and ease the recovery of data for the previous delivery.

4. Basic Operation

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The probe constantly monitor the position (angle with vertical from 0-360 degree) by calculating the change in angle, one can get the angular speed (in rpm) or in tangential speed in m/s if the circumference of the drum is known. The probe also makes several measurements of temperature and pressure and can detect at which position it enters and exits the concrete.
The angle, speed, temperature and pressure are further analyzed and compared to some calibration table to estimates the slump and volume and, if a proper sequence of drum speed was performed, the probe also calculates the rheological properties. These data are sent every 10 seconds to the receiver for storage and display.

When no motion is detected for more than 5 minutes, the probe goes to sleep and stop sending data the display on the receiver also changed reduce electric consumption. As soon as the drum will start to turnv-again, the probe will wake up and restart to make automatic measurements.

The speed of the drum is always calculated and updated every 10 seconds. The slumps will be displayed is the drum speed is between 1 and 3 Rpm in the loading direction (or positive speed on the display).

To get the rheological properties, the truck operator will have to turn the drum at a speed between 4 and 6 rpm (referred to as medium speed) for at latest three turn, when the speed and load will acquired, the speed can be reduced between 1 and 3 rpm (referred to as low speed) for at least three turns. The measurement at low speed must be taken within 5 minute from the last measurement at medium speed. When this is completed, the probe will calculate the viscosity and the yield.

Because the viscosity do not change much with time (unless some modification is done to the mixture composition) the calculated viscosity will be kept ''alive'' for 30 minutes. As long as the speed will remain in the low range speed of mixing direction, the yield will be updated every turn.

If Concrete Can Speak

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

Some of you will remember this well-known 1965 song and film title, "What's New Pussycat". It was sung by Tom Jones for the film starring Peter Sellers, Peter O'Toole, Romy Schneider, Capucine, Paula Prentiss and Ursula Andress. Now what is new for me, concrete?

The recently held 37th Conference on Our World in Concrete and Structures, was specially dedicated to Mr. Willie Kay, a long time supporter of this continuous series of conferences in Singapore first held in 1976. Singapore Concrete Institute and ACI Singapore Chapter became sponsors of OWICS in 1984 besides the founder sponsor, RMCAS. During this Conference I discover "What's New" in developments for concrete, me. I shall only touch on three of them in this issue of Concretus, more are available in the conference proceedings (1).

Many are aware that my big carbon footprint comes from the clinker component of Portland cement that binds me with my aggregate partners together to perform the many tasks during my service life. Although good efforts have been made to reduce my carbon footprints in the product process of cement, it remains the highest contribution to my footprint as concrete. Two new developments were presented at the recent OWICS in August, 2012. Both involve the development of a new binder for me to partner with conventional aggregates to perform just like my partnership with Portland cement. The first is a new type of proprietary geopolymer (activated fly ash) which can develop strength at similar rate as conventional Portland cement at normal ambient temperatures (2). Hence, I can be cast on site besides in precast plants where heat curing is available. The second is another binder which consists of 95% ggbs with a special proprietary activator as an alternate to Portland cement. It is very close to my cousin, CEM III/C who has 5% clinker as activator (3). The absence of Portland cement makes its carbon footprint very much reduced. These are truly green cementitious binders and turn me enviously in to a GREEN concrete. Without the presence of tricalcium aluminate (heat of hydration, 910 J/g) tetracalcium aluminoferrite (heat of hydration, 420 J/g) and other hydration products are likely to be mainly ß-dicalcium silicate hydrates (heat of hydration, 260 J/g) compared to tricalcium silicate hydrates (heat of hydration, 526 J/g). Such binders can be expected to be very low in heat of hydration. Hence, I can be produced with a much higher cement content to achieve very high compressive strength without getting too hot in thick sections, and without the need for special internal cooling systems or cooling my constituent components to lower placing temperature (and hence lower peak temperature) at a high cost.

Thirdly, I have a new monitoring friend, a rheological Probe, who can tell my consistence, e.g. slump or slump flow diameter, my temperature and even my bulk (volume) when I am still inside the truck mixer (4). This will save time at delivery to carry out these measurements before placing me into the forms. The continuous monitoring also provide feedback on rate of slump loss and temperature rise due to travel time between plant and site, thus enabling minor adjustment, when necessary, to the concrete design during the course of supply.

All the above developments are "What's New" for me. They will make me GREEN if you adopt them and turn others green with envy of the NEW ME.

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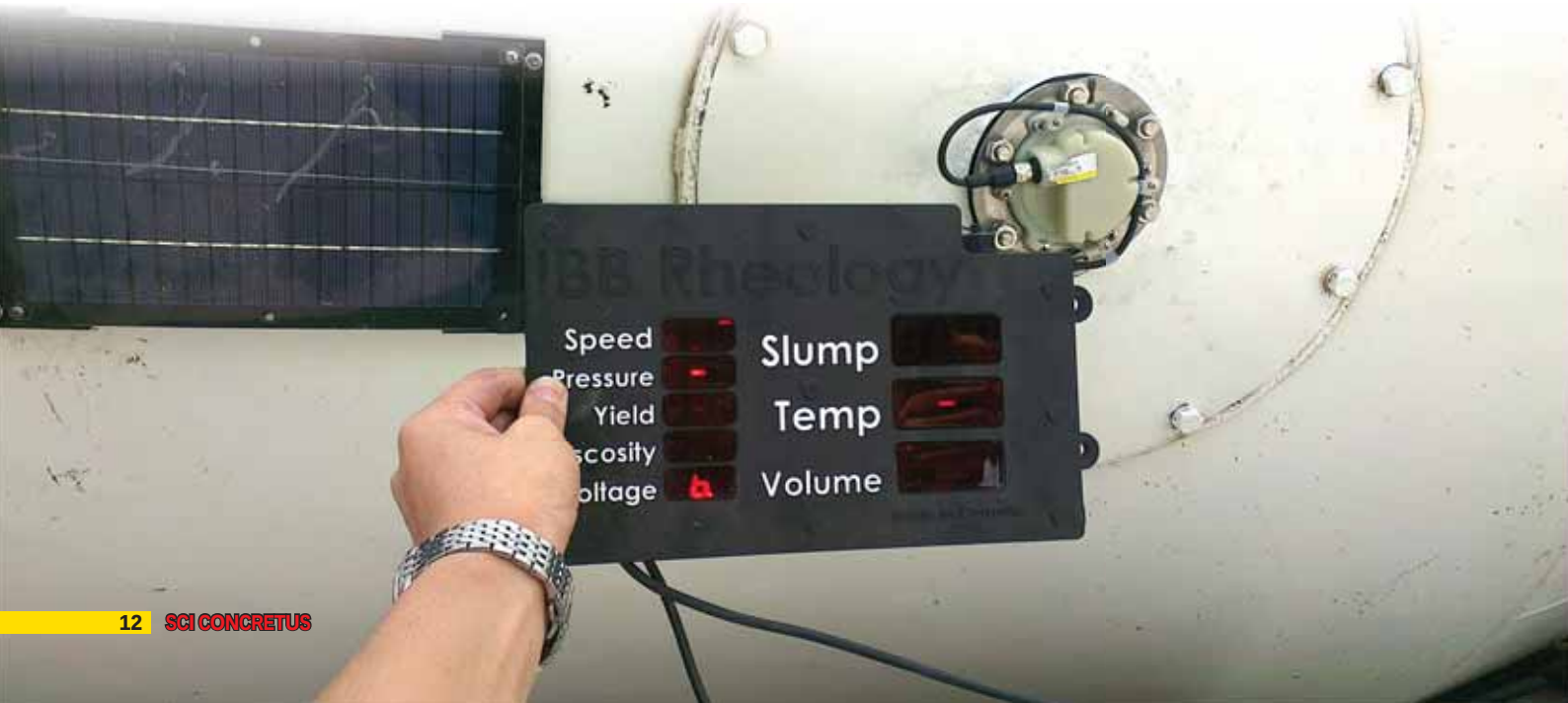

PERFORMANCE SPECIFIED CONCRETE, PRODUCTION AND COMPLIANCE

Mr Willie Kay
Managing Director , WAK Consultants Pte Ltd / WAK Technologies Pte Ltd

The term "High Performance Concrete" (HPC) conjures visions of grand applications and inspires exciting possibilities leading to new levels in concrete construction. In reality, HPC and the technologies associated with it has been available in Asia for at least the last 20 years.

However, it is rather disappointing that application of HPC has only been sent in a handful of high profile projects in the region. There are compelling reasons for this lack of application, the chief of which is that the level of understanding of the material and methods of specifying is still an area which needs massive development. Due to the lack of market demand, investments in the development of production and processes including QA/QC, specific to HPC on the part of concrete suppliers has also been understandably low.

So where do we go from here? Education specific to HPC in all its aspect is a key area that needs to be developed. Understanding the possibilities, specifying performance as well as consistency standards and then developing the means and methods of producing such performance in the concrete is key.

Realistic testing frequencies related to specified performances must also be developed to monitor performance.

1. INTRODUCTION

High Performance Concrete (HPC) is being used in ever increasing application. The types of HPC are many and various and Table 1 lists some common examples

Specifications vary immensely in both content and detail. Durability in one Singapore specification is defined by a chloride diffusion test coupled with a cement/silica fume content per cubic metre of concrete. High consistence mixes are often wrongly in my opinion defined by a slump test with a range of 190 – 220 mm. We would always use a flow test using either a flow table or a slump flow. This is much more meaningful in defining workability and the amount of vibration needed.

In Singapore, the government department in charge of water and waste water, the Public Utility Board (PUB) has been specifying high durability concrete for many years. Table 2 lists the requirements for the mainly underground water reclamation plant at Changi.

Table 1: Types of H.P.C

Description	Typical Performance Measurement	Typical Performance Requirement
High Strength	Compressive Strength	75 - 100 N/mm^2
Ultra High Strength	Compressive Strength	100 – 150 N/mm^2
Self Compacting Concrete	Slump Flow	660 – 750 mm
High Consistence	Flow Spread	> 560 (Flow Class F5 & F6)
High Durability	Engineer Selection	Engineer Specification
Waterproof Concrete	Engineer Selection	Engineer Specification

Table 2: Concrete Specification

Grade	C55	C50	C45	C40	C35	C20
Characteristic Strength at 28 days (N/mm^2)	55	50	45	40	35	20
Minimum Cement Content in kg/m3 of fully compacted	420	400	375	350	350	270
Silica Fume as percent of cement by weight	7%	7%	7%	7%	7%	Not reqd
Maximum w/c ratio for concrete NOT containing HRWR	0.45	0.45	0.45	0.45	0.45	0.45
Maximum w/c ratio concrete containing HRWR	0.35	0.35	0.40	0.40	0.40	0.40
Maximum Air Content	< 2%	< 2%	< 2%	< 2%	< 2%	< 2%
Slump Range for Concrete NOT containing HRWR	75 – 125 mm					
Slump Range for Concrete containing HRWR	115 – 200 mm					

Waterproof Concrete in the Asia Pacific region is often specified as follows.

The concrete is to contain a hydrophobic pore blocking additive and a superplasticiser to ensure a maximum water cement ratio of 0.45. The concrete shall have a corrected 30 minute water absorption of not greater than 1% as measured by BS 1881 Part 122 : 1983 except that the age of the test will be seven days.

Some watertight concrete specify the maximum allowable seepage of 5cc/m2/hour. If in excess remedial methods are required.

2. PRODUCTION

All high performance concrete specifications usually require trial mixes. This can be expensive, time consuming and wasteful in many instances if we are using identical specifications.

The implementation of EN 206 will remove this need in certain specific situations. If the HPC is a new development or specification then trial mixes are essential.

However it is equally important to also test and record the quality of the constituent materials.

The method of batching these concrete is also critical. Many HPC specifications are very detailed in mix constituents, testing and hardened concrete performance but assume the concrete producer understands how to achieve this.

A good example of this is silica fume. This material is usually specified as a powder with additions from 3 – 12 % depending on who wrote the specification.

Durability Compliance Requirement						
Grade	C55	C50	C45	C40	C35	C20
Absorption BS 1881 : Part 122 : 1983	< 1%	< 1%	< 1%	< 1%	< 1%	N/A
Permeability AASHTO T-277 (Coulombs)	< 1000	< 1000	< 1000	< 1000	<1000	N/A
Water Penetration DIN 1048 : Part 5 : 1991(mm)	< 10	< 10	< 10	< 10	< 10	N/A
ASTM C642 - Absorption - Permeable Voids	< 4% < 10%	< 4% < 10%	< 4% < 10%	< 4% < 10%	< 4% < 10%	N/A

If the silica fume is just added into the mixer let us say with the cement many of the properties will be lost.

Worse still if the silica fume is not correctly dispersed then balling of the silica fume can occur and this can cause ASR reactions and an early failure of the concrete. In the future there will be concrete technology training that will include the production and testing of high performance concrete.

Where HPC mixes are specified, stakeholders must have the concrete producer's commitment to seek the knowledge to produce consistent quality HPC. Some operators in batch plants sadly do or will not recognise this different process and if they are not replaced concrete failures will occur.

3. COMPLIANCE

As already discussed to produce compliant HPC concrete can be difficult. The testing of concrete is normally a straight forward operation. The testing of HPC concrete is not so simple. Tests are often more than just compressive strength and many technicians are not familiar with these tests. Compression testing of high strength concretes need attention to detail.

In Singapore in early 90's Marina Singapore was one of the first if not the first to use Grade 55 concrete produced on site ready mix plant. Trial mixes were carried out but target strengths were not achieved or had a pair difference greater than 10 N/mm2.

We then realised that the cleanliness and alignment of the cube mould was critical. The early age curing of the concrete specimens also had a major effect on strength. When all of these points were addressed we were able to produce compliant concrete on site.

The Marina Mandarin Hotel is still in use and with no visible signs of concrete deterioration. When tests for permeability, permeable voids and chloride diffusion are specified often compliant concrete appears to fail.

When ever we are involved with these and other tests we are very specific of the mould condition and the compaction and curing of the specimen.
In many situations where HPC is used, no analysis of test results is carried out. Results either pass or fail. This can have disastrous consequences. One project producing high strength precast segments failed to adopt any cumulative strength data. Due to this they failed to see that the strengths were available and decreasing. Due to this drop in strength the client rejected over 2,000 units. Over a period of time with thousands of N.D.T. tests we managed to prove not all of the concrete was defective.

Table 3: Strength Data Analysis

Period	All			Mar 2002			Apr 2002			May 2002		
Age (days)	3	7	28	3	7	28	3	7	28	3	7	28
n	124	125	88	14	14	14	43	44	44	67	67	30
High	51.5	64.8	79.3	46.8	53.3	71.8	41.5	55.5	74.5	51.5	64.8	79.3
Low	23.5	35.3	50.5	23.5	37.5	53.8	24.3	35.8	52.8	24.5	35.3	50.5
Mean	35.2	48.4	65.8	32.4	44.3	59.7	31.1	45.5	65.6	38.5	51.2	69.1
Std Dev.	6.2	5.9	6.5	7.1	5.1	5.5	4.0	4.3	5.4	5.4	5.7	6.4
Char Strength	25.0	38.7	55.2	20.8	36.0	50.7	24.6	38.5	56.8	29.6	41.9	58.5

Table 3 shows some tabulated statistical analysis from HPC project with a number of different mixes.
Figure 1 shows variation on a month by month basis for standard deviation returned on statistical analysis of compression strength results for a single Grade 75 in graphical form.

4. CONCLUSIONS

The growth of HPC will continue. We have to document and teach all the methods of converting specifications into real concrete. The failures in the production of HPC are still in my opinion at an unacceptable level. The need for institutions like the Indian Concrete Institute and the Singapore Concrete Institure.to lead this teaching and training is essential.

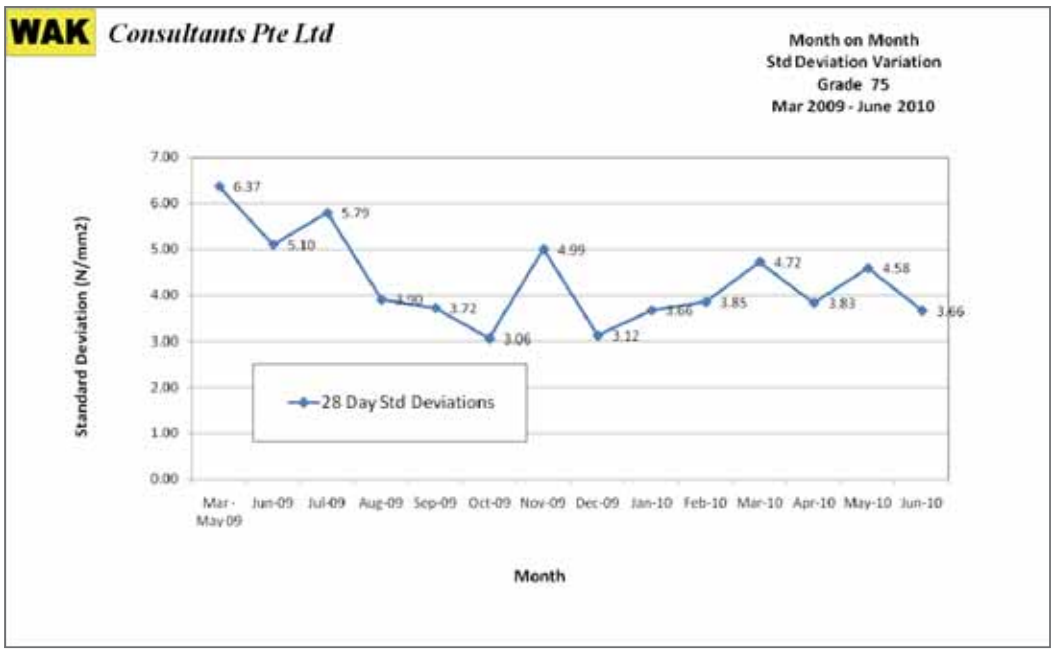

Figure 1: Month on Month Standard Deviation

RE-CON ZERO: THE INNOVATIVE ADMIXTURE FOR SUSTAINABLE CONCRETE

The concept of sustainable development was introduced in 1987 by the Environment and Development Commission of the United Nations as "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs"[1]. This concept arises from the concern, regarding principally the future generations, that our economical needs - the availability of goods and services, social needs and economical development - are growing at such a rate, and without any form of constraint, that the capacity of natural resources to be renewed, the natural absorption of waste and the sustenance of different forms of life, including humans, could be undermined.

Figure 1 – Venn diagram of sustainable development.

All industrial activities interact dynamically with the environment (extraction of raw materials and input of pollutants, use of land), society (welfare, employment, workers' rights) and the economy (profit, production costs, technology and application). The environment, society and the economy are considered the "three pillars" of sustainability and they must always be considered and evaluated together. Sustainable development – far from being a stable condition of harmony – is rather a changing process where the exploitation of natural resources, how investments are made and social development must be consistent, not only with present needs, but also with those of future generations. A condition of sustainability can be represented by the following scheme, and may only be achieved if environmental, social and economical sustainability are accomplished at the same time.

Sustainable Concrete

According to a recent survey, 10 billion m^3 of concrete are produced every year around the world. Every day, hundreds of thousands of concrete trucks load, transport and offload concrete in every corner of the planet. Concrete, which is consumed at a rate of 3.5 tons/year pro capita, is the second most used material after water.

Such a wide diffusion depends on its universality (it is readily available all over the world), versatility (it can be mixed to resemble natural stone or to create modern and contemporary buildings), healthiness (allows safe, healthy and comfortable structures to be built), durability (it can last for centuries, creating a safe environment for current and future generations) and low cost (concrete buildings are the most cost-efficient compared with those built with other materials).

The environmental impact of concrete structures must be evaluated through a holistic approach that considers every aspect: from the extraction of raw materials to the production of cement and concrete, their use in construction work and maintenance, and the demolition and disposal of waste materials. CO_2 emissions during the life cycle of a concrete building are much higher compared with emissions produced during its construction, and the amount of energy saved by concrete structures during their service life more than compensates for the amount of energy required for its construction and installation.

Even though the cement and construction industries contribute less than 10% to the total amount of greenhouse gas emissions due to industrial activities[2,3], there is a strong commitment to reduce the impact these sectors have on the environment. In the United States, the Portland Cement Association (PCA) issued a sustainability program (1990 – 2020) which focused on 4 main objectives:

- 10% reduction of CO_2 emissions
- 60% reduction of landfill disposal of cement dusts
- implementation of environmental management systems in 90% of cement plants
- improvement of energy efficiency of the plants[4].

Construction and Demolition Waste

The sustainability of products and materials cannot disregard the evaluation of their "end of life" process and their resulting impact on the environment. The production of waste from the construction industry (C&DW – Construction & Demolition Waste) is proportional to the amount of concrete produced, and in industrialised countries is much higher than that of urban waste. More than 500 million tons are produced in Europe every year, more than 300 million tons in the Unites States and about 80 million tons in Japan[5]. Many countries, like Holland, Japan, Belgium and Germany, have reached high levels of recovery and recycling of C&DW, but in many other coun-

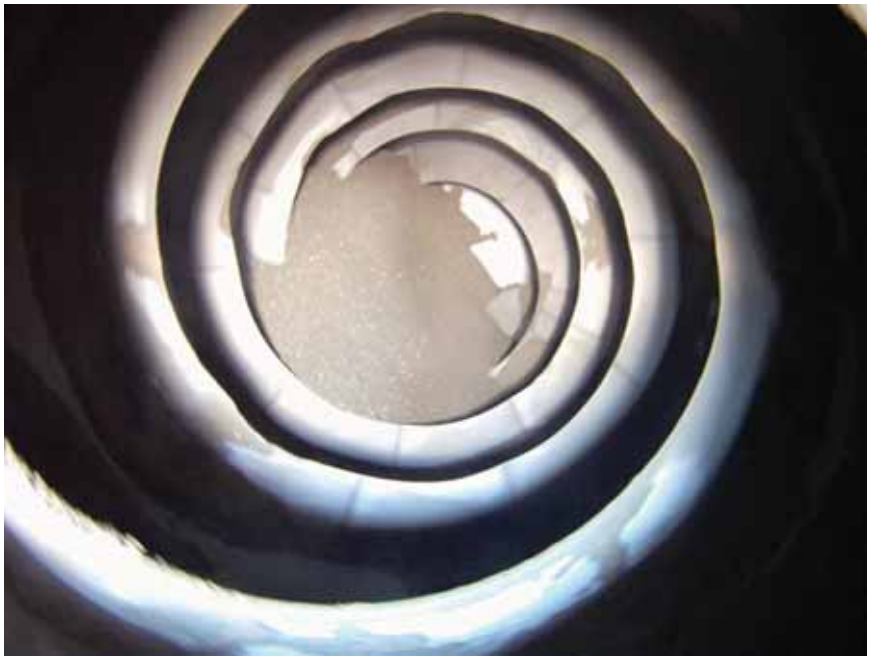

Figure. 2 – Interior of a fresh grain after treatment with RE-CON ZERO.

tries, landfill is still the preferred practice.
Concrete has unique properties, and the way it is recovered is an intermediate of the classical definitions of "reuse" and recycling". Concrete can rarely be reused in its original form, nor can it be recycled into its original materials; it is rather divided into small fragments by crushing or other means and then transformed into aggregates for a new cycle of life.
Concrete can be recycled and leads to the following benefits:
1. Reduction in the amount of waste produced and sent for disposal as landfill, which means a lower impact on the environment;
2. Replacement of natural aggregates and reduction in the exploitation of quarries;
3. Reduction of transport costs (concrete can often be recycled in sites close to ready-mixed concrete plants);
4. Reduction of costs for disposal in landfill sites;
5. Employment opportunities in waste recycling industries.
Therefore, concrete recycling is one of the main issues for the sustainability of this important material.

The Problem of Returned Concrete

Returned concrete is the amount of ready-mixed concrete that is not used on site and is sent back to the cement production plant in mixer trucks. The main reason for concrete to be returned to the plant is that contractors prefer buying a "surplus" of concrete compared with the estimated amount required, to avoid the risk of interrupting casting due to a shortage of material. The rate of returned concrete is about 0.5% of the amount produced at the plant; at peak times, however, this amount may be as much as 5-9% of the whole production. Estimates say that more than 50 million m^3 of concrete is produced every year all around the world, and the problem of returned concrete represents a heavy burden for ready-mix concrete plants.

There are no sustainable systems currently available to handle returned concrete, because those used neither eliminate landfill nor optimize the value of returned concrete, as well as being characterised by their high handling costs.

The New RE-CON ZERO Technology

Mapei has developed RE-CON ZERO, a new admixture for recycling returned concrete. RE-CON ZERO means "REcycling CONcrete at ZERO impact". RE-CON ZERO transforms returned concrete into a granular material that can be used as aggregate to partially substitute natural aggregates in the production of new concrete. The yield of the process is 100%: 1 m^3 of concrete is transformed into 2.4 tons of aggregates, without any solid or liquid residue, leaving the concrete truck perfectly clean and ready to load a new batch of concrete.
RE-CON ZERO is based on the combined action of 2 admixtures - RE-CON ZERO Part A and Part B – whose main function is to absorb and consume the free water in the concrete. When added to the concrete in the concrete truck, RE-CON ZERO Part A starts to absorb the water, then swells and slowly dissolves, making the concrete stiffer and more viscous. By rotating the mixing drum, in 4 minutes the cement and the finer fractions of the mix (sand and, in some cases, fillers) form a composite material with the admixture which wraps around the aggregates and covers them. The addition of RE-CON ZERO Part B completes and integrates this drying process by consuming the residual excess water and, at the same time, consolidates the cement matrix thanks to the formation of a dense crystal structure (Figure 2). After 3 minutes of additional mixing, the original fluid concrete is transformed into a mass of granular material that can be offloaded and spread on the ground and cured (Figure 3).
The typical dosage of RE-CON ZERO per m^3 of returned concrete is 0.5 kg of Part A and 6 kg of Part B. The product is made up of a kit of 7 water soluble bags in a cardboard box. The bags are added in sequence into the mixing drum of the concrete truck through the manhole (first the bag of Part A followed by 4 minutes of mixing, then 6 bags of Part B followed by 3 minutes of mixing) (Figure 4). For amounts of returned concrete higher than 1 m^3, the dosage of RE-CON ZERO must be increased proportionally. In order to get the best results, the slump value of returned concrete must be no higher than 210 mm (class S4 according to EN 206 standards); it is necessary, therefore, to avoid washing returned concrete excessively.
After at least 12 hours and within 24 hours, the bulk of the granular material must be turned over with a digger or similar equipment in order to break the bonds of hydrated cement that may have formed between the grains, and prevent the aggregates forming clusters that would be much more difficult to break up later on. The most suitable time to carry out this operation – very easy but

Figure. 4 – A RE-CON ZERO kit to treat 1 m^3 of returned concrete comprises 7 water soluble bags (one 0.5 kg bag of Part A and six 1 kg bags of Part B).

Figure. 3 – Offloading the granular material from a concrete truck after treatment with RE-CON ZERO.

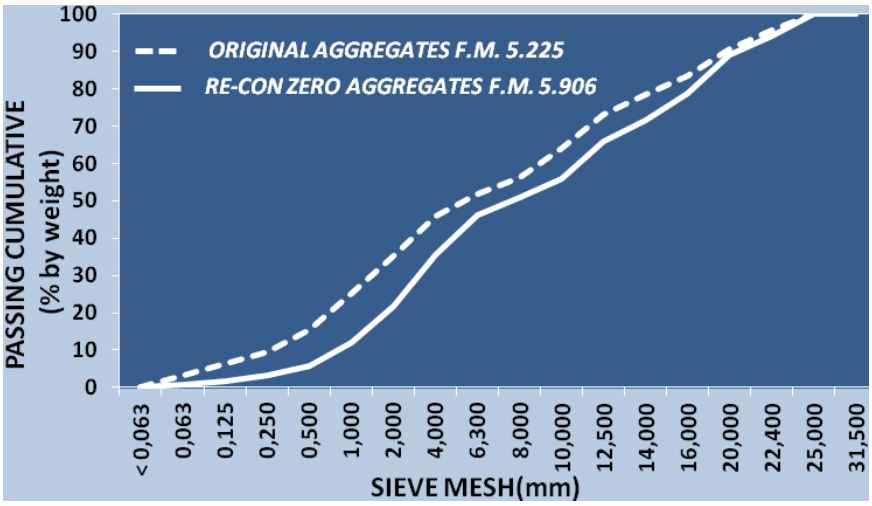

Figure 5 – Comparison between grading of aggregates before and after treatment with RE-CON ZERO.

essential for the success of the whole process – depends on a number of factors, such as the time of year, the class of concrete and whether the concrete contains retardant admixtures. If it rains during the first 12 hours of hydration, we recommend covering the granular material with a plastic sheet. After 48 hours of hydration, the material may be moved to a storage area without any further risk of the aggregates clustering together or being affected by atmospheric agents.

Characteristics of RE-CON ZERO Aggregates

Covering the original aggregates with the composite material slightly increases the fineness module of RE-CON ZERO aggregates and reduces the percentage of the finer fraction of aggregates. A typical variation of the fineness module of aggregates after treatment with RE-CON ZERO is shown in Figure 5.

The other properties of the aggregates obtained with RE-CON ZERO depend on the characteristics of the original concrete (type of aggregates, type of cement, water to cement ratio) and comply with the requirements of EN 12620:2008 standards on aggregates for concrete.

Characteristics of Concrete with RE-CON ZERO Aggregates

RE-CON ZERO aggregates can be used to partially substitute the coarser aggregates in the production of new concrete. Substitution rates of up to 30% can be reached without significant variations in the mechanical strength of the concrete, as shown in Figure 6, where the compressive strength of concrete made with natural aggregate (yellow bars) is compared with that of an equivalent concrete with the same composition, except for the substitution of 30% of the coarser aggregates with RE-CON ZERO aggregates (blue bars).

The Benefits of Using RE-CON ZERO

RE-CON ZERO solves the problem of returned concrete, with the following benefits:
Environmental Benefits
• Returned concrete is completely recovered, reducing the amount of waste sent to landfill.
• The use of recycled material is increased, with a corresponding reduction in the exploitation of quarries and the processing of virgin materials.
• The use of road transport is reduced because part of the aggregates is produced in the plant.
Social Benefits
• RE-CON ZERO is very easy to use and contains no harmful, toxic or carcinogenic substances, so contributes to improving health and safety in the work place.
Economical Benefits from using RE-CON ZERO
• Transforms 1 m^3 of returned concrete into 2.4 tons of high quality aggregate.
• RE-CON ZERO eliminates the cost of disposing of returned concrete and significantly reduces the cost of treating and disposing of sludge.
• RE-CON ZERO allows all returned concrete to be recycled without the need for capital investments in treatment plants.

RE-CON ZERO is the latest product from Mapei Research for sustainable concrete, and is a clear sign of the company's commitment to the development of products for the protection and improvement of the environment.

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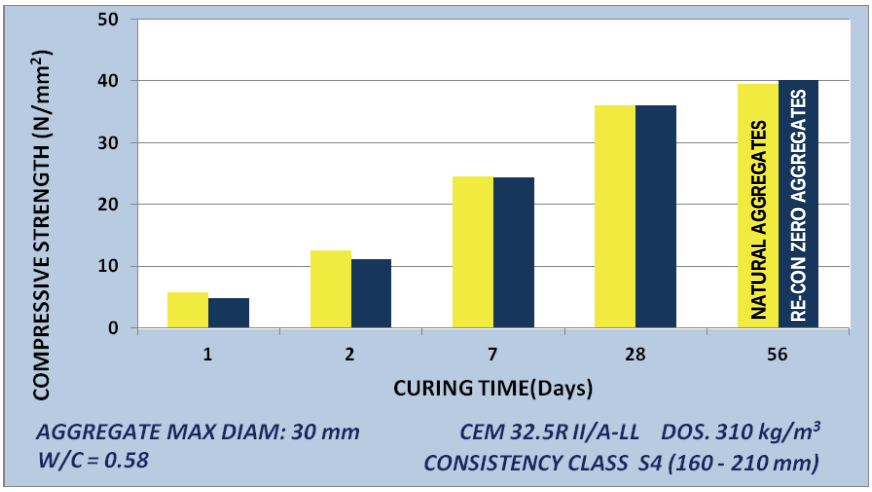

Figure 6 – Comparison between compressive strength of concrete made with natural aggregates and an equivalent concrete with 30% substitution of coarse aggregates with RE-CON ZERO aggregates.

Project Profile

Repairs to Reinforced Concrete Tunnel using Galvanic Anodes in Patch Repairs

Introduction

The delamination of concrete on the soffit of a tunnel due to carbonation of the concrete cover led to the investigation and assessment of its causes. A full durability investigation was carried out to determine the cause and extent of reinforcement corrosion. Recommendations were made to repair the spalled concrete. In addition to the repairs, galvanic anodes were used to prevent cracking around the perimeter of patch repair areas due to the "incipient anode effect".

Work Executed

The purpose of using sacrificial galvanic anodes in the patch repairs was to prevent corrosion from occurring at the perimeter of the patch repair as the zinc block inside the anode was "sacrificed", allowing the repairs to last longer. The type and spacing of anodes used was determined through the amount of steel that needed protection. During the installation of the anodes, particular attention was given to the continuity of the electrical circuit in the reinforcement grid, using additional reinforcement to aid with the continuity and the measurement of resistivity on the grid to satisfy the electrical continuity criteria.

Conclusion

The repairs were carried in May 2006. Regular inspection of the tunnel continues as part of the maintenance inspection programme. There has been no delamination of concrete on the soffit to date.

Keywords

Reinforcement Corrosion, Incipient Anode Effect, Sacrificial Galvanic Anodes

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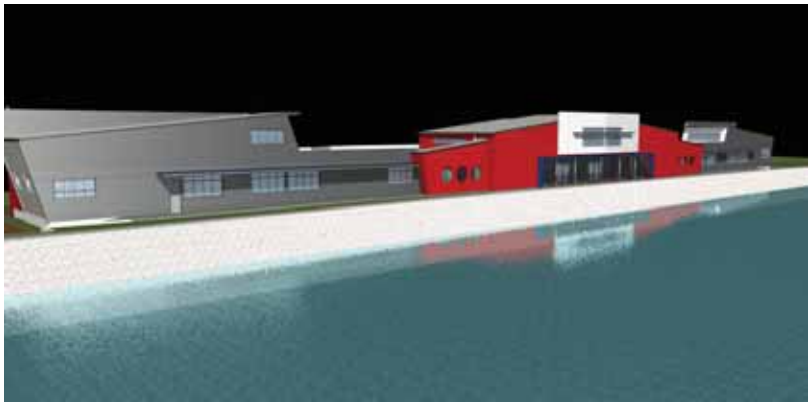

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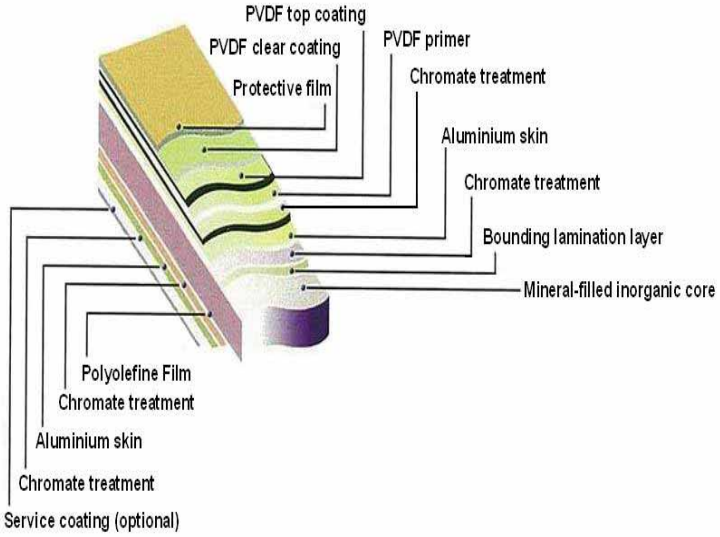

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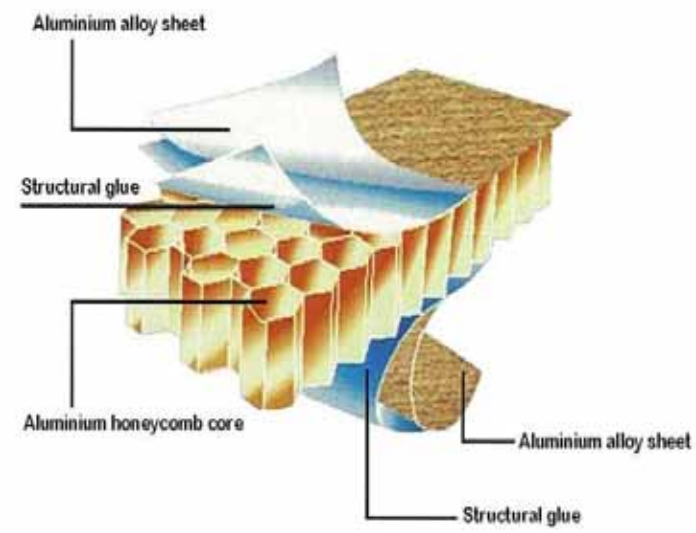

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- Fireproof
- Light weight
- Heat insulation
- Corrosion resistance
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THE INFLUENCE OF CONSTRUCTION CHEMICALS ON TUNNEL DURABILITY

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MC Bauchemie Muller GmbH & Co
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This article looks at the role construction chemicals in the Tunnelling Industry. Advances in both Tunnel boring machine technology (TBM) and ground conditions have accelerated the need and growth of specialised material.

Specialised additive and admixtures have revolutionised the durability and production of precast segments. The advancement of Alkali free shotcrete accelerators has enabled much safer working conditions. The uses of supplementary cementitious additives have allowed high build high strength concrete tunnels by robotic spraying.

This paper however will look at the role of injection resins in tunnels with case histories.

Figure 1

1. Injection Systems

Injection systems in tunnels and underground constructions are now often considered in the planning and design stage. They can be a means to simplify construction, enhance safety, and control potential leaks or many other applications.

The reason for this change is due to advances in materials in terms of set times in resin to particle sizes in cement suspension. Equipment technology in mixing has improved and pumps are now capable of handling just about any material even at tropical ambient temperatures around 35oC.

Engineers and clients need documentary proof of materials consumed and at what pressure to ensure correct grouting and this equipment is now readily available.

Injection resins based on polyurethane have been around for more than thirty years. In general these were a single component

Table 1. Typical Properties

Thixotropic Gels
• Swell up to 30% • Excellent adhesion to most substrates • Ductile up to 300% (see figure 2) • High tear resistance • Variable set times from less than 10 second to minutes

Figure 2. - Example of deformation

with an accelerator and reacted with water. There were and are many manufacturers with varying quality and properties. Figure 1 show a high quality water reactive resin foamed to approximately 35 times its original volume.
Newer technologies have two part polyurethane bases and have properties from highly elastic to highly rigid elastic. New technologies in gels allow swelling of up to 30% with negligible pressure on the substrate. Many of these products have both CE and REAch compliance. Table 1 shows some typical properties of a gel material.

2. Certification

REACh is the uniform chemical legislation with a strong focus on the protection of human health. Companies registered can be checked on the internet by contacting Helsinki. All the injection products we have been discussing all have REACh certification.

3. Polyurethane Injection Resins (Elastomer)

Polyurethane and Gel Technology have made major advances due to understanding the critical nature of mix ratio, mixing technology and advancement of twin line pump technology.

The term polyurethane is very generic and does not reflect the technical changes that have taken place over the last twenty years. The term elastomer is adopted to describe the material as it technically describes the material function. To many people, polyurethane is a brown liquid that foams and stops leak. This statement is simplistic, as it does not reveal some of the key properties of a water reactive resin. In order to fill a void and stop water ingress, of the following properties are needed.

1. Expansion of the material in contact with water
2. A stable dense foam
3. Non Shrinkage after foaming
4. Closed cell structure to prevent water permeation

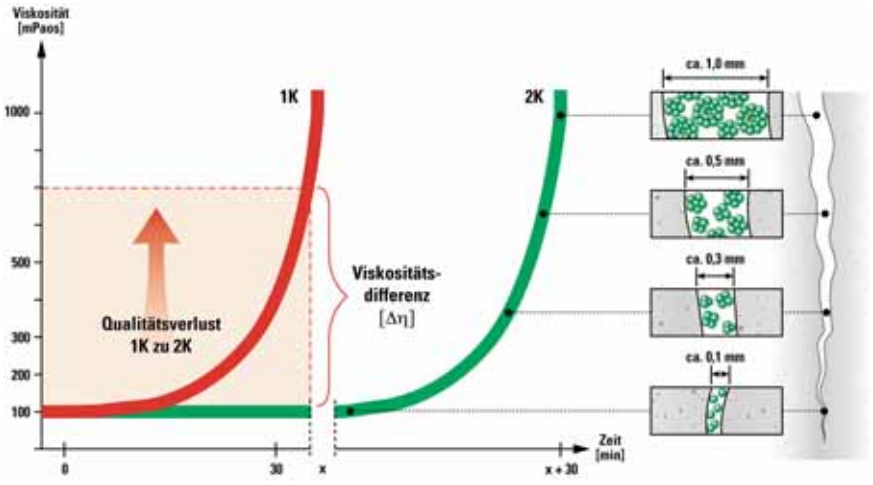
To achieve all these properties with a single component water reactive resin is impossible under all conditions. The foam density will depend on the amount of water and reaction time. The expansion will vary with the specific environmental conditions at each project. Due to these constraints, Europe and specifically Germany have adopted a two-stage process of injection to ensure permanent leak sealing. In applications of high water inflow a water reactive open cell foaming resin is first injected as initial seal. This is ten followed by a second injection using a two part elastomer resin, which will penetrate the open cell and give a permanent watertight seal. This method is adopted from the German Training Council and German Concrete and Construction Association Deutscher Beton UndBautechnik Verein e.V. (DBV) for injection of water leaks.

Two part elastomer resins have customisable stiffness properties and can be engineered from elastic and flexible, to strong and semi-rigid.

The ability to adjust the setting time is of great importance to ensure complete penetration of the crack as void viscosity is another critical factor and this will be discussed later in his paper. Table 2 shows some basic properties achievable in the market today.

	SOLIDIFICATION	SEALING FLEXIBLE	SEALING SWELLING
HYDRO-STRUCTURE RESINS	-	++	+++

+ dry ++ wet +++ water pressure



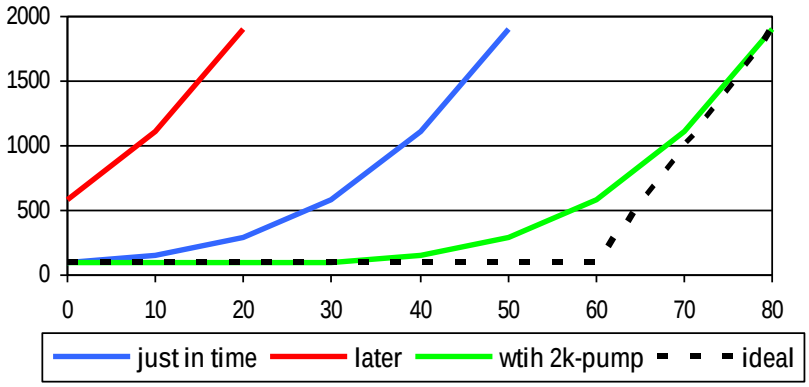


Figure 3. - Pump pressure versus injection duration

Table 2. basic properties achievable in the market of elastomer resin

Differing Properties of Elastomer Resin				
	Std	Long Life	UW	NV
Pot Life	30 secs	45 mins	43 secs	35 mins
Elongation	Rigid force transmitting			100%
Strength (N/mm^2)	60	60	80	Compressible
Viscosity (mPas)				

4. Hydro-Structure Resins

The name hydro-structure is used to dissociate these resins from the toxic acryl gels, which has caused major environmental problems in Europe. All the resins discussed and described in this paper comply with the highest standards of non-toxicity in contact with potable or drinking water. These resins cross-link and depend on water migration for long-term performance. The latest generation has “thixo” or skinning

Figure 4. The injection process

effect which makes them an ideal solution for buried leaking joints in car parks, stations and other underground structures. The ability to be pumped into very specific locations and then set, gives an ideal method of repairing joints and damaged membranes. The viscosity of these materials is very low thus making penetration into tiny voids and fissures very quick, which is impossible to achieve with a high viscosity resin. Table 3 lists some key properties.

These properties have simplified the repair of leaky segment joints. "Steps" often occurs when building tunnel rings in precast concrete and this can lead to failure of the gasket with subsequent leakage. The hydro structure resins with the thixo agents will be able to rebuild a membrane behind the joint and effectively waterproof the ring. Skill is needed in packer selection, gel time of the resin and pump pressure. The use of Twin Line pumps with the correct mix head technology is essential.

5. Equipment

Advances in equipment technology in the last twenty years have enable resin injection to provide a long-term durable repair where previously demolition and rebuilt would have been the only answer. Twin Line pumps with varying pressure and volume outputs allow correctly trained applicators to repair almost all leak problems in tunnels. The reason why Twin Line pumps are so important and especially in tropical climates are as shown in Figure 3. Figure 3. - Pump pressure versus injection duration

From this table one can see that the resin penetration is dependent on three factors; viscosity, time and pressure. Too high a pressure often causes more damage to the structure by re-cracking or worse. Time is something we cannot keep extending as the viscosity is increasing and the injection costs keep rising. Imagine a situation where each injection port requires a 15 minutes injection. Spacing of the injection ports could be at 250 mm centre so each linear metre of crack would take one hour to inject. The duration is also dependant on the thickness of the concrete structure.

The answer is the Twin Line equipment where the resin is mixed only at the point of discharge and this enables the lowest possible injection viscosity at the packer. This allows filling of the crack in the shortest possible time and to the finer parts of the cracks.

Twin Line pumps are only part of much bigger technical break through as both mix head technology and online monitoring have become available. Resins which have different viscosities or mix ratios require different degrees of mixing. Some resins can be mixed in 60 seconds with a shear mixer while others require 3 minutes for complete mixing. Each resin type has a specific mixer length and this is critical if the mixed resin is to achieve the designed property.

On many projects the Engineer would like to predetermine the pressures at which injection is taking place, others would like to restrict the volume of resin pumped into each packer. Other sites require a list of packers used and record of the volume, pressure and duration when the resin was pumped. All this information can be made available by using the German made control device.

This equipment pictured below Figure 4 comprehensively monitors the injection process. It ensures that the machine is calibrated and should the mixing ratio be out of margin it will stop and sound an alarm. Given that the machine is in good working order it will start pumping and record pressure volume and time. At the end of a shift the tagged packers are photographed and the information down loaded. This is then transferred to a computer and a report is generated automatically. This can be co-related to the site by grid reference and crack mapping showing an as built and as repaired document.

The equipment can also be used with water to carry out void surveys in structures with very heavy reinforcement when other techniques may not be suitable.

6. Applicators

With the sophistication of materials and equipment technology, a new approach to applicator training has evolved. Companies licensed to use the materials and equipments are required to have a government backed independent certification. This requires attending a two weeks residential course in Europe taking and passing an exam supervised by impartial and independent bodies. Manufacturers are not allowed to give this independent overview in a training course. The course is operated

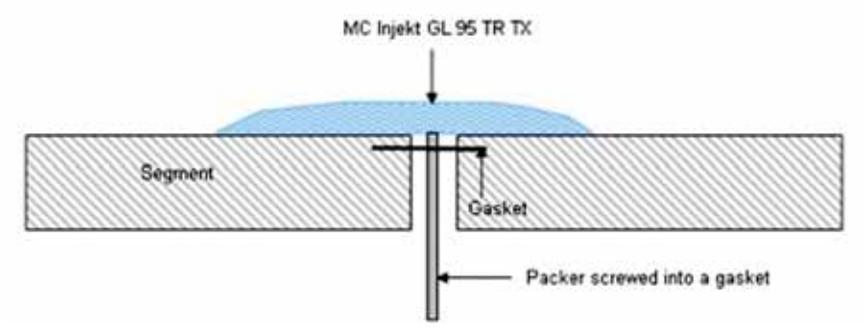
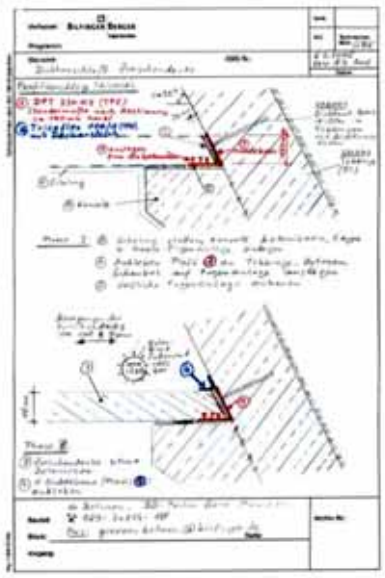


Figure 5. Tunnel joint injection with MC Injiekt GL 95 TR TX in SMART Tunnel

Figure 6

North South Bypass Tunnel - NSBT

by the BZB Akemie and the course topics include Basics of concrete and steel, repair of concrete construction parts, polymer and spray polymer repair mortars, and injec-



Suspended slab / Segment detail

tion of cracks cavities, joint repair, surface protection systems and strengthening using carbon fibre laminates. An examination occurs at the end of the course and if successful a certification is given. After which, these licensed operators then attend specific product and machine training to ensure the total system Man, Materials and Machinery works.

7. Case Histories SMART Tunnel Malaysia

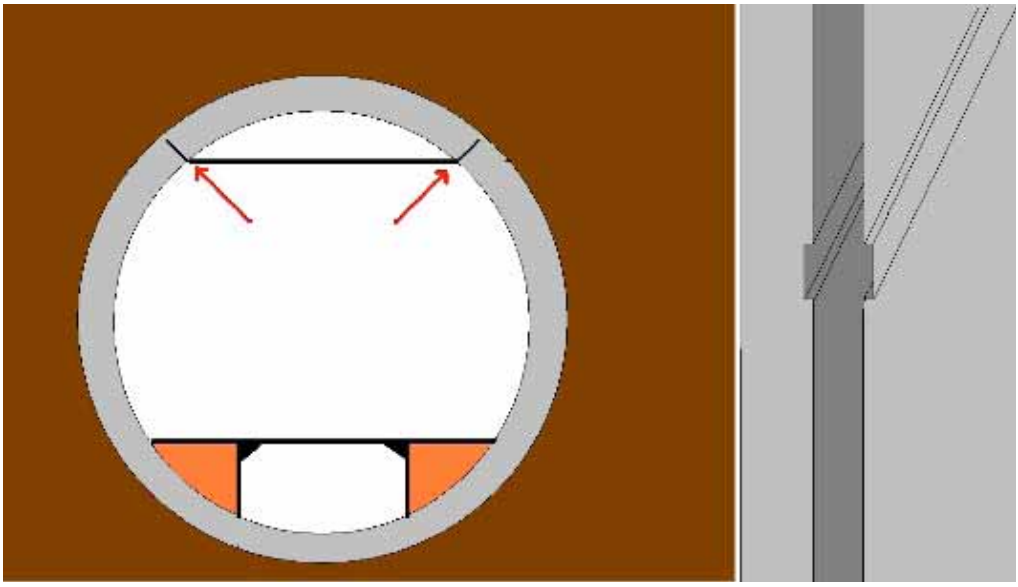
The SMART Project provides a storm water diversion scheme including floodwater storage and a 10 km, 11.8 m diameter bypass tunnel, sufficient to save the city from flooding in the foreseeable future. With no major flood event most of the year the tunnel a dual use was engineered, with double road decks built into the central three kilometre section, relieving traffic congestion by providing 2 x 2 traffic lanes for cars connecting the city centre to the southern gateway, the KL – Seremban Highway.

The flood water is diverted at the confluence of the Klang and Ampang rivers into a Holding Pond. From there the water passes through the tunnel into the Taman Desa Attenuation Pond and via a box culvert discharges into the Kerayong River.

MC was involved in supplying admixtures for both the backfill grout and the road deck concrete. We were also involved with all grouting to stop water ingress from within the tunnel.

Figure 5 and Figure 6 show two specialised injection systems. Figure 5 shows how we repaired damaged gaskets using specially developed packers and Figure 6 shows a specially developed packer for resealing leaking grout sockets.

Brisbane Road Tunnel – Case Histories



Application

Summary

As tunnel technology advances new materials have been developed to keep up with these advances and no doubt will continue in the future.

Area of Application *Application Preparation* *Shaft & Joint Sealed*

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

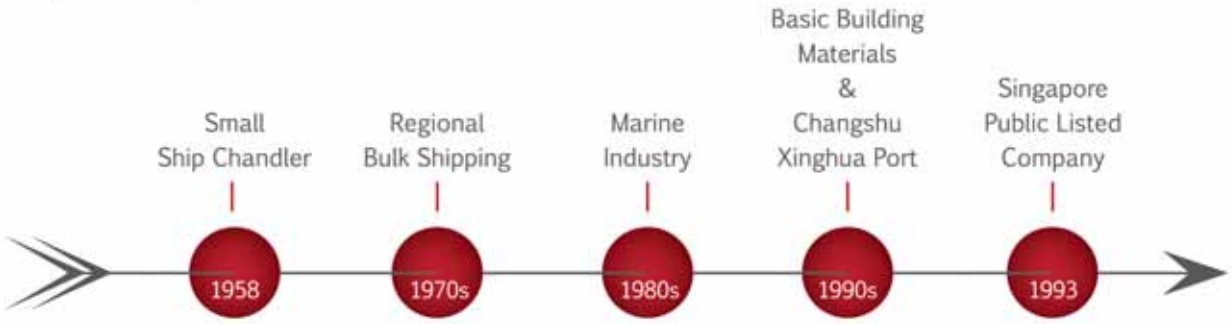
The Innovation Centre provides research & development and quality assurance on the raw materials and finished concrete products. Our Innovation Centre is Singlas Accredited modern laboratory, fully equipped with the latest technology equipments and the test for raw materials and Ready-Mix Concrete products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

PAN-UNITED CORPORATION LTD

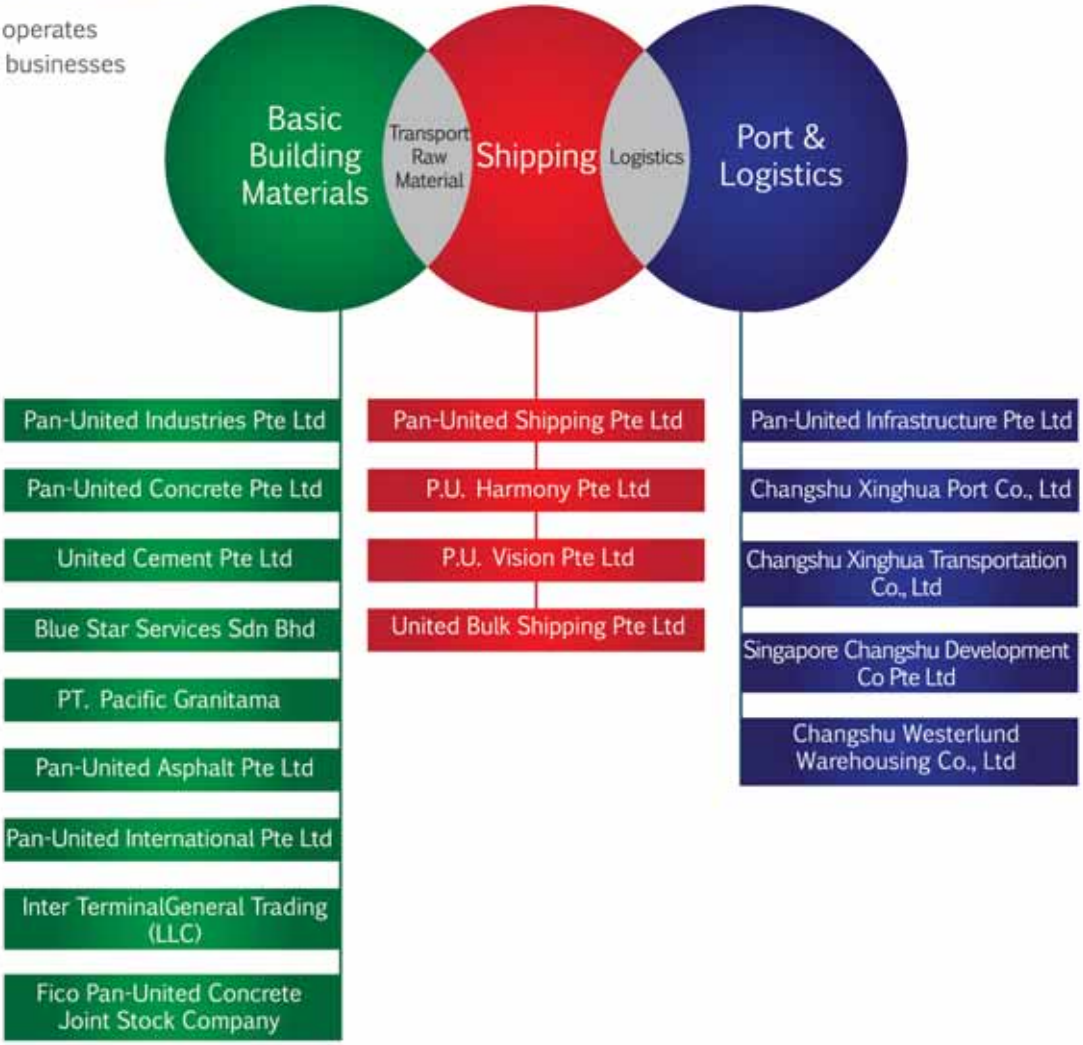
history

Pan-United Corporation Ltd is one of Asia's modern and dynamic enterprise



our businesses

the Group operates three core businesses



PAN-UNITED CONCRETE PTE LTD

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.

• concrete products

We have handled mega-sized projects requiring special concrete

Tampines Concourse
1st Asia-Pacific Carbon Neutral Development

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.

PAN-UNITED CONCRETE PTE LTD

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

High-Strength Concrete

High-Strength Concrete had been developed for its strength, durability and high modulus of elasticity. High-Strength Concrete columns reduces its size and allows for more saleable space.

The Sail
high-strength concrete was used for the first time in Singapore for the columns around the towers

concrete strength test

Fort Canning Tunnel
the asia longest shotcrete tunnel

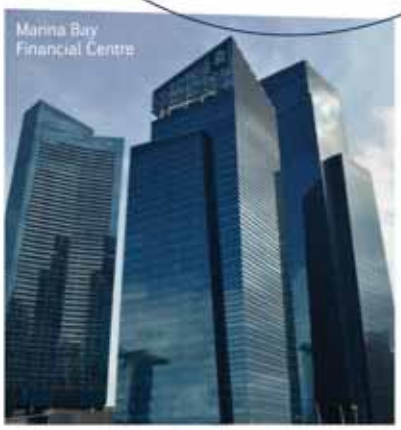
Shotcrete

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.

PanUnited

PAN-UNITED CONCRETE PTE LTD

• track record



Concrete so Super Workable it Moves

Grace Construction Products provides the solution for Super Workable concrete that quite literally moves. Truly effortless to work and place. Delivering high early strengths, improved finishability, reduced cycle times, and better productivity for the precast concrete producer.

To learn more about the Grace solution for Super Workable Concrete, contact asia.enq@grace.com

GRACE
Construction Products

www.graceconstruction.com

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

Optimise precast concrete production with Grace admixture solutions

If your operation calls for reduced cycle times, reduced costs, better productivity, improved product performance, then Grace Precast Concrete Solution is your answer.

ADVA® Cast Polymer - Based Superplasticisers

- Superior early strength enhancement
- High workability
- Great surface finish
- Superior water reduction

Grace can help you develop the most effective mix for your operation. Contact Grace today at asia.enq@grace.com.

GRACE
Construction Products

www.graceconstruction.com

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

T·Y·LIN INTERNATIONAL PTE. LTD.

civil | structural | geotechnical | mechanical | electrical

Introduction

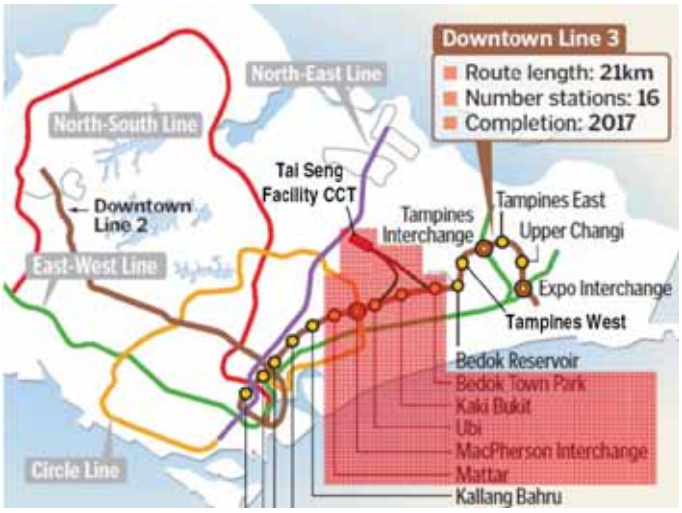
Established in 1972 to meet the demand for technical expertise in civil and structural engineering in South-East and East Asia, T.Y.Lin International Pte.Ltd. operates from Singapore as an affiliate office of T.Y.Lin International (TYLI) in San Francisco, USA. In 2007, T.Y.Lin International acquired PCR Consulting Pte Ltd, a specialist mechanical and electrical engineering consulting firm which was established in Singapore in 1970.

Our objective is to identify the specific business needs of our clients and provide added value through technical excellence, delivery through efficient organization, and flexibility through personal service and commitment.

The firm has provided consultancy services to more than 400 clients in the region and has handled over 600 projects involving a total investment cost of US$10 billion (construction costs for executed projects). Clients have included governmental agencies, private institutions as well as contractors.

Building upon our specialist skills in structural modeling, analysis, design and construction support, the firm has re-invented itself over recent years and taken on a project management role with proven capability to deliver an integrated package of services covering every aspect of the project, tackling complex projects requiring the co-ordination and management of many different experts and professional disciplines.

Our Current Projects



DOWNTOWN LINE STAGE 3

The proposed Downtown Line Stage 3 (DTL3) will be an underground Mass Rapid Transit (MRT) System extending from Downtown Line Stage 1 (DTL1) Chinatown Station and run through MacPherson, Bedok Reservoir, Tampines and ending at the East West Line Expo Station. It consists of 16 stations and a total route length of about 23 km including connection to Kim Chuan Depot. The project are divided into 3 packages, namely Package A, B and C.

For Package B, it consists of 5 underground MRT stations with 9km of TBM tunnels. T.Y.Lin International Pte. Ltd. is appointed by LTA as the Lead Consultant undertaking Civil & Structural and Mechanical & Electrical (water, drainage and sewerage), tracks & CSM services for DTL3B.

THOMSON LINE DEPOT

The proposed Thomson Line is an underground 4-car train MRT System with an approximately route length of 30 km. The Thomson Line Depot will stable 90 trains and undertake system and related level-3 maintenance for about 138 trains.

It will have an Operation Control Centre, a Depot Control Centre, stabling yards, administration buildings, storage warehouses, workshops and ancillary facilities for storage, cleaning, maintenance and overhaul for safe functioning and operation of the vehicle fleet and associated railway systems.

The Depot is classified as a National Critical Infrastructure. It shall be planned for integration with a future Bus Depot development of approximately 8.5 ha via a Development Deck above the Depot.

THOMSON LINE PACKAGE B

The Thomson Line underground 4- car train MRT System will enhance the rapid transit system network for commuters travelling in the direction of north-south corridor of Singapore. The overall TSL consists of 23 stations and a total length of about 30 km of underground tunnels including connection to the new Thomson Line Depot.

T.Y.Lin International was awarded the Package 'B' contract comprising approximately 14.5 km of bored tunnel and 8 stations which include the following:

- 1 integrated interchange cum CD station
- 1 station with an interchange link to an existing station
- 5 station of which 2 are CD stations
- 1 future stations
- 1 underground RTS facility building
- 1 at-grade RTS facility building

The project encompass the design and associated services for the track alignments, stations, RTS facility building, ventilation shafts, TBM launching/ retrieving shafts, tunnels and cross passages.

THE INTERLACE

Located between Ayer Rajah Expressway, Alexandra Road and Depot Road, the proposed Interlace development is a condominium housing development comprising 23 blocks of 6/12/18/24-storey apartments (total 1040 units) with commercial use at 1st storey and ancillary facilities. Car parking facilities are located at basement.

PROJECT HIGHLIGHTS

1. The Residential Development generally consists of 31 interconnected 6-storey blocks/ superblocks that are stacked together in a staggered arrangement based on a hexagonal grid. Each 6-storey blocks are approximately 70m long, 15m wide and 20m high. The highest superblock are stacked up to 4 stacks high and loads are generally transferred via the mega-columns through 23 cores.

2. The objective of the structural scheme is to present a structural system that will enhance flexibility in architectural layout and to achieve a buildable design within optimum time of construction for the project.

LEE KONG CHIAN NATURAL HISTORY MUSEUM

The Museum located at NUS consists of 2 floors of gallery area, 1 floor of dry collection and laboratories, 2 floors of wet collection and laboratories, and 1 floor of Office, meeting rooms and library. The project requires very strict temperature and humidity control for Gallery and Collection area to protect collections, while ensuring building safety and reducing energy cost.

The air conditioning system is designed to be robust, efficient, and space-effective to maintain invaluable scientific collections within strict preservation environment, 24 hours a day. The wet collection and laboratories involve use and storage of up to 60,000 Liters of alcohol & flammable materials. Hence, an efficient design of air conditioning, mechanical ventilation, gas detection system and strict design of fire protection system are required to ensure safety, along with explosion proof electrical fittings provision.

Engineered vapour scavenging ventilation system is designed to maintain safe level of flammable vapour explosive limits while minimizing make up air conditioned air to save energy. High COP heat recovery units serving Gallery and collection areas are provided to produce heating for humidity control with by-product of cooling, to achieve high energy saving while meeting space parameter. Explosion-proof high frequency non-UV emitting lighting is provided to protect the collections, ensure safety while achieving required lux level with minimum energy.

EDWARD LIFESCIENCES PHASE 2 EXPANSION

Edwards Lifesciences is a global leader in products and technologies to treat advanced cardiovascular disease and the number one heart valve company in the world. Edwards Heart Valve Therapy segment is the company's most significant business. The Phase II expansion project is a 5 storey Cleanroom manufacturing facility (ISO 14644-1 Class 7) for Transcatheter Heart Valves, new products, distribution and regional sales office.

The M&E design features Variable-speed drive chillers selected for excellent part-load performance for this 24/7 operation facility, dual fan Air Handling Units (duty and standby) with seamless changeover in the event of failure, energy reclaim from the exhaust air stream to reduce the air-conditioning load and heat Pumps used for Cleanroom, changeroom, handwash with the cool air introduced into the M&E plantroom for free cooling.

33rd SCI Anniversary Gala Dinner
Theme: "The Path Towards Productivity"

Held on 16 November 2011 and more tan 350 professionals attended the dinner at the Swissotel Merchant Court Singapore.

Highlights of the event:

Presenting the plaque to main sponsors

Tributes to Mr. Willie Kay, SCI immediate Past president

37th Our World in Concrete and structures conference (Singapore, 29-31 August 2012) was dedicated to Mr. Williy Kay. Mr. Fong Weng Khiong, SCI Hon. Treasurer delivered the following Opening Speech on behalf of SCI at OWICS 2012.

To Mr Willie Kay, all Conference Committee Members, Speakers, Partners, Participants, Ladies & Gentlemen:

It is indeed a great honour to recognise Willie Kay for his contributions to the OWICS conference series. It is also SCI's privilege to have Willie serving tirelessly in the Board of Directors since 1981. Willie has contributed in many ways to SCI over the years. He has supported SCI through numerous participation in conferences, technical talks, establishing network with overseas partners such as UK BRE, Japan Concrete Institute and Asian Concrete Federation, just to name a few. Willie, with his vast experience in the field of concrete technology in UK in his early years and later working with companies such as FOSROC and MBT, gave him widespread experience as a material technologist. He was one of the pioneers with other talented SCI speakers to run the very successful SCI course titled "Inspection, Appraisal and Repairs of Concrete Structures" for many years from late 80s to mid 90s. More recently, he, together with ACI-SC, with support from BCA, initiated and subsequently put into a framework of accrediting personnel working for ready mixed concrete plants to deliver quality concrete to SS EN 206. The certification, as we know, helps to ensure the quality of the ready-mixed concrete provided to our building and construction industry. He was also instrumental for SCI to partner Prof Ravindra Dhir of UK as principal investigator to carry out a study titled – Recycled and Secondary Aggregates (RSA) for use in Construction: A State-of-the-Art Review, tapping on BCA's Sustainability Construction Capability Development Fund and supported by industry players. Willie served as the 12th President of SCI from 2007 to 2009 and continues to serve as Immediate Past President of the Singapore Concrete Institute giving valuable guidance and advice to the current Board. Personally, I know Willie since 1991 through our work. He has always been a person willing to teach, guide and give encouragement for individuals to better themselves to contribute to industry and society.

And so, with this much said, and with much gratitude, on behalf of the Singapore Concrete Institute, we salute Willie Kay for all his contributions!

SCI EXCELLENCE AWARDS 2011

The SCI excellence award for Builders Category was awarded to
Expand Construction Pte Ltd

For their Project:

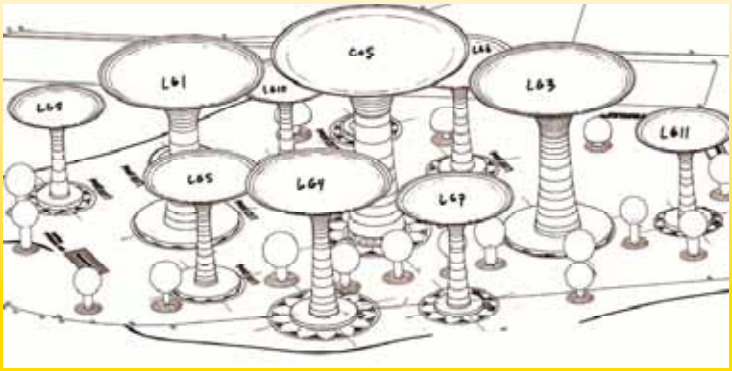
Proposed Erection of Lion Grove Supertrees At Gardens By The Bay (Marina South), Singapore

The Supertrees are structures that have the conceptual look of natural trees, but built in larger size proportions. There are 12 numbers of Supertrees (ST) in the Lion Grove area with varying heights; 5 ST (LG2, 8 to 11) are 25m high, 3 ST(LG4,5,7) are 30m high, 1 ST(LG4) is 37m high, 2 ST (LG1,3) are 42m high and 1 (C05) is 50m high.

Each Supertree has a circular main core in reinforced concrete structure. The shortest Supertree of 25m in height has an overallcore diameter of 2.07m while that of the 42m Supertree has a core diameter of 3.8m. C05 has a 4m outer diameter main core with another outer layer of circular wall measuring 7.3m in overall diameter.

Nine Supertrees which are 25m to 37m high have only the main concrete cores and are non-habitable. The other Supertrees namely 42m high LG1, LG 3 and 50m high C05 are habitable with lifts within the main cores and access staircases. Top portion of C05 is enlarged to cater for commercial space with a roof terrace viewing
gallery, making it distinctly different from the other 11 Supertrees.

Each of the Supertrees is cladded with stainless steel trunk skin from its base level up to throat level (approx. two third of height of the main structure). Above the trunk skin are the carbon steel core headribs and canopy elements which are supported on the upper level of concrete core. The canopy overall diameter is at the same magnitude to the height dimension of the corresponding Supertree.



Supertrees @ Gardens By the Bay

Commendation Awards for builders category was awarded to
HSL Constructor Pte Ltd

For Their Project:

Design And Construction Of A 15000 DWT Coal/Biomass Handling Jetty For The Tembusu Multi Utilities Complex

SCI EXCELLENCE AWARDS 2011

The SCI excellence award for Innovators Category was awarded to
BASF South East Asia Pte Ltd

For Their Project:

Sustainable Self Consolidating Concrete To Increase Productivity For Everyday Concreting.

Traditional Vibratable Concrete (TVC) of slump up to 150mm for Grade 25 to 40 is the most commonly supplied concrete. This type of concrete requires vibration to aid compaction which is labour, energy intensive and time consuming. Self Consolidating Concrete (SCC) of slump flow between 600 – 700mm overcomes the downsides of TVC but requires high fines content of between 550 to 600 kg/m3. Of these fines, no less than 450 kg/m3 is cement resulting in "overkill" in the concrete mix design – this is probably one of the biggest reasons why such a concrete, in spite of the immense benefits never grew popular in Singapore. The additional gap of 25 to 40MPa needs to be paid for resulting in high cost of the SCC mixes.

Singapore construction industry is highly reliant on workers as many of the activities are labour intensive. Low productivity has plagued the industry for a long time and all the stakeholders are looking into ways to improve productivity (especially reduction of labour) and increase the speed of construction. Due to shortage of construction materials worldwide, there is also an urgent drive for better utilization of materials for sustainable development. If TVC can be made to achieve the properties of SCC yet at a substantially lower cost than SCC, the concreting process can speed up and will substantially reduce labour, energy and time. A highly flowable mix will also bring added benefits of better surface finishes, improved hardened concrete matrix thus better durability and overall lower repair costs. The increased use of such a concrete will also contribute towards sustainable development due to its lower cement content as compared to traditional SCC and higher durability.

Commendation Awards for Innovators Category was awarded to
Holcim (Singapore) Pte Ltd

For Their Project:

Self-Flow Concrete Towards a More Environmental Friendly and Competitive Construction in the Alba Condominium at Cairnhill Rise for Far East Organization (FEO)

34th SCI Annual General Meeting 27 April 2012

SCI Annual General Meeting is organized once a year to select new board of directors. The 34th Annual General Meeting was organized on 27th April 2012 at NUSS Suntec City Guild House.

BCA Academy, SCI and ACI(SC) The fifth round for the "Certificate in Concrete Technology" course jointyly organised by BCA/SCI/ACI(Singapore Chapter) was conducted in March 2012.

SCI Social Networking Nights at Penny Black, 28 Boat Quay 21st June 2012

The networking night for 2012 was organized on 21st June 2012. This event was sponsored by Pan-United Concrete Pte Ltd and 40 participants attended the event with lots of camaraderie spirit and socializing mood.

Singapore Concrete Institute Supported the 37th Our World in Concrete and Structures Conference and awarded Dr. D. V. Reddy.

PREMIER CONFERENCES

Singapore Concrete Institute sponsored the SCI Award in this year conference which was presented to Dr. D. V. Reddy for his original paper titled
"Response of a freshly placed full scale concrete drilled shaft to vibrations induced by adjacent shaft installation"
D.V. Reddy, C.S. Gonzalez-Mier and K. Sobhan

SCI Supports The Institutions Of Higher Learning For Academic Excellence

Singapore Polytechnic : SCI Gold Medal S$700 for Academic Year 2011/2012 - FOONG GUOWEI, ALVIN
****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 for Academic Year 2011/2012 - JONG MING CHUAN

National University of Singapore : Gold Medal S$100 Book Prize for Academic Year 2011/2012 - CHEONG WEI BOON
****Paid from the proceeds of a capital sum of S$15,000 donated by SCI in 1997.**

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

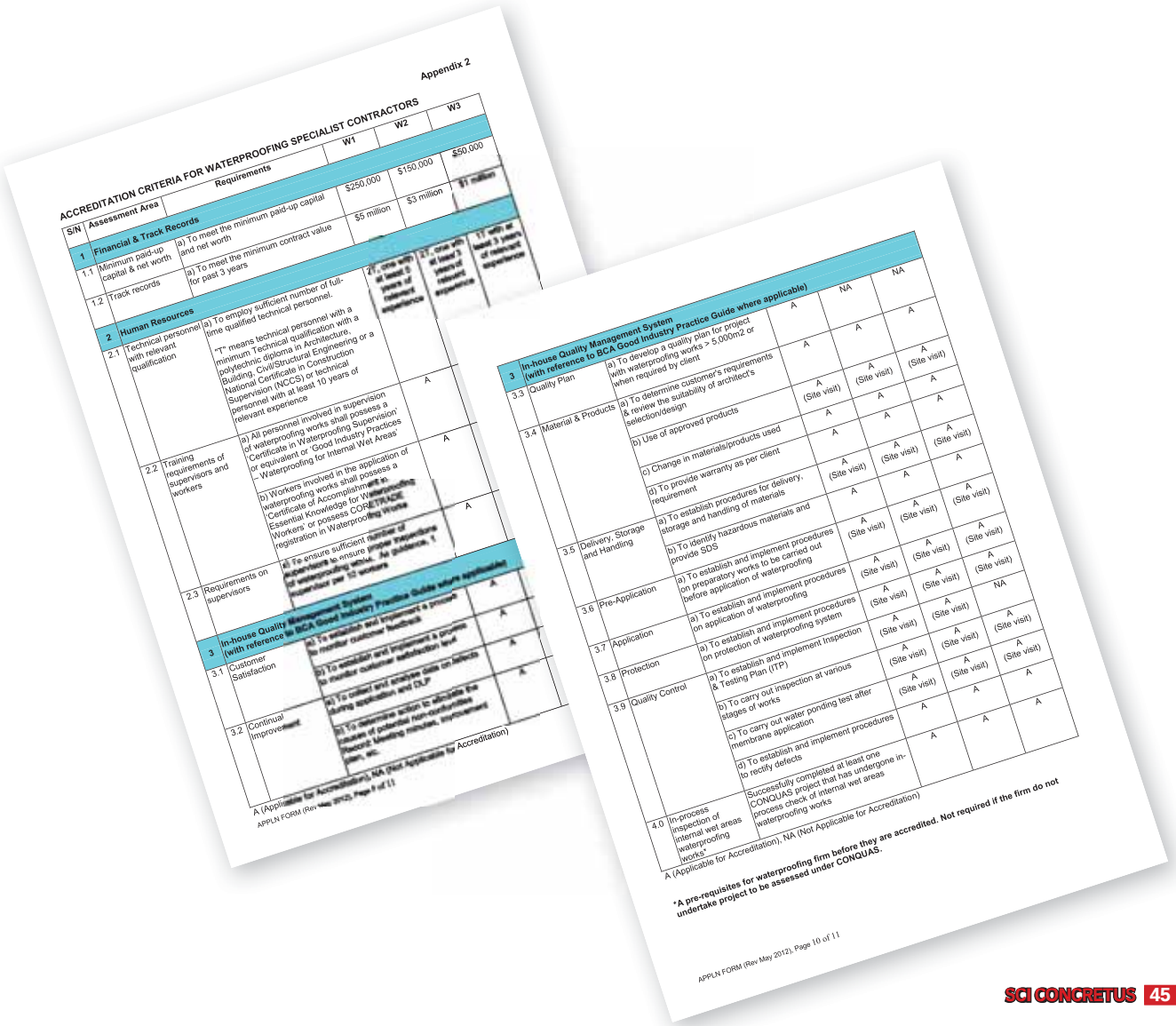
Benefits of Accreditation

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).



Accredited Waterproofing Firms

Waterproofing Accredited Contractors W1

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

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 ASIA PACIFIC (WP) 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.
10 Admiralty Street
#06-15 North Link Building
Singapore 757695
Tel: 67550055 Fax: 67531398
info@uniseal-waterproofing.com
www.uniseal-waterproofing.com

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

Waterproofing Accredited Contractors W2

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 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

Waterproofing Accredited Contractors W3

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

KHIAN HENG CONSTRUCTION PTE LTD
157B Goldhill Centre,
Singapore 307586
Tel: 6255 7355
Fax: 6253 7696

MAXISEAL PTE. LTD.
7030 Ang Mo Kio Ave 5, #05-19, North Star building, 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
jumari@hitchins.com

SOURCE WATERPROOFING PTE LTD
6 Harper Road #01-07 Leong Huat Building Singapore 369674
Tel: 67444693
Fax: 67444367
source46@singnet.com.sg

VECTRON WATERPROOFING PTE LTD
6001 Beach Road #13-11 Golden Mile Tower Singapore 199589
Tel: 65151004
Fax: 65155003
vectron@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

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

Accredited Precasters PC 1

SUNWAY CONCRETE PRODUCTS (S) PTE LTD
4 Tampines Industrial Street 62
Spore 528817
Tel: 6583 8089
Fax: 65810482
sunwaycp@singnet.com.sg

Accredited Precasters PC 2

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

ENG LEE ENGINEERING PTE LTD
12 Kian Teck Crescent, Spore 628873
Tel: 6261 9119
Fax: 62683955
angeline@engleepl.com.sg

QINGJIAN PRECAST PTE LTD
31, Tannery Lane, #07-01, Hb Centre 2, Singapore 347788
Tel: 67487117
Fax: 67487227
qjprecast@qdcgsb.com.sg

K L PILE SDN BHD
No. 60 Jalan Laksamana 2 Taman Ungku Tun Aminah 81300 Skudai Johor
Tel: 607-5576509
Fax: 607-5576463
klpile@ymail.com

SUNWAY SPUN PILE (ZHUHAI) CO. LTD
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Singapore, 22-23 August 2013

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The conference will be dedicated to
Mr C R Alimchandani

OWICS 2013 will be celebrating the Golden Jubilee of STUP Consultants Ltd. STUP helmed by Mr C R Alimchandani has been involved in numerous infrastructure projects within and beyond the Indian subcontinent. STUP Consultants Ltd has supported this conference series with the STUP Highly Commendable Paper Award first established in 2000 and so far ten HC paper awards have been given out to deserving authors. I would like to invite you to join us in the celebrations planned for OWICS 2013.

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Special event

Prof Gyorgy Balazs, the President of 'fib' shall be making a special presentation on the "fib Model Code 2010" and the activities of 'the fib the international federation for structural concrete" .
(Note! If you are interested to know more about the fib, contact the Secretariat)

For enquiries and submission of abstracts, please direct to the Conference Secretariat:

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b) Mohammad Khalajmasoumi	24 April 2012
c) Selvaraja Joseph	24 April 2012
d) Kyaw Kyaw Soe	21 May 2012
e) Kasiviswanathan Anand	18 June 2012
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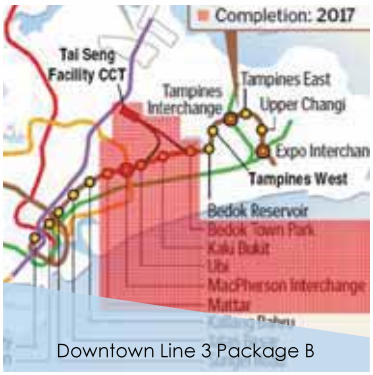
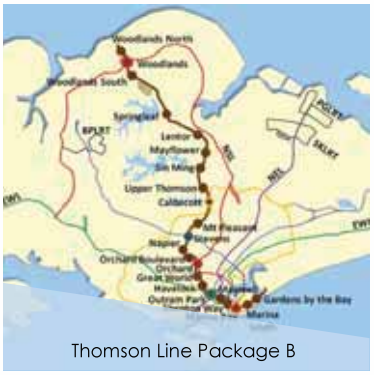


Downtown Line 3 Package B



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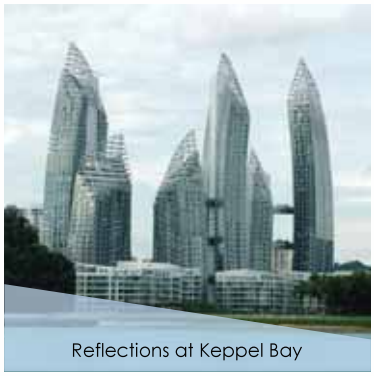
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