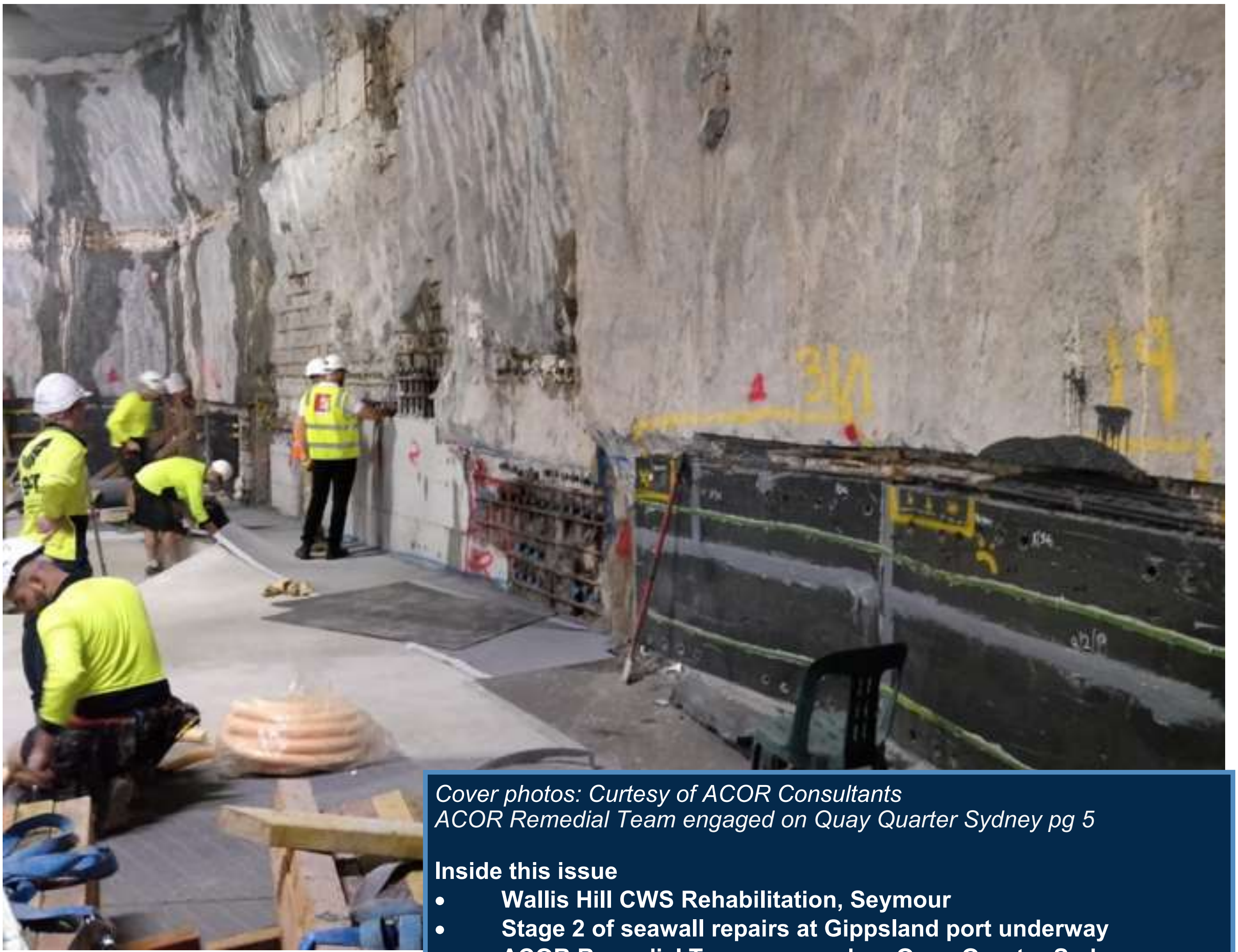
Setting the standards in the remedial industry since 1991

CONCRETE CONNECTIONS



Cover photos: Curtesy of ACOR Consultants
ACOR Remedial Team engaged on Quay Quarter Sydney pg 5

Inside this issue

President’s message

Winter’s here and it is vivifying to see the energetic work of our committee members and the board; thank you for your time and energy. The winter season has and will be a busy one as we have lots going on. You’ve probably seen in the last few messages about ACRA’s new expansion.
We are thrilled to be introducing 3 categories of the Corporate Membership as Concrete Repair, Remedial Waterproofing, and Remedial Building. More information on how to apply for these subcategories will be released shortly.
Membership renewals have been emailed to the primary contacts for Corporate Membership and its good to see that the majority have already renewed. Individuals have also been sent their renewal invoices and reminders will be posted soon.

We strive to inspire excellence in all the members by highlighting the significant role ACRA has to play by introducing the new sub-categories. We are very excited and proud of the new expansion. To ensure success, we would be offering dedicated training courses in new sub-categories that provide the skills and expertise necessary for the professionals to become future industry leaders. Preparation of planned Remedial Waterproofing course is on track and the first one will be in NSW for which the date will be announced shortly.
I would like to thank the Board and members for their unwavering support during the process. Working together would make our targets achievable. Thanks once again for investing the time into these initiatives!

We are pleased to see an increasing interest for ACRA Corporate memberships. I would like to congratulate all the new corporate and individual members and look forward for your active participation in the association activities. Our newest Asset Service members are SA Water and James Cook University, Callaghan Innovations (NZ).

The active committee participation has resulted in some outstanding events across the States. Some of the exciting upcoming seminars are:

- WA has a seminar on Modern Tools for Concrete Remediation on 28 August.
- NSW is planning a Strata Q&A breakfast panel discussion for 18 September at the Kirribilli Club
- VIC has a 19 September seminar on Concrete Repair in the Water Industry and Maximising the Service Life of Existing Concrete Structures.

All these events and more can be found at www.acrassoc.com.au

The State committees have recorded joining of new young members. These members are pivotal to a sustainable brilliant future for the association.

Finally, I encourage all members to continue flowing your suggestions and feedback to the ACRA executive officer about what ACRA could be doing better. I want to assure that the board listens to and executes the new ideas. Your feedback in the past has always led us to be more innovative and active.

-Hamid Khan - ACRA President 2017-2019

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Project Overview – Wallis Hill CWS Rehabilitation, Seymour

For over a century, Wallis Hill Clear Water Storage tank has provided potable water to the town of Seymour. In December 2018, Goulburn Valley Water awarded MCM the contract to rehabilitate the tank's concrete substrate and replace the tank's liner to prolong its service life.

MCM has completed concrete patch repairs and crack injection repairs using a hydrophilic polyurethane-based product. Failed joint sealant around the perimeter of the tank has also been removed and replaced. A reinforced ethylene interpolymer alloy was installed over all submerged interior surfaces, using a novel approach.

The project delivery team was challenged with blazing summer heat, working at heights and working in a restricted space without incurring any significant environmental or safety incidents. The reservoir has now been filled and tested for leaks and has proved itself 100% watertight.

www.marineandcivil.com.au

MCM Marine & Civil Maintenance
www.marineandcivil.com.au

Project Overview - Stage 2 of seawall repairs at Gippsland port underway
By Elisa Lannunzio

Gippsland Ports is continuing works to shore up the Narrows seawall on the eastern side of Bullock Island with funding from the Victorian Government's $15 million Protecting Victoria's Iconic Beaches and Coasts Program.

Stage 1 of the works was completed in June, with 30m of the wall replaced.

Stage 2 will involve the installation of 80m of preformed concrete panelling, and when completed, the old
unstable masonry rock seawall will be replaced with a precast concrete panel structure.

The foreshore adjacent to the seawall is a popular destination for recreational fishing, and the rehabilitation of this wall means the amenity of this area is better and safer for the community and can be enjoyed again.

Printed in Infrastructure Magazine

Project Overview - ACOR Remedial Team engaged on Quay Quarter Sydney
ACOR Consultants Pty Ltd

Following on from ACOR's ground-breaking work in waterproofing design for one of Sydney's landmark buildings, our Remedial team has been engaged to undertake waterproofing design work and quality control inspections at Quay Quarter Sydney.

Located in Circular Quay on the northern edge of the Sydney CBD, this multi-billion dollar development has a total site area of 11,121m² and incorporates six existing properties, including two heritage buildings.

The proposed development will comprise the amalgamation of six individual properties, consisting of conventional concrete structures up to twelve storeys above ground, with multi-level basements. As some of the buildings are less than 145 meters to the south of the Circular Quay shoreline, they are considered "Coastal" structures.

ACOR will lead and direct the architectural sub-consultants in order to achieve water tightness to below water table basements, all internal wet areas within buildings, façade weatherproofing and external area weather-proofing.

www.acor.com.au

AC OR CONSULTANTS

Project Overview - Infrastructure Upgrades
NQBP Wharf 3 &5 Remediation

North Queensland Bulk Ports Corporation is the only port authority in the world managing three major ports in a world heritage area and they are committed to minimising any adverse impacts to the environment from their port operations.

Various repairs were required at wharves 3 and 5 at NQBP's Port of Mackay operations, Queensland's fourth largest multi-commodity port by throughput. The port operates 24 hours a day, seven days a week and extends over 800ha of land and water.

To significantly extend the wharves' service life, we repaired the existing pile wrapping system, applied a new silane coating to the wharf deck, soffit and concrete fender panels. We also performed concrete repair and installed sacrificial anodes.

Project highlights included:

- We conducted a comprehensive survey at the commencement of project to quantify the repairs
- Remedial works were carried out to suit the port's shipping schedule and tidal changes

Photo: Completed pile wrapping system repair

www.duratecaustralia.com.au

Project Overview - Infrastructure Upgrades
HMAS Coonawarra Wharf Remediation

The works will ensure the ongoing capability of accommodating Australia's fleet of Armidale-class patrol boats well into the future.

HMAS Coonawarra is a Royal Australian Navy (RAN) base located in Darwin, Northern Territory, and is home to 12 fleet units of the RAN.

The project included structural steel and concrete jacketed pile repairs, marine and lead paint removal as well as the fabrication of new staircases.

Photo: Work platform around concrete piles to complete crack and spalling repairs

Highlights of the works included:

- Wharves remained operational throughout the project
- Flexibility required to change work stages based on Defence requirements at short notice
- Working around live Defence training and refuelling operations
- Environmentally critical project with no solid waste of any kind to be deposited into the harbour
- Working with the challenges of Darwin's 8m tides
- Continual monitoring of air and water quality to ensure blast and paint operations had no negative impact on base operations and the health of base personnel

www.duratecaustralia.com.au

Victoria moves to mandate engineering registration
By Andrew Heaton

Introduced into Parliament in April, the Professional Engineers Registration Bill 2019 will establish a mandatory system of registration for those who perform work across the five categories of civil engineering, structural engineering, mechanical engineering, electrical engineering and fire safety engineering.

Under the scheme, anybody who wishes to perform professional engineering services across any of the five aforementioned categories will be required by law to hold professional registration.

The law also makes it an offence for those who are not registered to represent, that they can provide professional engineering services.

Exemptions will only apply for those who are either working under direct supervision or who are working to a prescriptive standard.

The scheme will be enforced via a co-regulation model involving input from both government and industry. Under the scheme, the state will provide the legislative backing to enforce the scheme's requirements and will administer the scheme as well as enforcing compliance.

This will involve action from the Business Licensing Authority, Consumer Affairs Victoria and the Victoria Building Authority.

Industry associations such as Engineers Australia, meanwhile, will be responsible for assessing individual practitioner qualifications, experience and professional development.

Around Australia, Queensland is the only state which currently has a comprehensive scheme for the
mandatory registration of engineers.

Such schemes are also being considered in New South Wales, the Australian Capital Territory and Western Australia also considering mandatory registration.

In a paper explaining the scheme, the Victorian Government said the scheme was necessary to address an anomaly whereby lawyers, doctors, nurses, architects, teachers and many trades such as electricians and plumbers are required to be registered but registration was not required for engineers.

Given the impact of engineering work on critical infrastructure such as power and water systems, bridges, roads, dams and buildings as well as with-in other areas such as industrial product design, the Government says registration is necessary to ensure the quality and safety of design output.

Victoria moves to mandate engineering registration
By Andrew Heaton

This was especially important with the state expected to invest around $10.1 billion per year on infrastructure over the forward estimates period, it said.

Engineers Australia Victorian President Alesha Printz welcomed the introduction of the legislation.

“This Bill provides a legislative framework that will give the community, policymakers and industry confidence that engineers working in Victoria meet a strict set of professional standards and have the qualifications expected of being an engineer,” Printz said.

“Registration of engineers is vital to accountability and safety standards within the profession. It will help determine that engineers have the adequate skills and competency to undertake complex projects including around infrastructure and fire safety.”

“At the moment in Victoria, anybody can call themselves an engineer with little accountability.”
“Mandatory registration will put an end to this.”

The scheme is expected to commence from mid-2020 and be rolled under a staged process lasting three years.

Printed in Sourceable.net

Using drones in confined space inspection
By Jason De Silveira

Inspections in confined spaces have always posed a significant challenge for many industries and they often come at significant cost, but a solution could come from an unlikely source — a drone.

Confined space inspections can be slow, dangerous and costly. When human entry is involved, some of the risks and challenges include:

- Personnel may be exposed to hazardous substances.
- Risk of fire or explosion.
- Inadequate oxygen for inspectors.
- Challenging physical conditions can limit or restrict the technician's ability to handle the test equipment.
- Costly downtime of the asset under inspection.
- Costs involved in preparing the site under inspection and enabling access (e.g., scaffolding may be required etc.).

While surface-mounted robotic devices (crawlers, climbers and tractor cameras) are generally seen as the way of the future for confined space inspections in industries such as power generation, oil and gas, water management, brewing, chemical, facilities, construction and shipping, the development of specially designed unmanned aerial vehicles (UAVs) opens up a whole new avenue of thought.

At first glance, the idea seems impossible.

Don't drones need open spaces? Don't they crash if they collide with something? What about turbulence inside the space? Dust or hazardous gases? Doesn't the operator have to maintain visual contact with the drone? What about maintaining signal transmission? Wouldn't reflective surfaces inside the spaces have a negative impact on the quality of images or video collected?

The concept of a drone flying deep into the recesses of confined spaces where there's no light and probably complex internal geometry seems like fantasy, but it is, in fact, a reality.

Several organisations are investigating the use of drones for confined space inspections with Swiss company Flyability, recording positive successes with its innovative designs. Its Elios inspection UAV was designed specifically to perform indoor visual and thermal inspections in confined spaces with engineers using specific flight algorithms, advanced sensor technologies and special onboard LED lighting, thermo vision camera and transmission systems.

Using drones in confined space inspection
By Jason De Silveira

Applications include boilers, sewers, tanks, stacks, ducts, sumps and culverts with a diversity of industries from civil to maritime and mining standing to benefit from this rapidly evolving technology.

A key advantage of the Elios drone is its use of gyroscope technology to enable it to manoeuvre around and inspect complex geometries without causing any damage to the sensors or any other component part. A carbon fibre decoupling system between the drone itself and the outer cage creates a protective ‘ball’ which renders the device collision-tolerant in flight.

Other advantages of drones for confined space inspections include:

- Asset immobilisation can be reduced by up to 90%.
- Significant reduction in cost and time involved in accessing the confined spaces (e.g., scaffolding, rope access etc).
- Faster inspections.
- Reduced labour costs.
- Reduced risk to personnel (hazardous spaces, toxic gases, liquid and chemicals, heights, etc.).
- Device can be controlled beyond the operator’s line of sight.
- Detailed real-time information from high-resolution sensors and cameras.
- Ease of transport.

While there is still a way to go, there are several drone options already on the market which are being used successfully for confined space inspections. These devices are getting ‘cleverer’ all the time and many experts believe that the technology could ultimately be the most popular solution for unmanned entry into hazardous confined spaces.

Printed in Safety Solutions 10 May 2019

Engineers to the rescue! Art deco survives. Brittens sell quake-damaged Christchurch heritage building.

By Lisa McDonald

The building at 116 Worcester St in central Christchurch has been sold after protracted insurance negotiations.

A heritage art deco building featured on a list of Christchurch's worst post-quake eyesores is set to be restored. The Worcester St office building, built in the 1935 for State Insurance, was bought by celebrated motorbike designer and property developer John Britten and his wife, Kirsteen Britten, a former international model, under the name Windlass Holdings in 1994. John Britten died in 1995, aged 45.

Until recently the company had been in insurance negotiations over the property.
The buyers, who have not yet been identified, are reportedly engineers with plans to strengthen and restore the building. The building was designed by Cecil Wood and has a heritage listing with Heritage New Zealand.

The Worcester St building has been on the city council's "Dirty 30" list but is now facing a new future.

Printed in New Zealand Herald

New Innovation — Solar Technology to Arrest Corrosion in Concrete Structures - Remedial Technology

The repair of concrete structures can be challenging when the cause of concrete deterioration is chloride-induced corrosion of the steel reinforcement. The use of electrochemical technology such as cathodic protection (CP) is often the solution for the corrosion protection of chloride-affected structures.
While impressed current cathodic protection is a proven technology which can provide long-term corrosion prevention solutions, it has been viewed by many asset owners as overly complex and expensive. The primary reasons include the need of 240 VAC power supply and complexities associated with the maintenance and monitoring of the CP control equipment, especially when a proprietary system is installed.

In the past year, Remedial Technology's R&D division has developed a simple, reliable and heavy-duty solar powered unit which can provide cathodic protection current to reinforced concrete structures. The primary advantage of this new innovation is its ability to be installed in remote locations, its minimal monitoring and maintenance requirements and its capacity to achieve optimum corrosion protection based on the current Australian Standard for steel in concrete (AS 2832.5 – 2008). The commercialisation of this technology is expected late 2019.

MicroNex – Solar PS

The Challenge of Deteriorating Water Assets

Paul Vince - WSP

SUMMARY: Aging infrastructure presents a key challenge to the water industry. Deteriorating assets threaten to undermine continuity of water supply and water quality. Industry wide reform is required to ensure long term asset investment decisions can be made without causing significant increases in the cost of water. Water utilities need to make prudent investment decisions in order to maximise the life of water assets. This paper considers the rehabilitation of concrete tanks for example. It was found that a large multi-site rehabilitation program can be executed to effectively extend service life and maintain safe water supply.

Keywords: Concrete rehabilitation, carbonation, chloride ion ingress, potable water tanks.

1. Introduction

The Australian Water Industry owns and operates assets with a combined value of over $160 billion[1]. There are 220 urban water suppliers supplying water to over 20 million people and employing over 31,000 people[1]. A total of 75,544 gigalitres were supplied in 2015-16[2]. It is a significant industry adding over $13 billion to the Australian economy in 2015-16[3]. Annual capital expenditure is estimated to be between $3.5 and $4.5 billion, 8.7% of national infrastructure investment[1]. The price of water is low but, unless some significant reform in the industry occurs, prices are set to rise dramatically in the coming decades. In 2017 the annual cost of water to households was $1,226. In order to maintain the current standard of water supply, Infrastructure Australia modelling predicts the annual household water bill will increase to $1,827 by 2027 (50% increase) and to $2,553 by 2040 (more than double)[4].

Maintaining, renewing and replacing aging infrastructure is one of the major drivers for cost increases and presents a key challenge to the water industry[4]. The Australian Water Association 'State of the Water Sector 2015' Report found that investing in asset maintenance, upgrades and augmentation was the number one priority for water sector reform[5]. The 2017 Infrastructure Australia Report 'Reforming Urban Water' noted that some urban water systems will require a step change in investment[4]. The 2018 Australian Industry Standards Water Industry Key Findings Paper found that "the water industry is highly reliant on infrastructure, which requires ongoing maintenance and renewal. Given the dependency on aging infrastructure and increasing urbanisation, new challenges are anticipated to emerge. Water supply management, quality control, and compliance will present complications that must be addressed."[3]

Water utilities need to consider the long-term interests of customers when making investment decisions[4]. The Water Services Association of Australia (WSAA) identified that additional infrastructure and expenditure for water distribution systems will be required to meet the challenge of aging infrastructure[1]. A key element of the water distribution system is water storage within the system. The Australasian Corrosion Association (ACA) Corrosion Challenges study found that approximately 5% of the total cost of deteriorating assets was caused by tanks and similar assets[6]. This equated to an annual cost across the water industry of $42M per year. This paper outlines the approach of a large water authority to rehabilitation of concrete water storages to ensure supply and meet long term demand for water.

The potable water supply in South Australia is primarily supplied by SA Water. They have a large network of reservoirs, treatment plants, tanks, earth bank storages, pipelines, and pump stations which carry the water from the source to the customer[7]. Included in these assets are over 700 storage tanks, of which over 600 are concrete tanks. SA Water has a dedicated team of asset managers that manage these tanks, prioritise maintenance and renewal works, and plan for capital works.

In 2015, upon reviewing available data, SA Water identified 92 tanks that required various levels of structural renewal in order to ensure water supply and maintain service to SA Water customers. In 2016 SA Water began a four-year program to upgrade and refurbish these 92 tanks. These tanks were prioritised due to condition, criticality and opportunity. The majority of these tanks were concrete tanks with steel roofs . The cost of the refurbishment is approximately $70 million.

This is a major investment in ensuring safe and reliable water for the people of South Australia. This is the largest renewal program of its type that SA Water has ever undertaken.

This paper provides an overview of the program to date, challenges experienced and solutions and innovations undertaken to resolve issues arising.

2. Overview of Tank Design

The common tank design employed by SA Water is an in situ cast concrete floor with a ring beam, in situ cast concrete walls and a galvanized steel sheeting roof (Figure 1), with a galvanized steel roof support structure supported by concrete columns within the tank (Figure 2). Some of the columns were precast but the majority were cast in situ.

Figure 1 External view of a typical concrete tank

Figure 2 Internal view of a concrete tank with columns (roof partially removed)

Tank capacity ranged from 200KL to 56ML. Tank diameter ranged from 12m to 77m. Tank wall height ranged from 2m to 12m. Tank date of construction ranged from 1890-2000.

The scope of work for each tank was determined through a series of inspections. In order to capture the various aspects of the scope, the tanks were broken down into elements as per Figure 3. This breakdown is largely consistent with the WSAA Condition Assessment Guidelines for Civil Structures[8]. Each element was assigned a Condition Grade correlating with the observed condition during inspection and repair actions were determined.

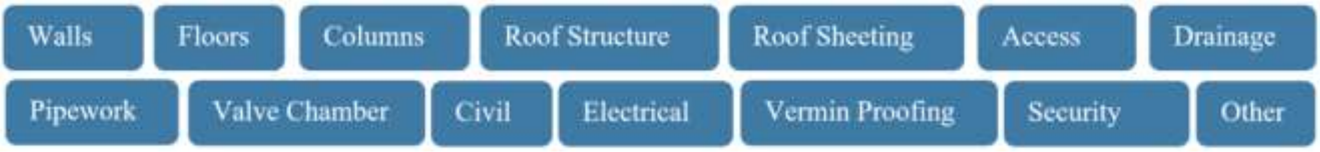

Figure 3 Elements of each tank

3. Description of Rehabilitation Works

For a state-wide renewal program with so many different sites and so many variations of tank configuration, it was not efficient to design a specific rehabilitation solution for each site. Therefore, some typical drawings were developed for expected scenarios for the rehabilitation of spalling concrete and for repair of concrete columns.

3.1 Concrete Rehabilitation

Two types of concrete repair were developed, see Table 1.

Table 1. Concrete Repair Types

Type	Description
1	Concrete repair where reinforcement corrosion results in less than 30% loss in cross section
2	Concrete repair where reinforcement corrosion results in more than 30% loss in cross section

The requirement for the concrete repairs was to return to standard configuration and provide an additional 40 years life. A schematic view of the typical repair is provided in Figure 4.

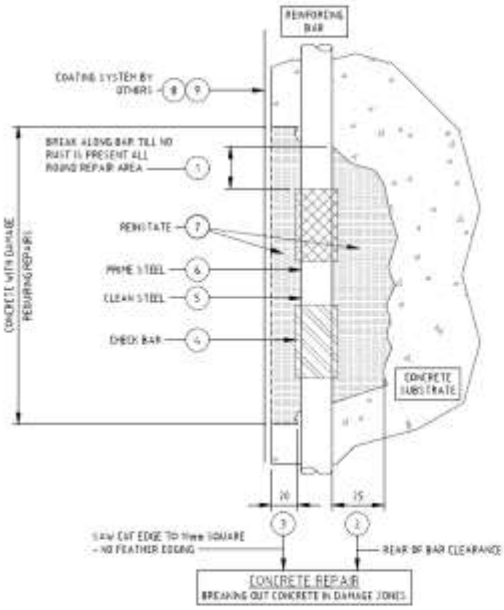

Figure 4 Typical Concrete Repair

The simplified sequence of work was as per Table 2.

Table 2. Concrete Rehabilitation Sequence of Work

Step	Description
1 & 2	Break out spalled and deteriorated concrete.
3	Saw cut edges.
4	Assess reinforcement condition. Replace if metal loss is greater than 30%.
5	Blast or wire brush the reinforcing bar clean.
6	Apply zinc rich primer to reinforcing bar.
7	Patch repair concrete with an approved product.
8&9	Apply approved coating if specified.

3.2 External Condition of Concrete Walls

Delamination of concrete on external walls was found by tap testing. Simple pH testing for depth of carbonation was conducted using a drill and phenolphthalein solution. Concrete repairs for deteriorated areas were conducted in accordance with the procedure outlined in Section 3.1. For many tanks in the program, only a small number of repairs were required, less than 3 m^2, although the most significantly affected tanks required up to 30 $m^2$of repair.

The mechanism for this type of corrosion of reinforcement and subsequent spalling is carbonation. This will be discussed further in Section 4.1. Concrete spalling was more noticeable in areas of low cover.

3.3 Internal Condition of Concrete Walls

The internal condition of the concrete walls was generally good. The common design included more than 50mm concrete cover to reinforcement and this has proven to provide good protection to the reinforcement. Minor issues had occurred with old fittings and remnants of formwork that had been embedded in the concrete. Ellis[9] reported issues with circumferential construction joints and these continue be common in older tanks. These were repaired with Hypalon® strip. Some tanks exhibited minor cracking believed to be associated with movement. These were repaired by crack injection methods.

Two instances of severe corrosion of reinforcement had occurred as shown in Figures 5 and 6. These areas had suffered localised severe pitting and metal loss. In both cases the concrete appeared to have been poorly compacted which may have contributed to severe corrosion in these locations, whereas nearby areas

Figure 5 Visual appearance of concrete surface with evidence of steel reinforcement corrosion within the wall

Figure 6 Reinforcement condition of the area identified in Figure 5 after concrete was broken away

3.4 Reinforced Concrete Column Rehabilitation

The columns presented some specific structural challenges in terms of concrete rehabilitation. The columns are tall slender elements that have a foundation in the floor slab and are connected at the top to the roof support structure.

SA Water tanks constructed before the 1960s were designed such that the roof directed rainwater into the tank. However, this created water quality issues due to pollutants from the air, leaves and debris entering the water. From the 1960s onward the roofs were constructed so that the rainwater flowed to perimeter gutters and into a site storm water system. Consequently, the roofs had to be raised to achieve the required pitch and this was done by increasing the height of the columns. A number of methods were used; steel stubs, stainless steel stubs and in situ cast concrete either to the same dimensions as the original or to a larger cross section to provide additional concrete cover to the reinforcement.

It was found during site inspections that the tops of the extended concrete columns often suffered steel reinforcement corrosion and spalling. When the spalled concrete was removed, the most common contributor to premature failure was low concrete cover to the reinforcement. In that case, reinstating the column to the original dimension by patch repair would not provide the durability required for the ongoing service of the column due to the cover remaining low. Therefore, additional concrete material needed to be applied to achieve the required cover to reinforcement. Installation of this additional material created a construction challenge.

Initially, it was planned to construct conventional formwork and pour additional material at the top of the column. This presented construction issues due to working at heights and created significant weight at the top of the column which was undesirable from a structural perspective. Industry feedback led to designs that incorporated fibreglass jackets as formwork. These jackets could be stacked for the full height of the column, filled with grout and create a new larger column, Figure 7.

Figure 7 Columns rehabilitated with fibreglass jackets

Further review led to the use of a carbon fibre wrap solution which could readily be applied to the tops of the columns without creating an increased weight issue, Figure 8. This solution was found to be more efficient in terms of time and cost than the other jacket style solutions.

Figure 8 Columns rehabilitated with carbon fibre, columns at rear with an additional epoxy coating

4. Concrete Column Deterioration

It was anticipated that the two main contributors for concrete deterioration were carbonation and chloride ion ingress. This was based on previous experience at SA Water as described by Ellis[9]. The approach by Ellis remains the standard approach as described by SA HB 84 'Guide to concrete repair and protection.'[10] Green et al (2018)[11] have given an excellent overview of the mechanisms associated with this type of deterioration.

4.1 Proposed Mechanism for Internal Above the Typical Water Line Reinforcement Corrosion

The main spalling observed inside the tanks was at the top of the columns (Figures 9 and 10). It was observed that the reinforcement in the top sections of the columns often had low concrete cover. The original design for these columns included 25mm of cover in early designs although this was later increased to 50mm cover. However, in practice cover as low as 15mm was observed. This was possibly due to poor reinforcement placement, movement of the reinforcement during concrete pouring or movement of the formwork during concrete pouring. Note also that the 25mm chamfer on the corners of the column reduces cover on the corners. Corners have increased susceptibility to corrosion as the edges receive a contribution from each of the two sides. As a result, carbonation of the concrete can lead to low pH at the reinforcement and subsequent corrosion of the reinforcement for the columns earlier than the internal walls that have a much higher thickness of concrete cover. It was assumed that the carbonation was due to the exposure to air in the air space above the water level inside the tank[9].

Figure 9 Top of column showing corroded reinforcement with low cover and concrete cracking

Figure 10 Top of column showing corroded reinforcement with low cover

4.1.1 Carbonation - mechanism

Steel reinforcement in concrete does not corrode due to the high pH and thermodynamic conditions (Green 1991)[12]. Within the concrete pore water, carbon dioxide can dissolve to form carbonic acid. This reacts with the cement to form calcium carbonate. The reaction will continue until the pH in the concrete pore water is reduced to such an extent that the steel is no longer passive, and corrosion can occur. The rate of deterioration is controlled by the rate of access of carbon dioxide to the pore water. The passive layer of iron oxide (Fe_2O_3) on the steel reinforcement surface is dissolved as the pH of the pore water decreases below 10 and under these conditions the steel can readily corrode. Note the photo below in Figure 11 which shows carbonation from the surface and near cracks. When steel corrodes, the oxides of iron have a much greater volume than the pure metal. Concrete has low tensile strength and, when subject to the pressure of an expanding corrosion product, spalling, cracking and delamination occur. Carbonation can contribute to a minor increase in strength of sound concrete due to the products produced by the reactions.

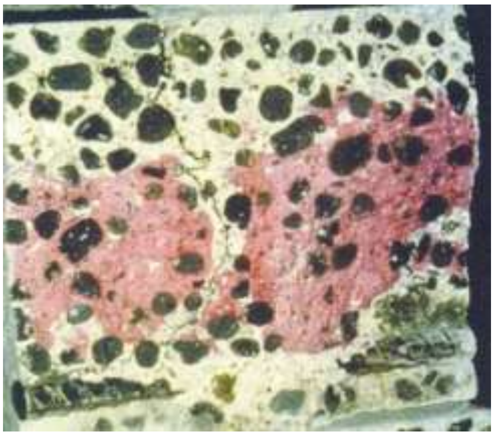

Figure 11 Carbonation of reinforced concrete. The pink colour is phenol-phthalein indicator which turns pink with pH greater than 9.5. (After HB 84[10])

4.1.2 Soft Water Attack – mechanism

An alternative explanation for the loss of pH is that it is due to soft water attack. The water in the tank undergoes a cycle of evaporation and condensation every day and this process may lead to some soft water attack of the top of the columns as the condensed water trickles down the column faces. Ellis[9] reported typical loss of alkalinity over a distance of 3-8mm from the top of the column, due to this type of leaching. This effect will exacerbate the corrosion of steel reinforcement if cracking exists as the soft water can enter the cracks and leach away calcium compounds and further reduce the pH of the pore water. This process will also reduce the concrete strength.

4.1.3 Incipient anode mechanism

In a small number of specific instances corrosion of the reinforcement had occurred immediately below the location where the concrete column extension had been installed. This is an example of an incipient anode effect where an anode cathode combination was set up on the steel reinforcement surface at the interface of the old column and the new repair. The reinforcement in the old column will corrode preferentially.

4.1.4 Beam Attachment Arrangement

It is also worth noting the influence of the attachment arrangement between the column and the roof support beams. The tank roof goes through an expansion and contraction cycle every day. The stresses of this cycle are transferred to the column via the attachment arrangement at the top of the column. Significant stress can occur if there is no allowance for movement or if the components become rusted together to prevent movement. There are multiple different arrangements for the tops of the columns and some have been found to increase the stress in the columns.

4.1.5 Location of Column

Finally, the location of the column may have contributed to the speed of deterioration. It has been found that some locations more commonly required rehabilitation than others. This is related to the location of the inlet and outlet and the extent of mixing inside the storage. Potable water is treated with chlorine to ensure that all harmful bacteria are killed[19]. If this chlorine is released from the water within a tank then the atmosphere inside the tank can contain an elevated level of chlorine. This can lead to increased corrosion of the roof support structure which can increase the stress in the columns.

In reality, combinations of all of the above mechanisms were occurring above the typical water line.

4.2 Proposed Mechanism for Below Waterline Reinforcement Corrosion

In all of the previous reports from SA Water and for the large proportion of tanks in this program, corrosion of the reinforcement in the columns below the typical water line was not reported. In reviewing tank inspection reports for all tanks for the previous 20 years, only one instance of corrosion of reinforcement below the water line in a column was reported. However, in three tanks in mid 2018 severe corrosion of reinforcement in the lower half of columns was found. Anecdotally, all of these tanks had high turnover of water (Figure 12 & 13).

Figure 12 Concrete column surface after removing rust tubercules

Figure 13 Exposed reinforcement at location where rust staining was evident on the column surface

Once again, the locations most prone to this type of effect were those where there was low concrete cover to the reinforcement . Clearly, carbonation is not an issue below the waterline, see Figure 15 which shows a high pH adjacent to the corroded reinforcement. The most likely cause of this corrosion is chloride ion ingress. As a result of finding this corrosion, a significant investigation has commenced in order to assess pH, chloride ion content and other parameters of the columns to confirm the mechanism.

Figure 14 Pitted reinforcement

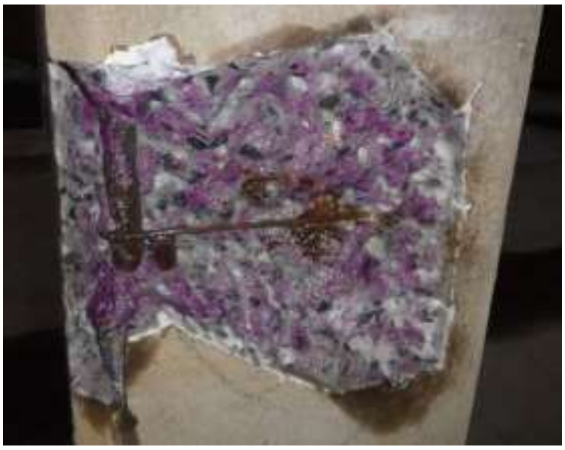

Figure 15 Concrete broken out and tested for pH with phenolphthalein

4.2.1 Chloride Ion Ingress – mechanism

HB 84[10] provides guidance on chloride levels and associated risk, Table 3.

Table 3. Probability of Corrosion from Chloride Ions in Portland Cement Concrete

Total Chloride W/W cement, %	Corrosion probability
<0.4	Low
>0.4, <1.0	Dangerous
>1.0	Very dangerous

Potable water provides a source of chloride ions which can migrate through the concrete columns to the steel reinforcement. Green[11] has summarised the impact of the chloride ions. If the concentration of chloride ions at the steel surface is sufficient, pitting corrosion can occur as seen in Figure 14 . The chloride ions interact with the passive oxide layer, causing the oxide layer to breakdown locally and allowing the formation of corrosion pits. If the conditions at the steel surface remain suitable then the pits will continue to grow and significant metal loss can occur which impacts the structural capacity of the columns. The rate of metal loss can be high due to the large area of steel surface which has the passive iron oxide layer intact (cathode) compared to the small area of the pit (anode). Note that poor quality steel with high levels of inclusions can enhance the corrosion reactions and increase the rate of metal loss.

From the above discussion it can be seen that the presence of chloride ions at the steel surface is critical to the pitting of the steel. Experience has shown that measures to decrease the rate of diffusion of chloride ions through concrete have been beneficial in reducing the corrosion of reinforcement, i.e. higher concrete cover, lower permeability concrete and higher density concrete.

Melchers[13] has noted that in fully immersed conditions the rate of inward diffusion of chlorides is usually assumed to be low. In the case of SA Water tanks, perhaps the diffusion rate is low but the age of the tanks is sufficiently high that the chloride levels at the reinforcement are higher than those indicated in Table 3. However, across other tanks with similar water chemistry and age, the same phenomena were not observed. Some other factors are influencing the behaviour of the columns.

Melchers has observed that in real life examples of reinforced concrete structures corrosion can occur in localised areas at high pH and that corrosion does not always occur when the chloride concentration of the concrete is high, even up to 3%. He found it was the outward leaching of alkalis away from steel reinforcement (and hence a lowering of the pH) that was the determining factor for the time to corrosion initiation. Melchers and Chaves (2016)[14] found that chlorides accelerate the alkali leaching process. Thus, the total time to the commencement of active reinforcement corrosion must consider the inward diffusion of chlorides and the outward rate of loss of alkalis.

In relation to the severe corrosion of the reinforcement as observed in Figure 6, Melchers observed a similar phenomenon in concrete piles for the Hornibrook Bridge. Melchers (2015)[15] postulated that this occured due to the anoxic conditions which can occur at fine cracks intersecting with the reinforcement. Melchers (2017)[16] also noted that these cracks could aid the leaching of alkalis by providing an outward pathway.
The observations of corrosion of reinforcement of concrete columns at SA Water match many of the observations of Melchers et al. Further work is ongoing to gain a better understanding of the observed phenomena.

5. Concrete Rehabilitation Options

5.1 Above the Waterline

The repair detail outlined in Section 3 above can be utilised to repair the damaged concrete at the tops of the columns. Deteriorated reinforcement is replaced and the passive environment around the reinforcement is reinstated to provide extended life for the column. A protective coating is applied to prevent future interaction with carbon dioxide and soft water. The fixing arrangements between the top of the column and the roof structure are refurbished or replaced.

One of the contributors to the deterioration of the tops of the columns, the roof structure and sheeting is the humid environment above the waterline. If new roof sheeting is installed in a tank, then ventilation via ridge vents and whirly birds are installed to aid air turnover inside the tank. Site testing has shown that this has had a dramatic effect in decreasing the humidity above the waterline with expected extension of asset life and the water quality benefits due to mitigating surface temperature effects and stratification. Vertically suspended thermistor and humidity sensors have also been deployed for data logging and ongoing asset performance review.

5.2 Below the Waterline

Initial repairs have been conducted in accordance with the repair procedure outlined in Section 3.
Further investigation is ongoing as to the extent of chloride contamination and subsequently the extent of repairs. All repairs have been coated to prevent further ingress of chloride ions. Green (1991)[12] identified that one of the requirements to sustain the pitting at the steel surface is the diffusion of chloride ions from the bulk pore solution. If this can be halted by the removal of high chloride concrete and the application of a coating,

then further corrosion in the repaired areas is not expected. The coating application will also seal fine cracks which contribute to severe localised corrosion.

6. Summary

A significant concrete rehabilitation program for potable and raw water concrete tanks has been undertaken by SA Water. Assessment and rehabilitation of 92 sites across South Australia is being undertaken. This has involved detailed planning, site visits and construction activities. It has been found that steel reinforcement corrosion within concrete columns has occurred above and below the water line. The proposed mechanism for the above the water line corrosion is carbonation with additional influences from soft water attack and stressing of the columns due to daily expansion contraction cycles. The corrosion below the water line was unexpected as this type of corrosion has not been common at SA Water in the past. The proposed mechanism for the corrosion below the water line is alkali leaching coupled with chloride ion ingress. Severe reinforcement corrosion has occurred at anoxic zones adjacent to concrete cracks that extend to the reinforcement. Rehabilitation options for the deteriorated concrete have been developed.

The evolution of the renewal program has involved a number of unexpected challenges and continuous improvement opportunities. The size and complexity of this state-wide program has included up to thirty simultaneous work sites and created many logistical challenges. The condition of every tank at the start of work on each site has been different. An effort has been made to develop typical solutions to improve efficiency, but particular attention needs to be paid to the actual condition at each site to ensure adequate rehabilitation works are completed.

7. Conclusions

The water industry in Australia faces many challenges but key amongst these is aging infrastructure. Significant investment in asset rehabilitation is required in order to maintain the required level of service to customers, both in terms of water supply and water quality. This paper has provided a snapshot of one program at one water authority. Similar projects are underway across Australia as part of the ongoing effort to meet the challenge of aging infrastructure. If existing assets are not maintained, the cost of future replacement will result in increases in the cost of water. The AWA 2016 Australian Water Outlook states that lack of investment in infrastructure now will be costly in the long run.[17,18]

8. Acknowledgements

The author would like to acknowledge the support of colleagues at SA Water, Fulton Hogan and WSP in the preparation of this paper.

9. References

1. Water Services Association of Australia, Infrastructure Partnerships Australia (2015) 'Doing the important, as well as the urgent: Reforming the urban water sector,' WSAA/IPA, https://www.wsaa.asn.au/sites/default/files/publication/download/Doing%20the%20important%2C%20as%20well%20as%20the%20urgent%20Reforming%20the%20urban%20water%20sector.PDF
2. Australian Bureau of Statistics (2017) 'Water Account, Australia, 2015-16,' Commonwealth of Australia, http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/4610.0Main%20Features12015-16?opendocument&tabname=Summary&prodno=4610.0&issue=2015-16&num=&view=
3. Australian Industry Standards (2018) 'Water Industry: Key Findings Discussion Paper,' Water Industry Reference Committee, Australian Industry and Skills Committee, Commonwealth of Australia, http://www.australianindustrystandards.org.au/wp-content/uploads/2018/02/Water-Key-Findings-Paper2018V4Web.pdf
4. Infrastructure Australia (2017) 'Reforming Urban Water; A national pathway for change,' Australian Government, http://infrastructureaustralia.gov.au/policy-publications/publications/files/Reforming_Urban_Water_Web_version.pdf
5. Australian Water Association, Deloitte (2015) 'State of the Water Sector Report,' AWA, http://www.awa.asn.au/documents/SOTWS2015_Report_PRINT.PDF
6. G. Moore (2010) 'Corrosion Challenges Project, Water Sector Report,' Australasian Corrosion Association.
7. SA Water (2017) 'Reservoirs, Water Treatment Plants, Borefields, and Major Pipelines for SA Water,' https://www.sawater.com.au/__data/assets/pdf_file/0011/171011/Maps.pdf
8. WSAA, Inside Infrastructure (2018) 'Condition Assessment Guidelines for Civil Structures,' Water Services Association of Australia.
9. D. Ellis (2004) 'Condition Assessment, Materials Performance and Repair of Concrete Water Storage Tanks in South Australia,' Corrosion and Prevention, Perth, 2004, Paper 96, Australasian Corrosion Association.
10. SA HB 84 (2018) 'Guide to concrete repair and protection,' Standards Australia, Australasian Concrete Repair Association (ACRA). https://www.acrassoc.com.au/index.php/publications/guide-to-concrete-repair
11. W. Green, F. Collins, M Forsyth (2018) 'Up-to-date Review of Aspects of Steel Reinforcement Corrosion in Concrete,' Corrosion and Materials, p.64-76, August 2018, Australasian Corrosion Association.

12. W. Green (1991) ‘Electrochemical and chemical changes in chloride contaminated reinforced concrete following cathodic polarisation,’ MSc Dissertation, University of Manchester Institute of Science and Technology, Manchester, UK.
13. R. Melchers, I. Chaves (2018) ‘Service life estimation of concrete infrastructures,’ Eco-efficient Repair and Rehabilitation of Concrete Infrastructures, Elsevier, p15-41.
14. R. Melchers, I. Chaves (2016) ‘A Study of Initiation and active Reinforcement Corrosion in Conventional Reinforced Concrete,’ Corrosion and Prevention 2016, Paper 52, Australasian Corrosion Association.
15. R. Melchers (2015) ‘Field Experience and the Long Term Durability of Reinforced Concrete Structures,’ Second International Conference on performance Based Life Cycle Structural Engineering, University of Queensland.
16. R. Melchers (2017) ‘Modelling Durability of Reinforced Concrete Structures,’ International Brian Cherry Concrete Symposium Paper, Australasian Corrosion Association.
17. Australian Water Association, Arup (2016) ‘Australian Water Outlook,’ AWA, http://www.awa.asn.au/documents/Australian_Water_Outlook_report_2016.pdf
18. Australian Government Productivity Commission (2011) ‘Australia’s Urban Water Sector, Productivity Commission Inquiry Report,’ Volume 1, No 55, 31 August 2011, https://www.pc.gov.au/inquiries/completed/urban-water/report/urban-water-volume1.pdf
19. NHMRC (2018) ‘Australian Drinking Water Guidelines,’ National Health and Medical Research Council (NHMRC), Australian Government. https://www.nhmrc.gov.au/guidelines/publications/eh52
Hypalon is a registered trademark of DuPont.

9.1 Standards

AS/NZS 4020: 2018 ‘Testing of products for use in contact with drinking water’
AS 1397-2011 ‘Continuous hot-dip metallic coated steel sheet and strip - Coatings of zinc and zinc alloyed with aluminium and magnesium’

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Industry News

R. M. Watson Turns 60

On 19th April 2019, RM Watson celebrated 60 years of business. To mark the occasion, 150 industry figures, past and present, gathered at the top of Sydney Tower to celebrate the achievements of the company and its staff.

The ACRA Board were well represented on the evening with Greg Zambesi and Grant Dowling joined by Andrew Dickinson

Bridget Liang, Dennis Stephenson, Liam Doyle and Curtis Payne

Past ACRA Presidents, David Mahaffey and Peter Johnsson compare notes
and Peter Johnsson compare notes

Not a bad spot for a 60th

Kevin Hunt and Perter McKenzie discuss old times

Tim Womack, Nathan Gilroy, Simon De Graff, Chris Salz, Tony Watson

Tony Watson addresses the audience

R. M. Watson Turns 60

Ray Watson (left), Joern Utzon, Erik Andersson and Ove Arup inspect sandstone for the Opera House

Chairman, Tony Watson, marked the occasion with a talk highlighting the many landmark projects completed over the many years of a great family business. Starting with his father Ray's formation of the Company as a stone fixing business in the 1960's and 70's, where they were responsible for most of the sandstone, marble and granite cladding projects in Sydney and Canberra such as the Australian Mint and War Memorial in Canberra and Reserve Bank and 60 Martin Place in Sydney.

During the 1970's, with architects preferring precast concrete to stone on the facades of buildings, RMW moved from fixing stone to concrete panels. Due to the poor quality of precast concrete at the time, as well as installing precast panels, RMW's tradesman had to carry out many repairs to the new panels. This inspired
Tony's older brother Lindsay to move the company into the remedial field and by the mid-70's RMW was specialising in the repair of building facades with projects such as the Sydney Waterboard Head Office, one of the first major façade repair jobs carried out in Sydney.

Industry News

R. M. Watson Turns 60

Tony and wife, Frances, took over the business on Lindsay's retirement in 1997 and today oversee the operation of the oldest specialist remedial business in Australia. His speech, while mentioning many great projects completed during the last 20 years including The Astor Apartment façade upgrade and Northpoint Tower over clad, focussed on the people that have made the company great, the staff. With a number of employees marking 20 years of service to the company and several past and present staff with 2 generations of family members employed in the business, the Company has thrived on the experience and loyalty of its staff. By maintaining a full-time staff of the most experienced people in the remedial industry, RMW are able to offer clients a long-term commitment to quality and safety for every project undertaken by the firm.

The Astor Apartment, Sydney

Northpoint, North Sydney - Before and After over cladding

The future for RMW is also looking bright with a raft of younger staff, under the direction of new Director, Sam Coady, being promoted from site to run the office. By creating career paths for young employees, the Company is ensuring the legacy continues well into the new millennium.

www.rmwatson.com.au

RMW

Industry News

CE Construction Solutions have taken the reins for the complete range of Collomix force action and small batch mixing equipment in Australia.

CE's General Manager Dan Rowley said "It was feedback from a number of ACRA members, both material supplies and contractors, which really sealed this deal for us. When we began exploring the current mixing practices across Australia in construction it become clear that we could be doing things in a much smarter way. Collomix lets us make considerable improvement in material mixing quality alongside considerable throughput saving in labour and time."

Based in Germany, Collomix are a world leading in small batch and forced action mixing.
For over 40 years they have been innovating, refining and defining mixing equipment and paddle geometry. Collomix have a specific paddle for each and every material designed to achieve maximum product performance in the minimal amount of time. From single paddles through ergonomically designed handheld mixers to their Collomatic force action and levelling compound mixers, the offering to the concrete repair industry is impressive.

We're not saying your doing it wrong, but we're confident we can help you do it better. CE Construction Solutions are offering free consultations to review your current mixing practices and QC to highlight how and where the Collomix range could save you time, money and reduce the potential of LTIs in your construction practices. Contact Dan Rowley via email at daniel@cecsgroup.com.au for more information.

Industry News

News from BCRC

BCRC are delighted to welcome their latest addition to the team - Mr Faiz Khan, their new State Manager - Victoria. Faiz brings with him 20+ year's experience.

You can contact Faiz at BCRC Melbourne Office 03 9938 3830

f.khan@bcrc.com.au

News from Freyssinet Australia

Freyssinet Australia welcomes Werner POTGIETER as Business Development Engineer for their civil division. Werner is joining the growing Freyssinet team in Melbourne and will help to develop further the business in Victoria. Congratulations Werner!

www.freyssinet.com.au

Industry News

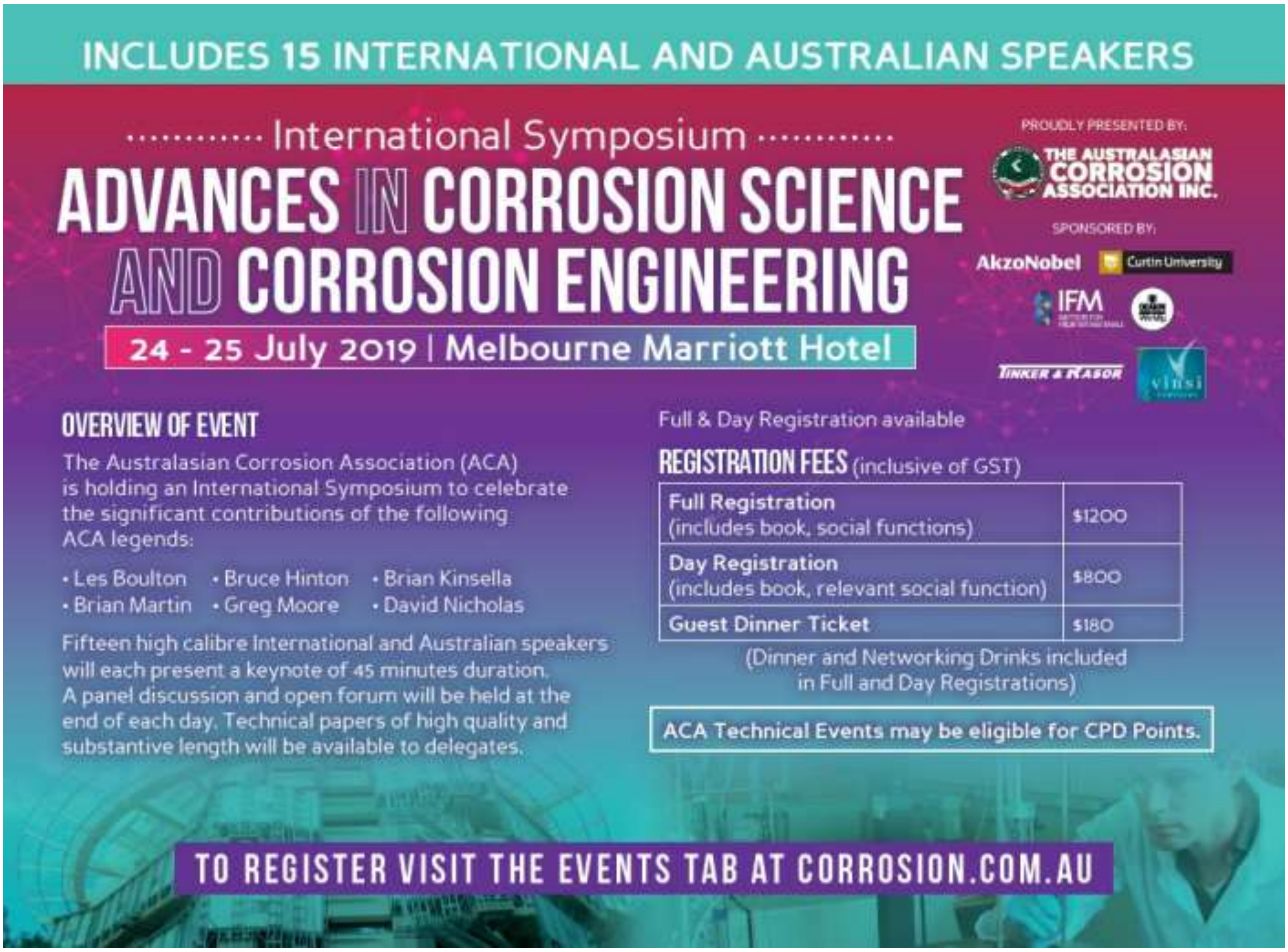
Triaxial Consulting have officially opened their new Bathurst office.
Their Bathurst office is managed by Bathurst local, Mr Rawdon Stanford.
The Bathurst office will be working in conjunction with their Mudgee and Parramatta offices to service Central Western NSW, the Blue Mountains and Greater Western Sydney.
If you find yourself in Bathurst, they invite you to pop in to say hello. 137 George St, Bathurst or you can contact Rawdon on **1300 874 294** or email rstanford@triaxial.com.au.

Industry News

Duoguard new website

Duoguard is proud to announce the launch of our new company website.
Duoguard have been working hard behind the scenes to create a new website that shares more about the service Duoguard offer and provides detailed insights into our project work and products.

www.duoguard.com.au



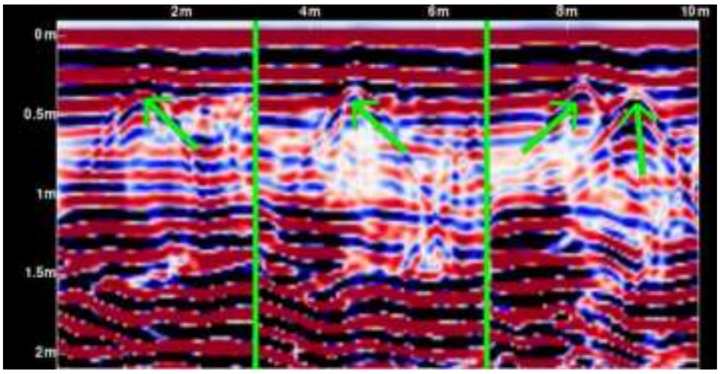
Industry News

Ground-breaking technology so you don't have to break the ground! -Kennards Hire

It's well known that ground plans often do not reflect the real situation on the ground. Often they are dated, inaccurate and people who use them as their sole reference point do so at their own peril. For instance, when new works are undertaken and an excavator breaches a water pipe that no one knew was in that position - it can cost time, money, goodwill from local residents and business owners who are left without water for a few hours whilst the damage is being repaired.

That all can be avoided with the use of products such as the [Utility Ground Penetrating Radar](#).

This advanced technology allows users to detect both conductive and non-conductive underground utilities using wide-band radar technology. This includes water pipes and electrical cables up to 8 metres in depth. It features an internal GPS, on-board Wi-Fi and a high-resolution touch screen.
A real benefit in using this product is the technology. It features a high-resolution touch screen that allows users to draw arrows on the screen to highlight features of interest (as seen below). Screenshots and tables can be saved as Jpg. files and emailed to colleagues using Wi-Fi. Data and images can also be exported via USB for archiving or inclusion in reports. All these features increase productivity, as well as supplying proof of the existence of utilities.



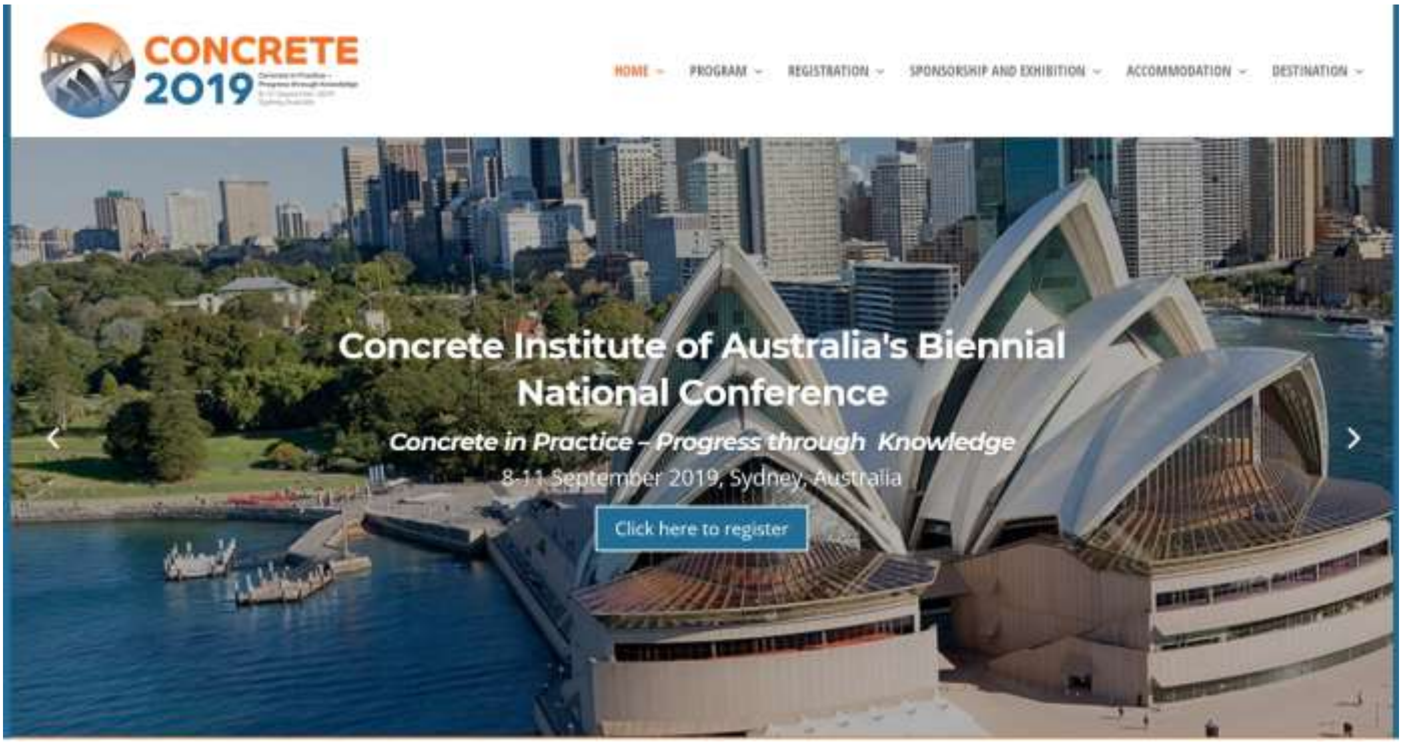
Kennards Hire chose this unit from Radio detection over its competitors because it is easy to set up and is user friendly. Some competitive products have taken up to 4 hours to set up and calibrate, comparatively the Utility Ground Penetrating Radar can be set up and working in minutes. Whilst it may look complicated, it is not. The technology makes usage easier, not harder. It is easily and compactly transported, and set up is easy. Thanks to the large wheels, the unit can be used over rugged terrain without fear of breakage.
The Utility Ground Penetrating Radar has proven its worth in two instances. A contractor hired one of these in November 2018 for works on the water mains in Melbourne, as workers were hitting pipes not shown in the plans they had obtained. The Utility Ground Penetrating Radar found 6 additional pipes they were unaware of, thus saving the project money, time, and assisted in growing goodwill.

Industry News

Photo: Ashleigh Woollam Test & Measure Laverton using the GPR

Another example of this unit being of great use involved a project in North Geelong where The contractor was planting trees in a major park. No plans were available and they needed proof that no utilities were present. In this instance the Ground Penetrating Radar confirmed this to be the case, however it would have been extremely costly in the short term had an excavator hit a utility. In the longer term, tree roots that grow and come into contact with utilities can cause damage, with use of the Ground Penetrating Radar, they were able to plant with certainty that there would be no future implications to any possible existing utilities.
The Utility Ground Penetrating Radar has proven invaluable to customers time and time again, saving them time, money on their projects, as well as offering peace of mind knowing where utilities are for the future. If you have any questions, don't hesitate to call on (03) 9314 8055 or email StevenKnowles@kennards.com.au

In other news….Kennards Hire's newly opened branch in Westgate, New Zealand meets the high demand of equipment for current construction projects in the area. Read more about the purpose-built branch on their blog: https://bit.ly/2HBYOkT



New ACRA Members

New Corporate Members

BUSS Group (WA) is a privately owned and operated company, with operations Australia wide.
At BUSS we specialise in working with our clients to implement value for money remedial solutions that will bring new life to their assets. Comprising of a team with more than 30 years' industry experience, we bring a wealth of expertise and capability to the market.
Our services include, but are not limited to:

- waterproofing
- concrete repair
- abrasive blasting and coatings
- roof plumbing
- joint sealing
- structural strengthening
- crack injection and facade refurbishment.

By operating on a 24/7 basis, with immediate mobilisation capabilities, BUSS ensure that the needs and requirements of our clients are met in a timely manner.

www.buss.com.au

New ACRA Members

New Corporate Members

Callaghan Innovation (NZ) people include more than 200 of New Zealand's leading scientists and engineers – empower innovators by connecting people, opportunities and networks, and providing tailored technical solutions, skills and capability development programmes, and grants co-funding.
Callaghan Innovation is New Zealand's innovation agency. Our purpose is to activate innovation and help businesses grow faster for a better New Zealand.
www.rd.callaghaninnovation.govt.nz

James Cook University (JCU) is a remarkable university recognised today as one of the best modern universities in the world. As a leading tertiary institution in Australia, and our Asia-Pacific region, we measure our success in research and teaching excellence that makes a difference through the development of human capital.
At JCU we offer degree programs across Chemical, Civil, Electrical and Electronics, Electrical Systems and Internet of Things, and Mechanical Engineering disciplines. Our approach is multidisciplinary with a focus on the design of resilient, efficient and sustainable engineered structures and systems.

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Thomas Hegarty—North Melbourne 0449 056 926
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Daniel Caruana—Prestons NSW 0427 209 979
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Chris Brooks—Derrimut VIC 0408 004 123

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