Technical Advice Note 12

Electrochemical Solutions

INTRODUCTION

Corrosion of steel reinforcement is both an electrical and a chemical process (see Technical Note 4 The corrosion of Steel in Concrete). When the alkalinity of the concrete is reduced by neutralising atmospheric carbon dioxide or if passivity is reduced and chloride ions are able to reach the steel reinforcement, corrosion of the steel occurs.

The corrosion process involves negatively charged areas of steel (anodes) being formed while the remaining positively charged areas of steel (cathodes) remain free from corrosion. By polorising the steel in a negative (cathodic) direction the flow of ions between the two points can be reversed and the same chemical reaction that encourages the corrosion to occur can be used to stop further degradation.

Steel corrosion to rebar in concrete pier

RE-ALKALISATION OF CONCRETE

Used for carbonated concrete. This is a treatment which restores the alkalinity of the carbonated concrete and restores the passivity around the steel reinforcement. A temporary electric field is created between the embedded steel reinforcement and a steel mesh which sits in a tank or bath or a sprayed coating onto the surface concrete. The electrolyte is usually a sodium carbonate or potassium carbonate. This wet anode on the surface containing the sodium or potassium carbonate penetrates the concrete under electro-osmotic pressure, re-alkalizing from the surface inwards, whilst the hydroxyl ions at the cathode re-alkalise the concrete from the reinforcement outwards.

CHLORIDE EXTRACTION

Chloride extraction or desalination also uses a temporary electric field between the steel reinforcement and a mesh or sprayed surface anode. When the low voltage is applied the negatively charged chloride ions are repelled by the steel cathode to the anode positioned in the tank or bath, which is attached to the surface mesh or sprayed coating, it is then dissolved by the circulation of the electrolyte. The electrolyte is usually calcium hydroxide. An additional electrochemical reaction occurs at the steel creating hydroxyl ions which alkalises the concrete around the rebar.

CATHODIC PROTECTION

Cathodic protection has been used for well over 100years and is used extensively in the marine industry on the hulls of naval vessels and steel marine structures. It works by preventing the anodic reaction of the metal. And can be achieved by either

- Sacrificial (or Galvanic) anode cathodic protection (SACP)
- Impressed current cathodic protection (ICCP)

They both use the same electrochemical reaction but the Impressed current system uses a power source (direct Current DC) and inert anodes, whilst the Sacrificial system uses the naturally occurring potential difference between the different metallic elements.

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There are four main methods for fitting the cathodic protection and these are discrete anodes, titanium mesh or strips, conductive cementitious overlay and a specialist conductive paint coating.

SACRIFICIAL ANODES, GALVANIC SYSTEMS

These systems allow the targeting of specific areas for protection. Areas that are to be repaired using traditional concrete repair techniques can be protected by installing sacrificial anodes direct to the exposed steel rebar around the perimeter of the defective area as shown or they can be fixed onto the surface providing they can still be connected to the steel. Galvanic jackets of zinc mesh or pre manufactured strips can also be used to fit around concrete columns.

Where larger areas are identified as needing protection such as areas where there are no repairs required but the area is chloride contaminated, anodes can be fitted in a grid series of up to ten cylindrical anodes wired together and linked to the reinforcement at each end by a weld or rivet. The exact spacing is dependent on the steel density within the structure and should be designed by a suitably qualified Corrosion Engineer.

TEMPORARY AND PERMANENT IMPRESSED CURRENT INSTALLATION

These systems use a small power supply sending a small electric pulse current (10-20 mAm^2) between the steel rebar and the newly fitted anodes. Reference anodes are also fitted and connected to a computer monitoring system.

Temporary systems use a battery or mains supply with a an agreed switch off time. Permanent systems are hard wired to the mains and also to the computer monitoring systems. These systems need to be fully designed by a Corrosion Engineer and monitored throughout their lifespan. The cost of these systems can vary greatly depending on the complexity of the anode pattern, shape of the structure and monitoring system required.