# Advances in Injection Techniques Increase Concrete Repair Application

*By Willie Kay – WAK Technologies Pte Ltd / WAK Consultants Pte Ltd*

For many reasons more and more underground infrastructure projects are being built underground. Whilst tunneling equipments and lining systems advance technically each year, leakages in tunnels is still a practical reality. The recent advances in both materials and equipment used to repair damaged or leaking concrete structures. Materials technology has advanced rapidly in the last ten years moving from simple single component water reactive polyurethane to multi component hydro structure resins. Advances in two component elastomer resins now allow full structural rebonding even underwater. Equipment technology has also seen dramatic change with automatic metering measurement and mixing using twin line pumps with a vario mix head. New patented measuring equipment allows the accurate recording of actual material consumption, pressure and time at each injection point. In order to ensure that the operators understand the technicalities of this technology, European-based-standards of training, which includes German Independent Certification, are slowly being introduced. Case histories illustrated how new areas of repair are being resolved. Tunnel injection to ensure long-term water tightness is has been recognized as a specialist specialised area of work. Resin technology has changed and improved and Table I summarizes some key resin types and properties their relative suitability in various applications.

Table I(+ dry; ++ wet; +++ water pressure)

| | Strengthening | Sealing | Waterproofing Swelling |
|---|---|---|---|
| Duromer | + | - | - |
| Suspension | ++ | - | - |
| Elastomer | +++ | +++ | - |
| Hydrostructure | - | +++ | +++ |

## Polyurethane Injection Resins (Elastomer)

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 condition 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 then 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 this paper. Table II shows some basic properties achievable in the market today.

Table II

| Differing Properties of Elastomer Resins | | | | |
|---|---|---|---|---|
| | 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) | 200 | 150 | 230 | 95 |

## 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 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 III(+ dry; ++ wet; +++ water pressure)

| | Solidification | Sealing flexible | Sealing swelling |
|---|---|---|---|
| Hydro structure resins | – | ++ | +++ |

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.

## 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 reasons why twin line pumps are so important and especially in tropical climates are as shown in Figure 1.

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 250mm center so each linear meter 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 on line 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.

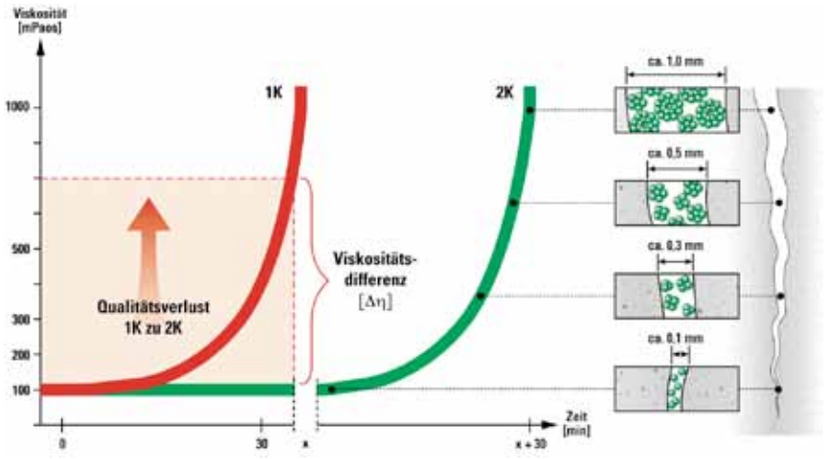


*Figure 1 Pump Pressure Versus Injection Duration*

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 (Fig. 2) 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 references 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.

## Operators

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 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, injection of cracks cavities, joint repair, surface protection systems and strengthening using carbon fiber 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.

*Figure 2 Monitoring Device, Mixer Device and Tagged Packers*

## Case History

1 **Thailand VSL Pile at Jetty** – Jetty pile sustained a 3 meter crack due to accidental barge collision. Client concerned about structural integrity of the jetty. MC-Injekt 2700 UW was proposed with adhesion packer and work commence using MC I 200 twin line pump. MC Inject 2700 UW is a high strength (80 N/mm2) non-foaming PU and thus allows injection from one side.



2 **Signature Park** – Leaking expansion joint in pedestrian underpass. MC-Injekt GL 95 TR TX was proposed. Packer holes were drill at 45º angle towards the joints to intercept the joints. 300mm GEL packers were placed in position followed by material injection. Previous injections using conventional polyurethane had all failed.


3 **Expansion Joint** – Water Reclamation Plant


## Conclusion

Technology changes today are occurring with greater speed than ever before. The advances in material technology on their own are no longer sufficient and need systems approach. Not just advances in new materials development but equipment advances and the training of people with new skills. Advancement in materials technology on its own may not be advancement.

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# A New Slump-Loss-Controlling Agent Without Affecting Early Strength Properties

*by Frank Göller, Stefan Dikty and Tatsuo Izumi*
*Kao Chemicals GmbH, Germany*

In recent years the economy has been the driving force for the development of new building technique, and improves construction processes, and as a result new types of superplasticizers. Self-consolidating concrete (SCC), also known as self-compacting concrete, has the special property that it flows to a uniform level, is non-segregating and deaerates under the influence of gravity only. As a high performance concrete, SCC is without a doubt advantageous where vibration compaction is particular difficult, for example due to heavy reinforcement and unfavourably shaped formwork, but also useful to reduce noise pollution.

Adjustments of traditional mix designs and the use of superplasticizers deliver these attractive benefits while maintaining all of concrete's customary mechanical properties and durability characteristics. Above all, the development of superplasticizer have made it possible to design flowing concrete without compromising durability, cohesiveness or compressive strength.

There have been many examples of the development of new type superplasticizers for retention of concrete fluidity. Various technologies based on water-soluble copolymers such as acrylic cross-linked polymer compound (1), reactive compromising copolymers of maleic anhydride and isobutylene (2) and special polymer activator of comb-type graft polymers (3) have been investigated to avoid the slump loss. The improvement of slump retention by using a certain kind of hydroxy acid has been reported too (4). These technologies have been found to be effective to avoid slump loss but sometimes they can cause problems such as set retardation and insufficient slump retention. In previous investigations (5, 6, 7) the polyether based superplasticizers with grafted chains of long ethylene oxides (EO) were found to give much higher initial dispersing ability of cement and less retardation in contrast to conventional superplasticizers, even if compared with polycarboxylate based superplasticizers with shorter polyethylene oxide chains.

In the present study, a new slump-loss-controlling agent (SLCA) based on the above mentioned polyether grafted polymer including a release compound, has been developed for SCC to reach a satisfactory workability retention as well as a better early strength (Figure 1 and 2).

The superior performance of this new SLCA will be presented i.e. a retention time for more than 90 minutes with minimal setting retardation or rather without affecting the early strength properties of the hardened concrete.

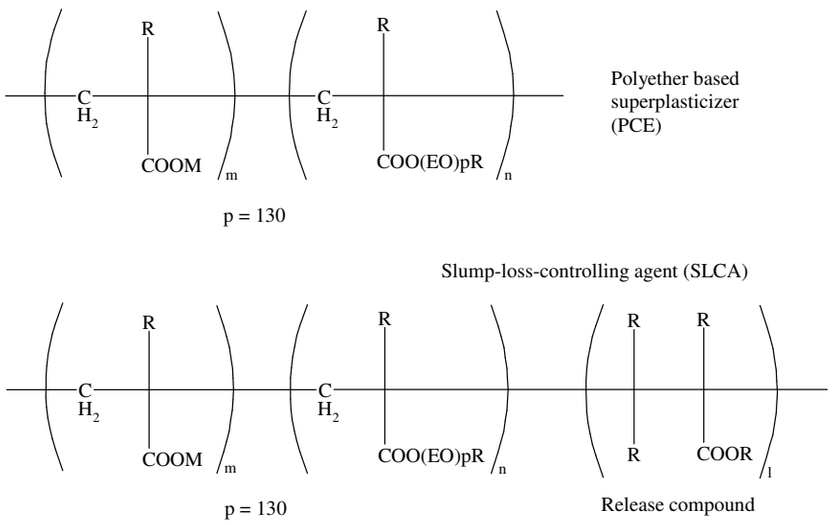


*Figure 1: Structure of polyether based superplasticizer (PCE) and new slump-loss-controlling agent (SLCA).*

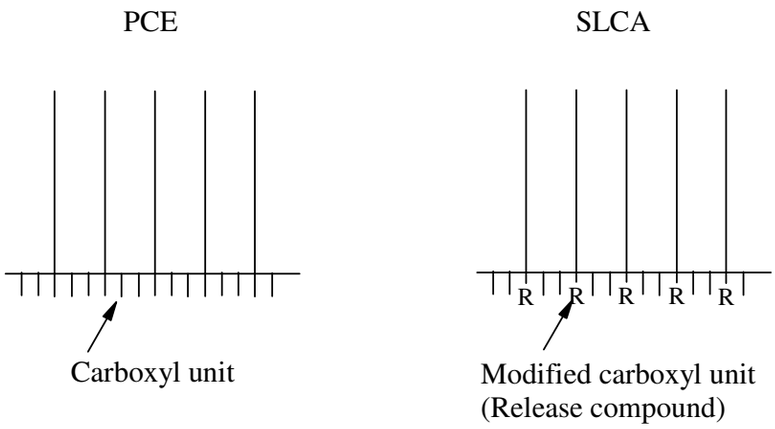


*Figure 2: Structure of PCE and SLCA with additional modified carboxyl units.*

## Experimental

Generally, polycarboxylate ether (PCE) superplasticizers consist of short main chains with carboxylic groups and long side chains of EO polymer (about 130 mol). Based on the molecular structure of this PCE type superplasticizer, a new slump-loss-controlling agent (SLCA) with a release compound has been developed to achieve higher slump retention ability with minimal set retardation.

In Figure 1, the molecular structures of the new SLCA and the PCE are depicted. The SLCA superplasticizer has been synthesized via co-polymerization of chemically modified carboxylic units in the PCE type structure (Figure 2). The adsorption amount of SLCA at the initial stage was designed to be much lower than the normal PCE type. The chemically modified carboxyl units co-polymerized in the structure can be hydrolyzed in alkaline condition (via hydroxy anions) of the cement slurry, and the carboxyl groups can be generated gradually (Figure 3).

A mixer with a capacity of 50 litres was used to mix 30 litres of concrete. First cement, sand and gravels were placed in the mixer and mixed for 10 seconds, then water containing the superplasticizer was added, and the mixing continued for 90 seconds. The fluidity of the SCC was evaluated by slump flow measurement at 0, 30, 60, 90 and 120 minutes after mixing. In this work, an Ordinary Portland Cement (OPC) with a density of 3160 kg/m3 was used. The SCC concrete was manufactured at water/cement ratio of 0.37. The SCC mixture proportion is given in Table 1.

Four different mixtures (Sample 1 to 4) were prepared to see the superior performance of the new SLCA, i.e. the ratio of the SLCA was increased to control slump retention (Table 2). Sample 1 is the PCE without any release compound (see Figure 1), sample 2 consists of 80% PCE and 20% SCLA, the composition of sample 3 is 60% PCE and 40% SLCA, and for sample 4 40% PCE and 60% SLCA were used. For a better comparison, the dosage of the blended superplasticizer was adjusted to achieve a comparable slump flow (at 0 min) for all batches.

All SCC mixture proportions had a good slump flow of approximately 700 mm as well as a good segregation resistance. For example, Picture 1 shows the homogenous SCC prepared with sample 4 at 0 minutes.

## Results and discussion

The slump flow retention behaviour is given in Table 2. The solid content of the superplasticizer was 40%.

It can be observed that the flow of sample 1 decreased from 690 mm at 0 minutes to 220 mm at 90 minutes. The fluidity retention was improved by increasing ratio of SLCA within the blend, i.e. from sample 2 to 4. Sample 4 showed a satisfactory fluidity retention for SCC at initial with 705 mm and at 120 minutes with 645 mm. At the same time the initial and the final setting time was studied for all concrete batches (Table 3). Although sample 4 contains already 60% SLCA a minimal set retardation in comparison to sample 1 was found.

The compressive strength was studied 1, 7 and 28 days after casting. The results are given in Table 3. The use of the SLCA also had only a slightly negative effect on the compressive strength. As expected from the slightly higher dosage (see Table 2), the concretes containing SLCA had a slightly lower strength at 24 hours than the concrete produced with the sample 1.

## Conclusion

The new slump-loss-controlling agent was developed utilizing the polymer framework structure of polyether-type superplasticizers such as those used for PCE. The long retention time of the dispersibility of the SLCA could be achieved through increasing the total amount of carboxyl units adsorbing gradually on the cement surface via hydrolysis reaction of the modified carboxyl units within the polymer structure. Additionally the slump retention could be governed for more than 90 minutes by adjusting the dosage of SLCA, at the same time no significant negative influence on setting and hardening properties of SCC could be found. The performance of the SLCA was confirmed in several field tests.

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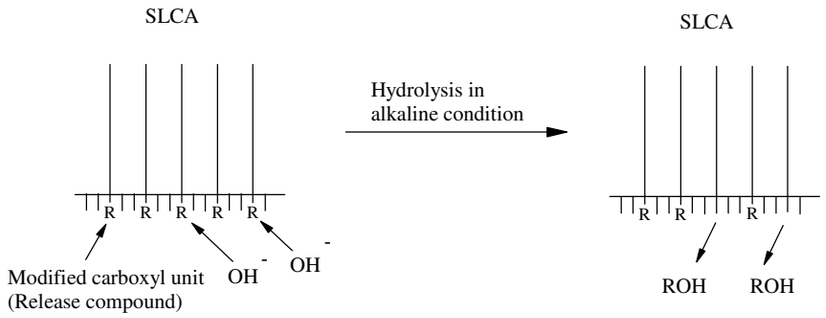


*Figure 3: Working mechanism of SLCA in alkaline condition.*

| W/C (%) | W/P (%) | Unit content (kg/m$^3$) | | | | | | Air |
|---|---|---|---|---|---|---|---|---|
| | | Water | Cement | LP | Sand | Gravel 1 | Gravel 2 | (%) |
| 37 | 30 | 165 | 450 | 100 | 817 | 329 | 497 | 2 |

Used materials:
Cement: Ordinary Portland cement (Taiheiyo/Osaka) (s.g.: 3.16 g/cm$^3$)
Limestone powder: Neoflow 150 (s.g.: 2.71 g/cm$^3$)
Coarse aggregate: Gravel 1: crushed stone (s.g.: 2.60g/cm$^3$, 15 – 20mm)
Gravel 2: crushed stone (s.g.: 2.60 g/cm$^3$, 5 – 15 mm)
Fine aggregate: mountain sand (s.g.: 2.57 g/cm$^3$)
s.g.: specific gravity P: cement + limestone powder

*Table 1: SCC mixture proportion.*

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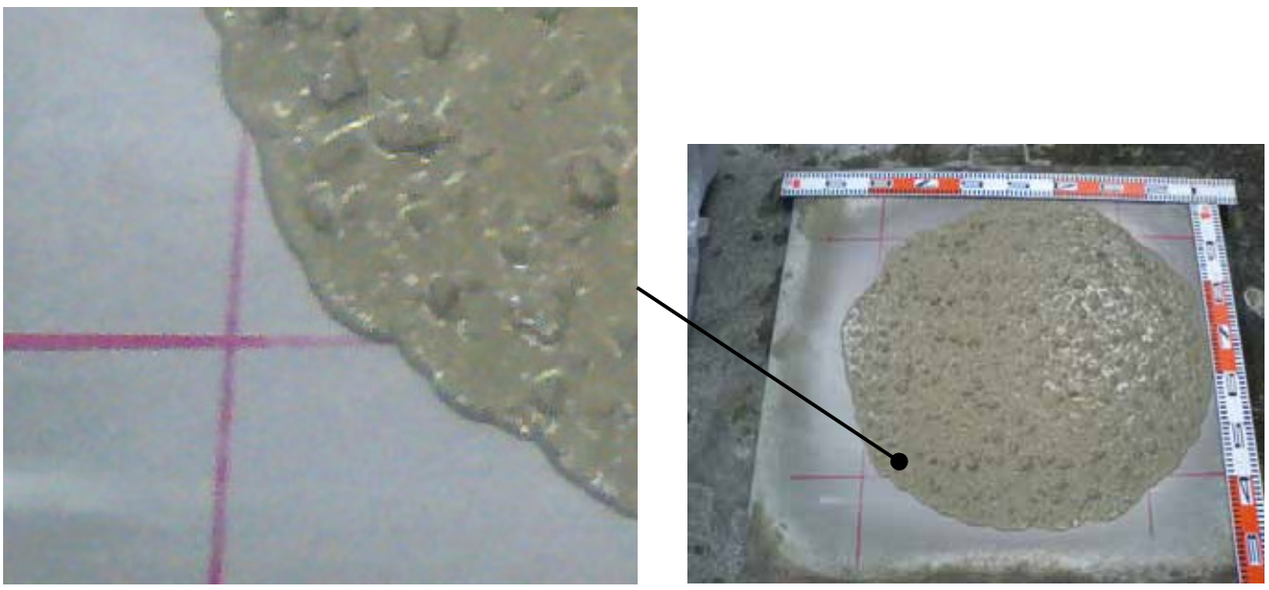
| Sample No. | Sample ratio (%) | Dosage (%) | Concrete properties | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 0 min | 30 min | 60 min | 90 min | 120 min |
| 1 | PCE 100 | 0,50 | Flow (mm) | 690 | 625 | 400 | 220 | - |
| | | | Air (%) | 1.9 | - | - | 2.1 | - |
| 2 | PCE 80 SLCA 20 | 0,55 | Flow (mm) | 680 | 630 | 495 | 290 | - |
| | | | Air (%) | 2.0 | - | - | 2.3 | - |
| 3 | PCE 60 SLCA 40 | 0,65 | Flow (mm) | 705 | 715 | 710 | 670 | 485 |
| | | | Air (%) | 2.1 | - | - | 2.6 | - |
| 4 | PCE 40 SLCA 60 | 0,75 | Flow (mm) | 705 | 725 | 710 | 710 | 645 |
| | | | Air (%) | 2.3 | - | - | 2.6 | - |

Table 2: Concrete properties of sample 1 to 4.

| Sample No. | Initial setting time (h:min) | Final setting time (h:min) | Compressive strength (MPa) | | |
|---|---|---|---|---|---|
| | | | 1 day | 7 days | 28 days |
| 1 | 3:27 | 5:01 | 16.5 | 61,9 | 74,0 |
| 2 | 3:31 | 5:18 | 16.2 | 64,5 | 74,7 |
| 3 | 3:31 | 5:27 | 16.0 | 64,2 | 75,5 |
| 4 | 3:51 | 5:47 | 15.5 | 63,0 | 73,5 |

Table 3: Initial and final setting time and compressive strength of sample 1 to 4.



Picture 1: Slump flow of sample 4 at 0 minutes.

*Participants measuring the sprayed MASTERSEAL® 345 with the thickness gauge during the site demonstration.*

# MASTERSEAL® 345 – a radical approach to waterproofing for underground structures

Technology development in waterproofing of underground structures has remained quite static until recently. Conventional sheet membranes are the norm, but are often susceptible to leakages that are notoriously difficult to rectify. Furthermore, sheet membranes are unsuitable for installation in complex tunnel geometries.

In response to industry demands, BASF MEYCO Underground Construction had developed on new generation spray applied waterproofing membranes MASTERSEAL® 345 that can simply be applied in a sandwich construction between permanent sprayed or cast concrete layers.

BASF organized a seminar to launch the MASTERSEAL® 345 waterproofing system in Singapore on 15th October 2010, which was attended by key personnel from the authorities, civil engineering consultants, international and local contractors and applicators who are involve in the design and construction of underground structures such as rock cavern, rail & road networks and tunnels.

In his opening speech, Mr Himanshu Kapadia, the Director of BASF Construction Chemicals Division for ASEAN, gave an overview of the products and systems offering from BASF Construction Chemicals Division. He stressed that BASF has been leading in the introduction of innovative construction solutions for ready mixed concrete, underground construction and sustainable construction. "In order to continue offering innovative construction solutions to the industry, BASF constantly engages experienced specialists to work with the chemists in the R&D centers to develop and improve its range of products." said Mr Kapadia.

The main topic of the seminar was presented by Mr Matthew Ross, the Head of BASF's MEYCO Underground Construction Division for Asia Pacific who explained the fundamentals of the spray-applied fully-bonded MASTERSEAL® 345 membrane, and their mode of action versus that of sheet membranes. He highlighted that conventional sheet membranes do not bond to the substrate onto which they are applied and are extremely complicated to install in structures with complex geometries. He shared that most of the time the leakages from conventional sheet membranes are due to the many weld seams, damages caused during installation of the reinforcement and the poorly installed inner concrete linings. As there is no adhesion between the conventional sheet membrane and the concrete, damage to the

*BASF demonstrates the spray application of MASTERSEAL® 345 to the participants.*

PVC membrane may lead to the migration of water along the tunnel alignment and may find their way into the tunnel often far from where the leakage began, he stressed.

Mr Ross explained that the MASTERSEAL® 345 waterproofing system seals the substrate with a sprayed-on layer that is only a few millimeters thick and is much easier to install compared to the conventional sheet membrane. He further explained that the uniqueness of this waterproofing system lies in the bonding properties between the membrane and concrete lining on both sides. This strong bond mitigates migration of water along the interface on both sides of the membrane and into the concrete. He further detailed that because of the unique dual side bonding of MASTERSEAL® 345 to the substrates, the construction of monolithic, single shell tunnel lining using permanent sprayed concrete is achievable and there has been more and more tunnels adopting such design. His presentation ended with a showcase of the underground structures utilizing the MASTERSEAL® 345 for application in NATM tunnel, cross passages, escape shaft, diaphragm walls, underground metro stations and rehabilitation of tunnel.

After the technical presentation, the participants were brought to a site to witness its application. At the site, Mr Sunny Lim, the Technical Specification Manager of BASF Construction Chemicals Division, Singapore narrated the procedures starting from the preparation of the equipment to the end of MASTERSEAL® 345 application. It is simple to setup and needs only 3-4 men team to apply the MASTERSEAL® 345 with the BASF MEYCO Piccola dry mix spray machine. He also highlighted the various quality control measures applied to the MASTERSEAL® 345 to ensure that the desired thickness and quality are achieved.

As a summary, the MASTERSEAL® 345 waterproofing system has the following features that can benefit the underground construction project :

<u>For designers</u>

- Significant project savings possible through composite lining
- A reliable waterproofing composite system for complex geometries
- Enables efficient tunnel refurbishment
- Waterproofing at the interface between base/roof slab and CBP/SBP wall

<u>For contractors</u>

- Minimal and easy detailing
- Uses standard dry spraying equipment
- Simple and safe to apply
- Up to 100m$^2$ per hour application rate with three operators
- Can be applied by fully automatic robotic system (MEYCO Logica) at up to 180m$^2$ per hour
- Sprayed final lining concrete with fibers is easily applied to membrane

<u>For owners</u>

- Total construction cost savings
- Extremely low maintenance cost
- Waterproofs your existing tunnels with just 5cm extra sprayed concrete

BASF's Construction Chemicals division is the leading supplier of chemical systems and formulations for the construction industry. Continuous innovation and tailor-made solutions ensure that its customers are provided with the best services. Its Admixture Systems business unit specifically helps customers in the ready-mix, precast, manufactured concrete and underground construction industry. The Construction Systems unit offers a wider range of products for industrial flooring, specialist repair and structural systems, waterproofing membranes, protective coatings and expansion joint sealants.

Enquiry : sunny.lim@basf.com

*The participants witness the demonstration on the watertightness of the sandwich panel waterproofed with MASTERSEAL® 345 under a hydrostatic pressure of up to 4 bars.*


*The MASTERSEAL® 345 waterproofing membrane is capable of bonding to both sides of the concrete substrates. pants.*

# Waterproofing Trades Association of Singapore (WTAS)

Do It Right

The Waterproofing Trades Association of Singapore (WTAS) was officially formed in 2008 by a group of committed waterproofing trades Specialist Contractors, Suppliers and Manufacturers, all whom are active participants in the waterproofing trade industry in Singapore and in the region.

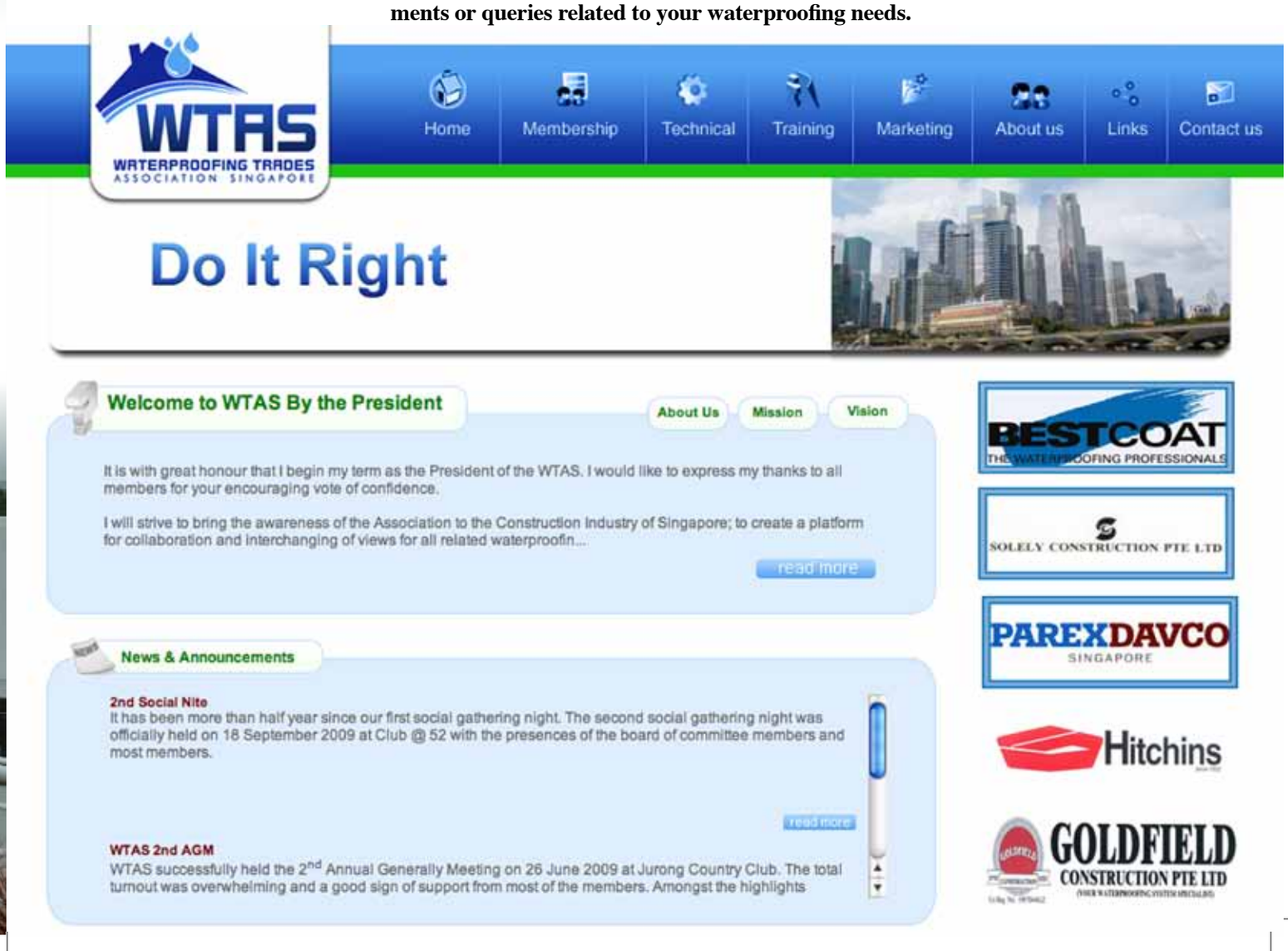
## Our mission as the WTAS:

- Be an avenue by which the government, regulatory bodies and other associations can have dialogue and gain feedback from our association on any planned implementation of various regulations, legislations and developments that would affect our industry.
- A means to promote the prominence of our waterproofing trade and the importance of specialist expertise, quality consciousness and professionalism.
- For us to share knowledge, exchange information, discuss technical issues and explore new technologies and partnerships.

## Current Developments in final stages of completion:

- Comprehensive Guidebook that encompasses the current CP82 and NPQS. Covering all topics relating to waterproofing needs in a development and ultimately serve as a guide to all Specifier, Consultants, Architects, Contractors and waterproofing applicators as well as members of the public.
- Training Handbook which is a guideline for best practices and methods of installation for a range of waterproofing materials and substrates.

**Please visit our website at www.wtas.org.sg to join us as a member or contact us if you have any requirements or queries related to your waterproofing needs.**



# The Basilica of Collemaggio

## Application of carbon fibre to make the biggest Roman church in the city of L'Aquila safe

A year and a half on and l'Aquila is still showing its scars. An earthquake in Abruzzo region (in Southern Italy) caused enormous damage to the artistic and religious heritage of the region, destroying the most beautiful medieval monuments and most famous places of worship; antique churches, monuments, works of art and pieces of history.

A heritage of mankind devastated by the earth's movements on the 6th of April 2009, and which is now propped up and stabilized just waiting to return to its antique splendour.

Mapei was in Abruzzo just a few hours after the earthquake, and is still there today to advise and supply the most up-to-date products and the professionalism of its highly-qualified technicians to help with the reconstruction of L'Aquila.

The earthquake, which damaged the entire artistic heritage of the city, did not even save the "spiritual heart of the city", the Basilica of Saint Maria di Collemaggio, the imposing Roman church which was particularly badly hit. Founded in 1287 thanks to the wishes of Brother Pietro da Morrone – named Pope Celestino V in 1294 and nominated by Dante in the 3rd Canto of his Divine Comedy's Hell as he who "due to cowardness", after just 5 tormented months in office, "refused" and resigned the post – the Basilica has a deci-

*The inside of the Basilica ripped out after the earthquake on the 6th of April 2009 which caused the roof to collapse.*

sive Abruzzo Roman-gothic architectural style, especially on the façade. The vaulted roof of the Basilica collapsed exactly in the spot where the mausoleum to Celestino V is located. His remains, which were miraculously unscathed, were pulled out of the rubble a few days later.

The remains of Celestino V are the main attraction of the Basilica thanks to his fame as a performer of miracles and his extraordinary indulgence in the "Forgiveness" (plenary indulgence) celebration, founded by him and celebrated from the 28th to the 29th of August every year.

The two apses were fractured and in risk of collapsing while the main and lateral altars were completely destroyed. The "Forgiveness Charter", the document issued by Pope Celestino V in 1294 which institutes the first jubilee celebration in history, was also recovered. The Charter was conserved in a coffer in the Civic Tower and was found intact. The crutch made from an olive branch which the cardinal uses to open the Holy Door of the Basilica at the start of the "Forgiveness" celebrations and the key for the same door were also recovered. The Basilica of Collemaggio whose façade is considered to be the most important work of Abruzzo art of all times, was founded in the second half of the 13th century, although most of it was built throughout the 14th century, and continued right up to modern times through various rebuilding, restoration and transformation projects following earthquakes, changes in taste and various other reasons. The result of such a complex and intricate process is an extraordinary weave of architecture and decorative arts with its maximum expression from the fundamental Roman and Gothic cornerstones, with sporadic hints of the Renaissance and Baroque eras, and even of the last two centuries.

*A post-card of how the Basilica used to be*

## Carbon Fibres on Site

The need for Mapei's most advanced products on site became necessary when the town council, together with the Civil Protection organization, decided to open some of the churces to celebrate the 2009 Christmas mass to give the people a sense of hope and continuity.

And the Basilica of Collemaggio, which has always been a symbol of the Aquilian community, could certainly not be left out of this renovation operation, in spite of the serious damage it had suffered. The work was contracted out by the local Civil Protection service to a company specialised in the renovation of historic buildings which involved clearing up the rubble, cataloguing any residues of artistic interest which had collapsed with the roof, a temporary plexiglass cover fixed to steel pylons where the roof had fallen through after the main pillars opposite the altar had collapsed and making safe the main ribs which remained standing, but without support, by means of an intricate design of carbon fibre straps.
The system to make the building safe was designed by Prof. Giorgio Croci from the Faculty of Engineering of the La Sapienza University of Rome, who decided to strap the masonry separating the naves with a network of fibres. Mapei technicians personally followed the application of the carbon fibre straps for the first few days to offer advice and technical support to the Visan restoration company. It was the first time the company had used Mapei products, and the Mapei technicians carried out weekly follow-up visits to the site to check the progress of the work and help solve minor logistics problems which had emerged. Let's now take a closer look at the sequence of steps to apply the carbon fibres.

*The two main ribs left standing were made safe using a complex network of MAPEWRAP carbon fibre straps.*

*Spreading on a layer of MAPEWRAP 31 epoxy adhesive.*

*Detail view of laying the MAPEWRAP C UNI-AX uni-directional carbon fibre fabric.*

*Final phase of laying the MAPEWRAP C UNI-AX fabric.*

The first and essential starting point was to prepare the surfaces to be repaired using MAPEWRAP PRIMER 1, a solvent-free, two-component super-fluid primer based on epoxy resins and used for preparing surfaces strengthened with MAPEWRAP fabrics. To even out irregularities in the substrate as much as possible the surfaces were grouted with MAPEWRAP 12 slow-setting two-component thixotropic mortar based on epoxy resins, selected fine inert materials and special additives. Some parts of the surface, where normal setting times were required, were smoothed over with MAPEWRAP 11.

MAPEWRAP 31 medium viscosity two-component, solvent-free paste adhesive based on epoxy resins, was used for applying and impregnating the MAPEWRAP C UNI-AX fabric using the "dry method".

MAPEWRAP C UNI-AX is a unidirectional carbon fibre fabric, characterised by high modulus of elasticity and high tensile strength. The product is suitable for repairing reinforced concrete structures damaged by physical-mechanical stresses, for confinement of axial loaded concrete elements or concrete elements subjected to compressive and bending stress, or for seismic strengthening of structures in high-risk areas, as in this case.

After applying the carbon fibre, in order to promote a quicker, stronger grip, the surface was sprinkled with QUARTZ 1.9, a selected graded blend of grey alluvium quartz with a trigonal crystalline structure and a maximum inert size of 1.9mm. Unlike work carried out using conventional techniques, thanks to their extremely low weight, fabrics from the MAPEWRAP C UNI-AX range may be put in place by a smaller team of workers. With the "dry system" or "damp system" (which only requires tools to make impregnation easier), application is carried out extremely quickly and often without having to interrupt the normal activities of the structure.

Compared with the plating technique using steel plates (beton plaque), the use of MAPEWRAP C UNI-AX fabrics may adapt to any shape of element requiring repair, they do not require temporary reinforcement during application and it removes any risk of corrosion of the applied reinforcement.

Mapei products were also used to carry out other applications: MAPEFILL grout was used to anchor the steel structure at the base of the Basilica. MAPEFILL is made from cement binders, graded aggregates and special additives and is characterised by

*The scaffolding which covered the façade of the Basilica during the works.*

*View of the Basilica after completion of the works.*

its high mechanical strength, even after short curing times (24 hours), and the high adhesion between steel and concrete.
Work progress was regularly checked personally by the head of the Italian Civil Protection national service organisation and special commissioner for the L'Aquila earthquake, Guido Bertolaso.
He was also on site on the 23rd of December 2009 to make sure that all work had been completed, so the people of l'Aquila could take part in the Christmas holy mass.
Mapei technology was once again the star of the show, with its most technologically-advanced products and its decade-long experience.
Solving difficult problems on site and a guarantee of completing the work in a reasonable length of time, in this case as many times before, made all the difference.
A place which is a symbol for the entire Abruzzo territory may be used once again.

## IN THE SPOTLIGHT

### MAPEWRAP C UNI-AX

It is a uni-directional carbon fibre fabric characterised by a high (230,000 N/mm$^2$) modulus of elasticity and high tensile strength. This product is suitable to repair reinforced concrete elements damaged by physical-mechanical action, for the confinement of axial loaded or bent concrete elements and for seismic strengthening of structures in earthquake zones. Some application examples:

- Repair, maintenance and static upgrade of deteriorated structures, where it is absolutely necessary to reinforce the tensile strength of the section;
- Confinement of axially loaded or damaged concrete elements (columns, bridge piers, chimneys) in order to improve ductility and load bearing capacity;
- Seismic strengthening and restoration of vaulted structures without the increase of seismic mass and without the danger of liquid percolation towards the internal surface of an archway;
- Repair of structures damaged by fire;
- Reinforcement of load bearing elements in buildings that have been restructured for architectural reasons or change of use. It may be laid using either a wet system or a dry system.

Source: Realtà Mapei
For more information, Visit www.mapei.com.sg

## TECHNICAL DATA

Basilica of Saint Maria di Collemaggio, L'Aquila (Italy)
Period of Construction: late 13th century
Period of Intervention: 2009-2010
Intervention of Mapei: supplying products for static upgrade and seismic strengthening of masonry structures
Client: Italian Ministry of Cultural Heritage and Activities
Designer: Prof. Giorgio Croci, La Sapienza University of Rome
Works Direction: Italian Ministry of Cultural Heritage and Activities
Contractor: Visan Srl (L'Aquila)
Mapei Distributor: Innamorati Edilizia Srl (L'Aquila)
Mapei Co-ordinators: Giulio Morandini, Marc Taccone and Corrado Villa Presutti – Mapei SpA (Italy)

## MAPEI PRODUCTS

The products mentioned in this article belong to the "Building Speciality Line" range. The technical data sheets are available at the web site: www.mapei.com. Mapei products for the protection and repair of concrete surfaces and structures have been awarded the CE mark in compliance with EN 1504 standards.
MAPEFILL (CE EN 1504-6): high-flow shrink-free grout for anchors.
MAPEWRAP C UNI-AX: high strength unidirectional carbon fibre fabric with high modulous of elasticity.
MAPEWRAP PRIMER 1: two-component epoxy primer specific for the MAPEWRAP SYSTEM.
MAPEWRAP 11: two component normal setting thixotropic epoxy putty for leveling concrete surfaces
MAPEWRAP 12: two-component slow setting thixotropic epoxy putty for leveling concrete surfaces.
MAPEWRAP 31: two-component superfluid medium viscosity epoxy adhesive for impregnation with MAPEWRAP "dry system".
QUARTZ 1.9: selected graded blend of grey, alluvium quartz with a trigonal crystalline structure and a maximum inert size of 1.9mm.

JOE just one earth
green concrete panel

# Just One Earth,
## Proud To Be GREEN Builders

**A sustainable green concrete panel with better buildability, superior quality and zero waste help professionals save our just one earth and be a green builder.**

JOE, "Light Weight Concrete Panels produced with 30% of Recycle Concrete Aggregates (RCAs)", is Singapore Green Label certified (No:022-015), eligible for BCA Green Mark Point and in compliance with Conquas for Buildability (0.90). JOE is reinforced with Steel Wire for superior Bending Strength which improve safety for High Wall, External Wet, Internal & Parapet Usage.

Advance engineering machine made JOE panels perform outstandingly in the Fire-Test, Sound-Test, Compressive Tensile Strength, Section Tensile Strength, Bending and Tensile Strength, Anchorage-Test,etc. Additionally JOE helps saving cost of lintel, stiffener, labor and time.

## BENEFITS

### 1. Greater Height

Customization up to 4.3M

### 2. Ease of Construction

No lintel & stiffener

### 3. Greater Strength

With steel reinforcing wires

### 4. Easy for M&E Installation

Easy cutting for M&E

### 5. Versatile Construction

Horizontal installation

### 6. Green Construction

Used of recycled aggregates

green concrete panel

# Just One Earth,

## Proud To Be GREEN Builders

## JOE Green Concrete Panel Performances & Test Reports

| FUNCTIONAL REQUIREMENTS | JOE Green Concrete Panel | | |
|---|---|---|---|
| | 70mm | 90mm | 100mm |
| **ASTM - E90** | | | |
| Sound Insulation (STC) | STC 42* | STC 44* | STC 46* |
| **ASTM C 518** | | | |
| Thermal Conductivity (W/m°K) | 0.649 | 0.66 | N/A |
| Thermal Resistance (m² °K/W) | 0.110 | 0.14 | |
| **BS 476: Part 22: 1987** | | | |
| Fire Resistance | | | |
| Integrity | 68Mins* | 132Mins* | 260Mins* |
| Insulation | 60Mins* | 71Mins* | 78*/155Mins** |
| Deflection Test (mm) | 105 mm | 44 mm | 17 mm |
| Difference of Area Under Curve with Standard (%) | 1.70 | -0.2 | -0.1 |
| **BS EN 680:2005** | | | |
| Moisture Movement (Drying Shrinkage) (%) | 0.300 | 0.530 | N/A |
| Average Dry Density (Kg/m3) | 1844 | 3118 | |
| **BS EN 772** | | | |
| Compressive Strength - Cube ($N/mm^2$) | Min. G35 | Min. G35 | Min. G35 |
| Water Absorption ($g/m^2 \times sec^{0.5}$) - Setsco Labs | N/A | 21.5 (90Mins) | N/A |
| **SS 271: 1983** | | | |
| Water Absorption (24 hrs Immersion) - CPG Labs (Should Not Exceed 23.5%) | 6.70% | 7.50% | N/A |
| Drying Shrinkage (Should Not Exceed 0.090 %) | 0.075 % | 0.086 % | |
| **SS 492: 2001 / BS 5234 (Impact Tests)** | | | |
| Determination of Partition Wall Stiffness | SD | SD | N/A |
| Surface Damaged by Small Hard Body Impact | SD | SD | |
| Perforation by Small Hard Body Impact | SD | SD | |
| Damaged by Large Soft Body Impact | SD | SD | |
| Structural Damaged by Large Soft Body Impact | SD | SD | |
| Door Slamming | SD | SD | |
| Lightweight Anchorage Pull-Out | Pass | Pass | |
| Lightweight Anchorage Pull-Down | Pass | Pass | |
| Heavyweight Anchorage Wash Basin (N) | 1500.00 | 1500 | |
| Heavyweight Anchorage Wall Cupboard | 4000.00 | 4000 | |
| Horizontal Load/Crowd Pressure (3.0 kN/m) | Up to 3.0KN/m | Up to 3.0KN/m | |
| a. Deflection (mm) | -0.26 | 0 | |
| b. Residual Deflection (mm) | -0.26 | -0.04 | |
| Bending Strength ($N/mm^2$) | 7.30 | 9.5 | |
| **SS 485: 2001 (Slip Resistance Test)** | | | |
| Wet Pendulum Test (Mean BPM Value 23oC) | N/A | N/A | 95 (Class V) |
| Stiffener | No | No | No |
| Lintel (Up to 4.3 meter Height) | Yes | No | No |
| Weight ($kg/m^2$) | 106 | 118 | 124 |
| Height (m) | Customized up to 3m | Customized up to 4.3m | |
| Installation Productivity (Sq M/Man - Day) | 12 | 12 | 12 |
| External/Wet Area/Parapet | Yes | Yes | Yes |

**NOTE:**
* Skim Coat Applied on Both Sides
**Hollow Cores are Filled Up

Cert. No.:022-015 Eco-Friendly Building Material/Low Emission Concrete/Cement/ 30% Recycled Content

Just One Earth, Proud To Be GREEN Builders

# PRODUCTION & INSTALLATION OF JOE GREEN WALL PANEL SYSTEM

# Just One Earth, Proud To Be GREEN Builders

## THINK GREEN

Construction materials and building practices have changed in the last ten years to become more energy efficient and environmentally conscious. By considering your construction options, you can simply increase the efficiency, safety, and quality of your project without putting undue stress on our natural reserve. By making your projects "greener", you help to reduce pollution, save guard the natural environment, and create a sustainable future for our next generation.

## BUILD GREEN

One of the central environmental considerations is the quantity of waste produced when a building is developed, refurbished or demolished. By recycling materials produced (recycled aggregates) from construction and demolition works are a practical and resource efficient model of maximize the value and sustainability of the building. Beside the environmental benefits, using renewable resources can have positive economic impact by reducing the material transport and disposal costs, as well as by diminishing the extraction of raw materials, the amount of waste at landfill sites and the entire life-cycle costs of building materials.

JOE just one earth
green concrete panel

GreenLabel SINGAPORE
Cert. No.:022-015
Eco-Friendly Building Material/Low Emission Concrete/Cement/ 30% Recycled Content

## PROJECT REFERENCE:


NUS U-TOWN


OASIS@Sembawang


Orchid Hotel


Jurong Data Center


NEX Mall


KTP Hospital


Sheng Shiong


Mandai Link

# Syscon, providing the best quality in pre-cast components to Singapore for over 30 years

Approximately 85% of Singaporeans live in Government Housing, one of the highest in the world by percentage. For over 30 years, Syscon has proven itself as an innovative and dynamic company. It has consistently assisted the Housing Development Board in the fabrication of high quality pre-cast components. Syscon's component includes Facades, lift wells, staircases and water tanks, just to name a few.

## Syscon Tower

Syscon's first foray into being a main contractor is the building of Syscon Tower. The development comprises of a 14 storey office building (tallest in the area), 10 story light industrial building attached to a 4 storey heavy industrial/ warehousing facility lengthwise and has a ceiling height of 8 -12 meters. The Gross Floor Area (GFA) is approximately 835,025 Square feet (77,583 $m^2$). The $4^{th}$, $7^{th}$ and $10^{th}$ floor of the office section is connected to the warehousing/ manufacturing facility via sky-bridges on each level.

# Gross Floor Area (GFA) Breakdown

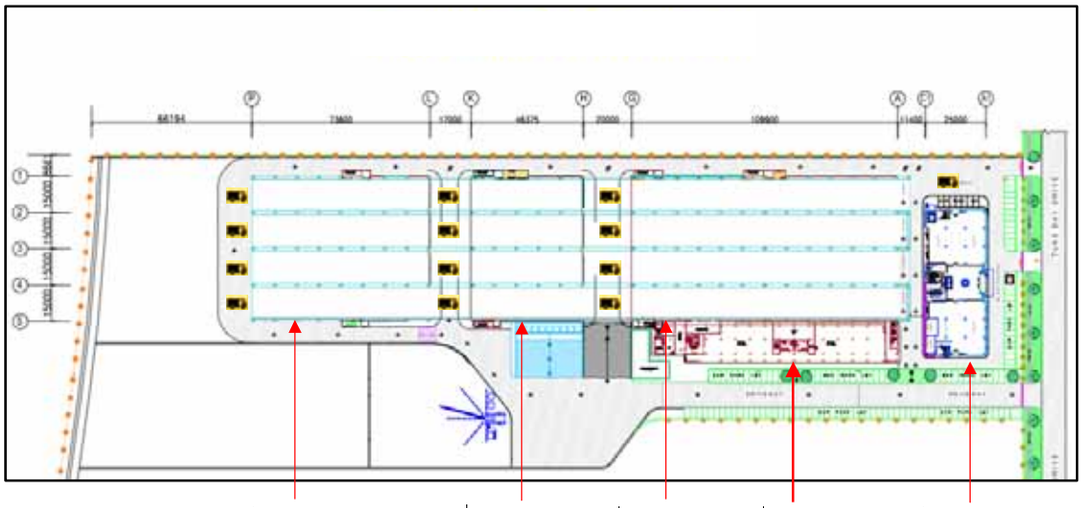
| Entire Facility Breakdown | | | | |
|---|---|---|---|---|
| **Building** | **Section** | **Square Meters** | **Square Feet** | **Sub-total** |
| **13 Sty** | Ancillary Office | 15,780 | 169,858 | 208,770 |
| | Ancillary | 3,615 | 38,912 | |
| **Heavy Industry (1/2/3/4 Sty)** | Production Area | 43,609 | 469,407 | 483,920 |
| | Ancillary | 1,348 | 14,513 | |
| **10 Sty** | Production Area | 4,633 | 49,874 | 139,642 |
| | Foodcourt | 1,843 | 19,843 | |
| | Ancillary Office | 344 | 3,703 | |
| | Storage | 1,368 | 14,729 | |
| | Ancillary | 4,784 | 51,493 | |

| Heavy Industry Area Breakdown | | |
|---|---|---|
| **Level** | **Production Area (Square M)** | **Square Feet** |
| **1** | 16,013 | 172,357 |
| **2** | 12,948 | 139,371 |
| **3** | 9,737 | 104,803 |
| **4** | 4,713 | 50,727 |
| **Total** | **43,410** | **467,258** |

## Additional features:

- 13 loading bays
- Multiple cargo lifts/ elevators
- Provision for overhead cranes which protrude out; enabling easy loading and off-loading
- Sky-bridges attaching office and industrial blocks
- Ground-level food-court
- A bank branch (TBC)
- Two full-service restaurants located on mezzanine level
- Top floor entertainment center and viewing promenade providing clear 360$^{o}$ views.



2 Storey Heavy Industrial Building

3 Storey Heavy Industrial Building

4 Storey Heavy Industrial Building

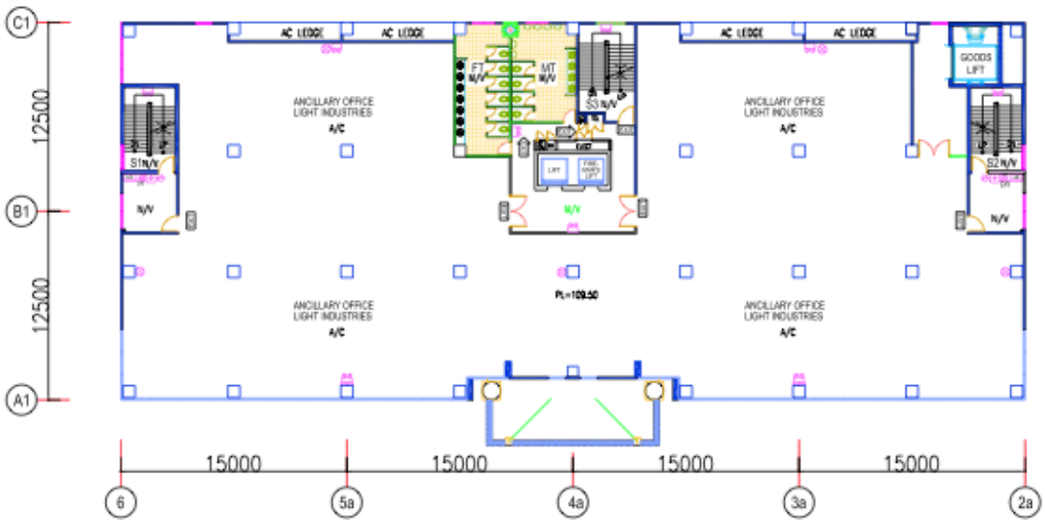
10 Storey Office/ Assembly space

14 Storey Office Building

Heavy industry Usable Area: 467,258 SF

Loading Bay retrofitted with crane hoists

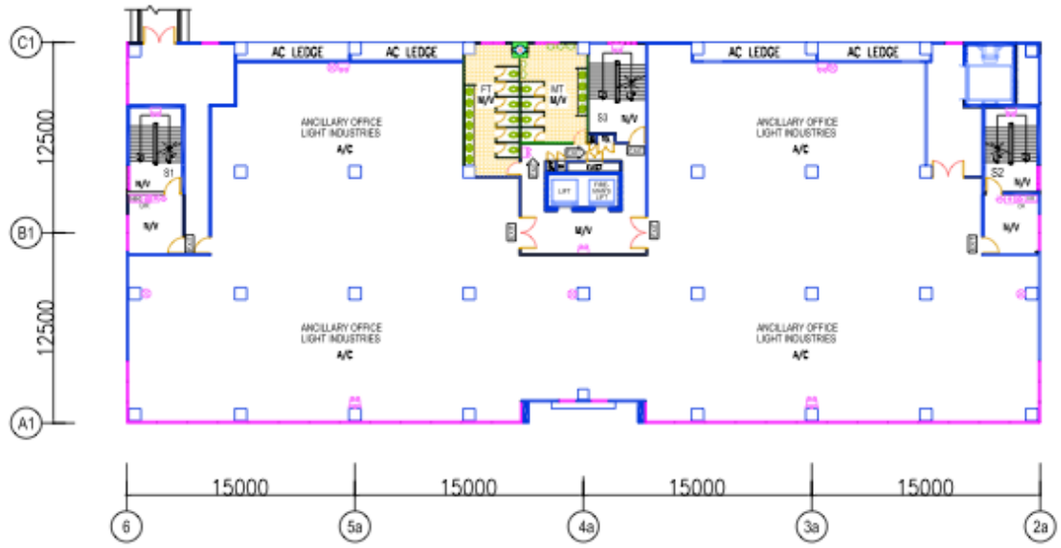
**Syscon Tower Site Plan**




| | Square Metres | Square Feet |
|---|---|---|
| Approved Usable Area | 1,219 | 13,126 |

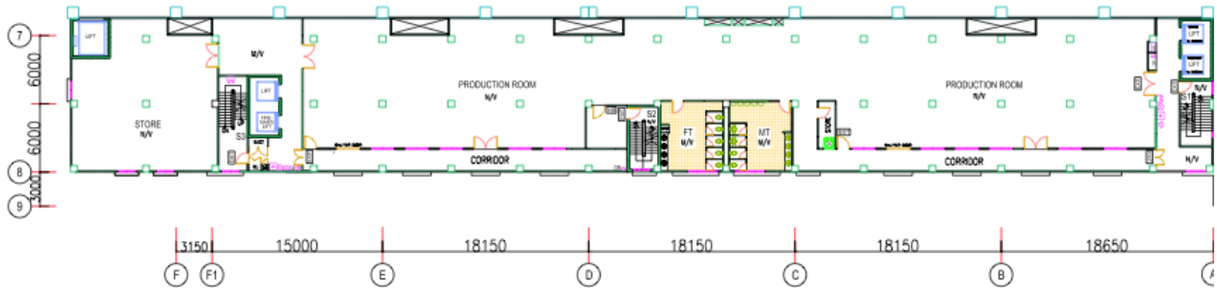
**Floor 2/3/5/6/8/9/11**
**13 Storey Office Plan**

**For Rental Enqurires, Please Email: iris.tay@syscon.com.sg/ shuyuan.ho@syscon.com.sg**




| | Square Metres | Square Feet |
|---|---|---|
| Approved Usable Area | 1,201 | 12,931 |

**Floor 4/7/10**
**13 Storey Office Plan**




| | Square Metres | Square Feet |
|---|---|---|
| Approved Usable Area | 545 | 5,862 |

**Floor 3/5/6/8/9**
**10 Storey Attached Office**

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NEWS RELEASE

EUROPEAN CHEMICAL INDUSTRY COUNCIL

# Italian industrialist to lead European Chemical Council

## *Mapei's Squinzi brings business know-how to push competitiveness, innovation*

ROME, 1 October 2010 – Mapei Group Chief Executive Officer Giorgio Squinzi was elected Friday President of Cefic, the European Chemical Industry Council. Dr Squinzi will lead the 29000-member organisation in that capacity with immediate effect. He replaces Mr Christian Jourquin, chief executive of Solvay, who completed his two-year term having led Cefic through a time of great challenge, notably the economic downturn.

Dr Squinzi, a trained chemist with 40-year-plus industry experience, has led Mapei since 1976, growing the family-owned, Milan-based chemical producer from a small flooring and coatings business to a multinational, bespoke producer. Annual turnover at Mapei most recently reached €1.7 billion, five per cent of which was re-invested into research and development. The company today operates 57 plants in more than 26 countries.

"I believe that chemical companies thrive when they adhere to three important pillars – innovation, globalisation and customer-focus," said Squinzi, who is also President of Federchimica, Italy's chemical industry trade federation and serves as Vice President of Italian business group Confindustria. "In Europe, producers can best compete in a rapidly globalised market when they have the means and support to invest in R & D projects."

### Sector faces unprecedented competitive pressure

Squinzi leads Cefic at a time when the European chemical industry is rapidly losing share in a growing global chemicals market. The sector's weakening status was highlighted last week in Cefic's latest industry economic publication Facts & Figures. According to the report, Europe lost its top ranking in terms of global sales among geographic regions for the first time in 2009, dropping down to second place below Asia. China is leading the Asian surge, as the country now produces 22 percent of the €1.9 trillion global market in terms of sales, ahead of North America and quickly approaching the 24 per cent European Union level of €449 billion.

"It's a situation where production continues to grow in Europe, but at a slower rate than emerging markets. Employment in the sector drops about two per cent each year in Europe," added Squinzi. "I know from experience previously heading research and development at Mapei that today Europe needs to harness its strength in R&D so it can move swiftly to more robust innovation that gives this high-tech industry a more competitive footing."

Although Europe experienced a drop in competitiveness, the EU chemicals trade surplus in 2009 amounted to €42.6 billion, a relatively strong result as the chemical industry represents only 1.1 per cent of total EU gross domestic product.

### Public perceptions of the chemical industry in Europe

Dr Squinzi represents a sector with a bulging trade surplus and a 42 per cent reduction in greenhouse gas emissions since 1990, but posts below-average public favourability ratings, according to a recent Cefic-led pan-European survey. The annual survey, which measures public perceptions of the EU chemical industry, found that respondents ranked the chemicals sector sixth out of eight benchmark industries, with no measurable improvement of overall perception between 2008 and this year.

"The survey's findings indicate the need to tell our story better, especially to young people," Dr Squinzi concluded. "Students will have a chance to learn more during the International Year of Chemistry in 2011, when we will have a chance to demonstrate how the industry provides solutions to growing societal needs."

For more information, please contact James Pieper on +32 (0)2 676 7398 or via email at jpi@cefic.be

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**Prof Olafur H Wallevik, Iceland for his support and significant contribution.**

Prof Olafur H Wallevik has worked with the rheology of concrete and other cement based particle suspensions since he finished his master thesis on that theme at the Norwegian Institute of Technology in 1983.
In the year 1987 he made the first version of the BML B Viscometer which is now available throughout the world.
He received his doctorate degree in rheology from the same University in 1990.
His special fields are Rheology of fresh concrete, high performance concrete, high strength concrete, self -compacting concrete and microstructures.
He is currently the head of the concrete division at the Icelandic Building Research Institute and the Manager of Contech Ltd.
He is a former vice president of the Nordic Rheology Society and a former chairman of the scientific commission in the Nordic Concrete Federation.

## CALL FOR PAPERS

**We invite original papers of relevance to this theme and the other traditional topics:**

- Concrete design & analysis for buildings & structures
- Concrete mix design, quality control and production
- Concrete technology, ready-mix, SCC, RCC
- Concrete prefabrication
- Concrete plant, equipment and machinery
- Concrete repairs and rehabilitation
- Concrete materials, composites
- Concrete construction and safety
- Concrete application in roads, bridges, tall buildings, tunnels, underwater, underground, etc
- SPECIAL SESSIONS on selected and special topics

## CALL FOR PAPERS

- Last date to receive abstracts (in one A-4 size) - 15 April 2011
- Notification of acceptance - 01 May 2011
- Full text in required format to be received by - 15 June 2011
- Conference dates - 14-16 August 2011

## Conference Awards

– for original and outstanding papers presented at the conference
There will be 2 "Young Concrete Researcher Awards", 1 Special Award and 10 open category awards

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**Among those who are invited to have a special paper:**

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Prof J Stark
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Prof H Justnes
Prof D Hooton
Prof Sakai
Prof De Shutter
Prof M Zhang
Dr P Sandberg
Dr P Billberg
Per Fidjestol
Dr K Kjellsen
Dr T A Hammer
Dr Jon E Wallevik
Dr N Roussel
Dr D Feys
Prof B Wigum
Dr K Reknes
Dr R Flatt
Dr L Trane
Dr S Kubens
Prof M Zhang

**Also invited to give special presentations are:**

Yogesh Chhabra
Michael Khrapko
I Nielsson
B Hhartarson
S Oesterheld
F Mueller
K Aleksandersson
T I Kristhansson
Sunna Wallevik

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

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