# Taking control

**Martin Davison** discusses why building surveyors should identify and treat corrosion in reinforced concrete structures at the earliest opportunity

Chloride (salt) induced or carbonation corrosion of reinforced concrete buildings costs billions of pounds in repair and maintenance worldwide to keep the structures safe and functional.

From commercial office blocks and multi-storey car parks to large highway bridges and coastal infrastructure, these corrosion agents attack to the point where demolition and loss of the structure can be an unfortunate reality. Even before this, progressive degradation of a structure can result in loss of income and seriously affect the asset value. Also, if parts of the building become unsafe, health and safety issues can produce unwanted bad publicity and thereby create the potential for a disgruntled tenant.

However, with timely intervention the corrosion can be brought under control by implementing cathodic protection techniques.

## Tell-tale signs

Generally, when steel corrodes it expands and exerts a tensile force resulting in delamination and spalling of the concrete cover, in effect an early warning that should be heeded.

One of the most common causes of steel reinforcement corrosion on multi-storey car parks is de-icing salts, picked up from the roads on car tyres during the cold winter months. Chlorides are deposited on the surface of the structure and find their way through the pores or defects (cracks) in the concrete cover to the steel.

The acidic agents destroy the naturally occurring protective passive layer on the reinforcing steel generated by the high alkalinity of the surrounding concrete material. This loss allows a corrosion cell to form (anode and cathode) on the steel. Once this happens, electrochemistry takes over and corrosion propagates. If left unchecked, complete loss of steel section will result.

Carbon dioxide (carbonation) is another acidic corrosion agent. Found naturally in the atmosphere, it reacts with water to form carbonic acid which neutralises the protective alkaline compounds in the concrete.

This is a slower process and generally less threatening to the integrity of the structure. Coupled with chloride contamination, it can exacerbate the attack by freeing up bound chlorides in the concrete – acting as a sort of lubricant in the process. With all the structural implications this creates, chloride corrosion should be viewed as a serious threat and a strategy for dealing with it when it occurs is imperative.

## Testing the structure

As soon as spalling has been noticed on a structure, testing should be considered to establish the causes. Concrete Preservation Technologies (CPT) has produced a guide for surveyors and engineers to demonstrate the importance of obtaining meaningful reports and evaluations when assessing structures for effects of steel reinforcing corrosion to ensure that the appropriate remediation option is applied.

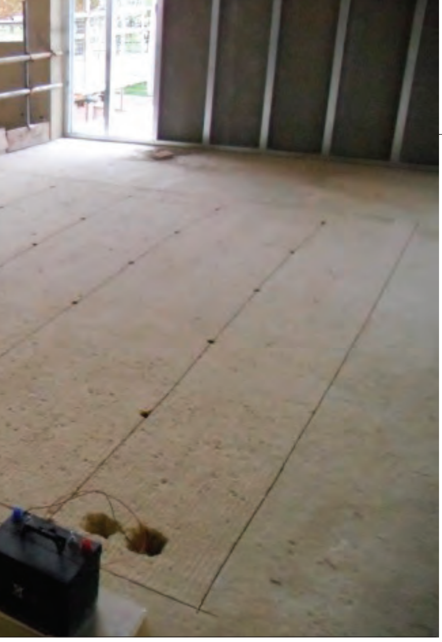
Half cell potential testing, which measures the potential difference in steel by replicating two halves of a battery, is one of the common tests used by CPT when undertaking surveys. One half is the measuring electrode cell and the other is the steel – the concrete material acting as the electrolyte. The electrode is moved along the surface and measured at given intervals so that a map is formed of the differing potentials in the steel. A more negative reading (using conventional testing procedure) would be indicative of local corrosion activity.

Corroding steel in concrete

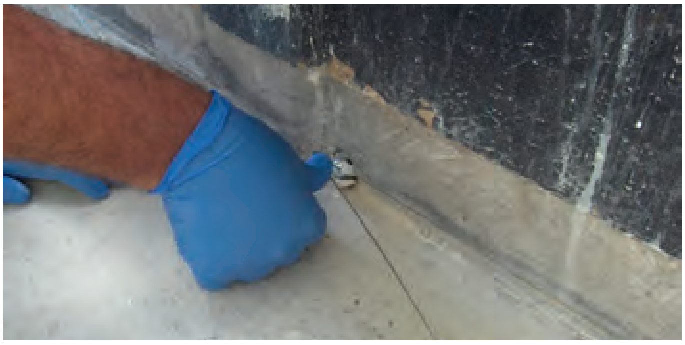
At the same time, samples of concrete can be taken and tested at the laboratory to corroborate the findings of the half cell analysis. Further tests for carbonation can include spraying recently broken out concrete with phenolphthalein indicator and noting the changes in colouration.

Armed with the test results, the corrosion engineer can make an objective assessment of the structure and formulate the most efficient and cost effective mitigation treatment by targeting the areas where protection is needed most.

It is important not only to consider any refurbishment works that will be required but also that whole life care costs are accounted for. This is where the installation of a cathodic protection system can be advantageous in protecting the integrity of the structure.



DuoGuard (hybrid) anode installation



## Cathodic protection

If patch repairs are planned, you will need to protect against further corrosion from the incipient anode effect. This effect is caused by the concrete repair process itself where the high alkalinity material negates the previous positive effect of the corroding steel on the surrounding area.

The area around the patch is typically still surrounded by residual chloride ions and becomes an anode. This causes corrosion of the steel and eventual delamination of the concrete cover material.

By placing sacrificial anodes such as CPT's PatchGuard around the perimeter of the patch repair a protective current is created to counter the incipient anode effect. This anode corrodes in preference to the steel while hydroxides are produced that help to maintain the protective alkaline environment around the steel. This electrochemistry will protect the structure from further corrosion for up to 20 years.

PatchGuard anode being installed at the edge of the patch repair area

Concrete deterioration caused the collapse of Pipers Row carpark

One of the advantages of sacrificial anodes is that they require no power source, acting like a battery with surrounding concrete material as the electrolyte. They are also responsive; they only deliver current when environmental conditions change or when further corrosion agents are introduced. Submerged into the concrete material, they can be a 'fit and forget' solution, although they can easily be monitored if required.

Located into the parent concrete, a PatchGuard installation offers a large sphere of influence over the reinforcing steel giving effective protection to the structure. Bonding primers and high resistivity repair mortars can also be used without any deleterious effect on the performance of the anode.

If a longer term treatment is required then an external power source can help to deliver more charge to the steel. This is referred to as impressed current cathodic protection.

CPT uses a hybrid (two-stage) sacrificial anode called DuoGuard, which is installed into the contaminated areas of concrete and connected in groups to a power supply. Just a couple of connections are required for a circuit of up to 200 anodes. In the first phase, an initial charge of 50kC is delivered using a temporary power source, which produces alkaline hydroxides at the steel helping to reinstate the all important protective passive layer.

The hybrid anode then reverts to the galvanic mode (sacrificial anode), which can protect the steel for up to 50 years. Being totally responsive to the local environment around the steel, no expensive control systems are required to operate the system. The anodes act like individual mini batteries, which are self-contained and only produce current when required thus conserving the anode material.

Both the PatchGuard and DuoGuard anodes have been installed on structures in 11 countries around the world. In the UK, clients have included Shell UK, Network Rail, ING Real Estate, Legal & General, Willmot Dixon, Hammerson and the Highways Agency.

## More information
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Concrete Preservation Technologies offers a free fully registered CPD presentation for corrosion prevention. For a free surveyors guide, visit *www.cp-tech.co.uk*

*Hybrid corrosion protection of chloride-contaminated concrete http://bit.ly/1ty8dfi*

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