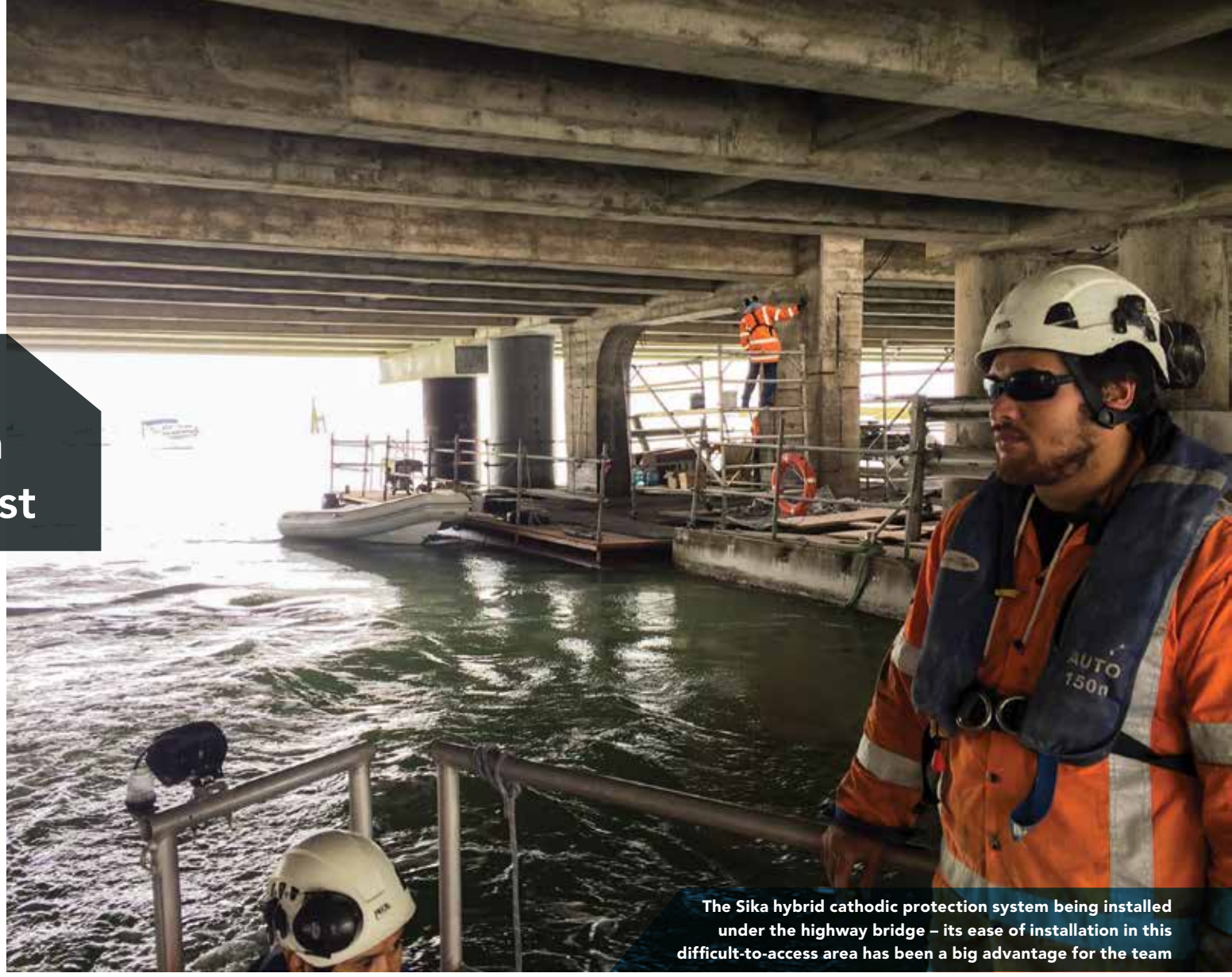
Hybrid cathodic protection system a New Zealand first



The Sika hybrid cathodic protection system being installed under the highway bridge – its ease of installation in this difficult-to-access area has been a big advantage for the team

For the first time in New Zealand, Sika (NZ) is providing a state-of-the-art hybrid corrosion protection system on concrete support piles under major highway bridges in Auckland.

The technology has been designed by international experts whose research has revolutionised the understanding of how impressed current cathodic protection (ICCP) performs.

Sika (NZ) is supplying the hybrid anode system on the highway project, currently being installed under the supervision of Dr Christian Christodoulou. He is a technical director with AECOM in the UK, and a leading international expert in the field of corrosion asset management, repair and refurbishment, and durability design of reinforced concrete structures.

Traditionally, the options available to asset owners for chloride or carbon contaminated concrete have included:

- Breaking out and replacing all of the contaminated concrete – obviously a costly and prohibitive exercise
- The application of a surface-applied corrosion inhibitor (SACI) – a short-term (10 years) lifespan and limited penetration with chloride-rich concrete environments
- Re-alkalisation or chloride extraction – can be difficult to achieve success
- Impressed current cathodic protection – drawbacks with ongoing costs of monitoring, control, power supply and cable maintenance.

The hybrid anode system combines elements of re-alkalisation, cathodic protection and galvanic protection which are then applied as an overall global or targeted protection system for the concrete element or structure.

THE HYBRID SYSTEM IN NZ

Repairing marine structures is especially problematic when they have been made of reinforced concrete. Heavy wear and abrasion from wave action and intertidal challenges mean chloride-induced corrosion can advance very quickly.

Some of the original piles on the highway project were installed over 40 years ago, and appear to have lasted well, according to Reuben Reeves, market field manager – refurbishment and strengthening, at Sika (NZ). Inevitably, though, some degradation had taken place.

As part of the initial survey of these piles, corrosion-potential mapping was used to provide an indication of the environment within the concrete. This mapping was conducted at the concrete's surface with either a silver/silver-chloride or copper/copper-sulphate half-cell in electrical connection to the existing reinforcing.

Once the results were analysed, reference electrodes were then installed on a predetermined grid design. These manganese dioxide anodes allowed the designer to measure the effectiveness of both the impressed current and cathodic protection systems, using readings taken from inside the pile structure. These readings were collected via data-logger and relayed to the designer.

This information allowed the designer to confirm the optimal placement of the hybrid anodes, which were then installed in drilled holes and connected via titanium wire.

With the hybrid anodes installed, monitoring has been taking place. With each pile installation the designer has the ability to adjust the amount of current to selected zones within each pile, be it predominantly a tidal, splash, or atmospheric zone. Once a suitable current has been passed in this impressed current phase and the zone is appropriately passivated, the power supply can be removed and a galvanic phase of protection is initiated.

As a responsive system, the output of the anodes adjusts when the concrete environment is influenced and changes are apparent – e.g. when water levels increase in flood. The galvanic protection increases when the corrosion potential increases within the concrete, so monitoring may also be removed when the power supply is withdrawn.

The New Zealand project was recently highlighted at a one-day seminar, 'Protecting Infrastructure and Assets against Corrosion', which was hosted by the Australasian Corrosion Association's (ACA) New Zealand branch in Auckland in May. It built on science described at the ACA's international conference in November last year.

BACKGROUND

In the UK and Australia, investigations have been conducted into the sometimes positive effects of interrupting cathodic protection on reinforced concrete structures. Preliminary laboratory results suggested that applying ICCP to a reinforced concrete structure over a period of time could transform the environment around the reinforcement, even after the protective current had been interrupted.

"ICCP has been the most popular electrochemical solution for the repair and maintenance of reinforced concrete structures worldwide," explained Dr Christodoulou, speaking at the ACA's conference in November.

In the case of many reinforced concrete marine structures, steel is typically de-passivated by chlorides migrating through the concrete from the external environment, building up in sufficient concentrations at the steel face to damage the naturally protective iron oxide film.

Once de-passivated, iron oxides and hydroxides develop at the anode, and can expand to twice or up to six times more volume than the original steel. This corrosion applies pressure to the surrounding concrete, leading to tensile strains within the concrete cover zone. When the strains exceed the tensile strain capacity of the concrete, cracking occurs followed by progressive concrete damage and detachment (i.e. spalling and delamination).

Concrete patch repair is a common repair technique for this challenge, involving the removal of physically deteriorated concrete, cleaning the steel reinforcement and replacing with a repair mortar. However, in many cases further corrosion is soon observed around concrete patch repairs. This phenomenon is usually known as incipient or ring anode formation.

ABOUT THE ACA

The ACA is a not-for-profit, membership association that aims to reduce the impacts of corrosion. Their international Corrosion and Prevention 2016 conference will be held in Auckland during 13–16 November 2016, bringing together researchers and practitioners who combat corrosion every day.

corrosion.com.au

The completed hybrid cathodic protection system in place