The economic Alternative

Cathodic corrosion protection as a preservation as well as preventive corrosion protection method is used in a wide field of civil engineering.

The imagination of maintenance-free building material does no longer correspond with the experience of the last centuries. Concrete is exposed to several external factors that lead to disintegration of material. Construction errors, for example a not sufficiently dense concrete cover, result in an enormous maintenance and repair work. It especially concerns transport facilities like bridges or parking garages, which are eminently exposed to chloride pollution.

The positive economic aspects of cathodic corrosion protection become apparent when the damages at the reinforcement and concrete are not too severe and the building elements are in a good structural order.

Proven Performance

Different repair and rehabilitation measures such as patching, sealers, inhibitors or membranes have only partially proven themselves. However, with constant patching the maintenance of constructions is neither useful nor cost-effective. The only possibility to stop the long-term advance of corrosion is the installation of a cathodic corrosion protection system.

The Method

The idea of using cathodic corrosion protection for the rehabilitation of steel reinforced concrete constructions was established in the mid-1970s in the USA. Background for this decision has been enormous damages on the concrete surfaces at the bridges of the Interstate Highway Systems. Conventional rehabilitation techniques had all failed. In Europe it has been Great Britain which did the first attempts with cathodic protection systems at reinforced concrete constructions. V&C has been carrying out cathodic corrosion protection at concrete structures since 1996 and is pioneer in the Central European region.

Cathodic corrosion protection as an active protection method attacks - in contrast to other systems - the problem at its roots. The success of the method rests on the connection between the potential of steel and the corrosion rate. The potential of the reinforcement is brought to a stable passive state through installation of a negative protective current. Through the formation of hydroxide ions on the reinforcement the protective passive layer is restored.
Loss of Durability

Why does the durability of bridges, multi-level car parks, supporting walls, tunnels, trash burning facilities and sea water structures decrease? Can the concrete protect the rebar?

The main problem in Central Europe is de-icing salt on the streets. These salts contain chlorides which penetrate into the constructions and destroy the protective layer of the rebar - the consequence: corrosion.

But also aggressive substances precipitated by the exhaust of burning facilities or even chloride containing groundwater are further sources of corrosion.

These factors together with a too thin concrete cover and too low density as well as changing weather conditions and humidity lead to an increased risk of corrosion.

Corrosion of the rebar reduces the steel cross-section and as a consequence the support safety. Furthermore it causes cracks due to the increased volume of the rust.
The Principle of Corrosion and Cathodic Corrosion Protection

The reinforcement in the concrete is protected against corrosion by a very thin protective film as long as the concrete remains chloride free and the alkalinity is sufficient (pH > 12). This protective film can be destroyed by chloride containing gravel or sand, concrete additives or the penetration of de-icing salt that forces its way through pores and cracks in the concrete until it exceeds a critical concentration.

The focus of corrosion is the anode - the still passive steel - the cathode. A corrosion current flows. The metal loss represents the anodic reaction, the oxygen reaction the cathodic reaction (see fig. 2).

The electrolyte is given through the reinforcement as well as the pore solution in concrete.

Very often carbonation is responsible for the starting of corrosion. CO₂ reduces the alkalinity of the concrete which is the basis for the passive layer. Furthermore the density of the concrete decreases.

Cathodic corrosion protection intervenes into the electrochemical corrosion process. Through application of an anode system on the concrete surface a protective current is opposed to the corrosion current. This protective current polarises the reinforcing steel in a way that the steel cannot corrode anymore.

The reinforcement which is bared in places is connected to the minus pole and the anode to the plus pole of a rectifier which serves as current source. The reinforcement is polarised through electron flow in a way that it is re-passivated.
Anode Systems

Depending on the case of application there are different kinds of anode systems that can be deployed. A very cost-effective solution is a conductive coating which reaches - relative to the required protective current - a life-time of up to 20 years. However, titanium anode meshes or titanium anode ribbon meshes guarantee a life-time of at least 40 years.

Conductive Coating

The method of conductive coating has been used since the 1980s in the USA and Great Britain. It is especially recommended in cases where an increase of weight is - due to statical reasons - not possible, concrete is showing only marginal damages and the building elements which should be protected are consisting of smaller centers of corrosion.

![Fig. 4: System design conductive coating](image)

Most of the conductive coatings are produced water- or polymer-based. The production of the conductive filler is based on acrylic resin in which fibres with high conductivity are placed or on carbon or graphite basis.

To reach an optimum effectiveness of the cathodic corrosion protection system the right preparation of the background is essential. It has to be ensured that the surface is clean, dry and prune of loose concrete.

The contact for the current flow is carried out by a copper- or titanium wire and alternatively ribbons that are placed in the coating. It is called primary anode. The conductive coating is applied in two easy work steps by rolling, brushing or spraying. A strength of coating of about 0,5 to 10 mm is generally enough.

A conductive coating can generally cover a protective current of about 20 mA/m² concrete surface. It has to have a low electrical resistance and ensure a homogeneous current flow.

Following past experience the life-time of this system is about 20 years. However, in the case of local defects the conductive coating can be renewed subsequently.

Titanium Anode Mesh

Cathodic corrosion protection with activated titanium mesh is the most commonly used system worldwide. It is mainly designed for the protection of existing buildings and can be adjusted to any structure.

The anode material consists of activated titanium in the form of a mesh which is embedded in shotcrete. The consumption of the anode material and the durability of the embedding material determine the life-time of the system. In practice a lifetime of up to more than 40 years can be assumed.

By sand and high pressure water blasting loose and deteriorated concrete is removed in order to ensure a good bond between the concrete surface and the anode mesh. The anode material is
Titanium Anode Ribbon Mesh

Titanium anode ribbon mesh is primarily used for preventive cathodic protection at new buildings or in cases where due to statical reasons an increase in weight of the building is not allowed.

In the case of rehabilitation or repair the anode ribbons are installed similar to the anode mesh directly on the concrete surface. In the case of preventive corrosion protection the anode ribbons are fixed to the reinforcement by keeping a certain distance from it by plastic bar clips.

The optimum distance between the neighbouring anode ribbons is determined by the reinforcement density and by the desired current distribution. Generally the anode ribbons are installed in intervals of 20 to 40 cm.

Irrespective of the anode system, before, during and after commissioning control measurements and tests from the EN-Norm 12696-1 prewritten protection criteria provide optimal operation.
Advantages that convince

Instead of carrying out repetitive repair and maintenance work on the construction a cathodic protection system offers durable protection of the whole building. The list of advantages is long:

- Chloride-contaminated concrete must not be removed.
- Further chloride exposures do not cause any further corrosion damages.
- The corrosion process is stopped.
- Cathodic corrosion protection allows rehabilitation while the building is in full operation and reduces down-times to a minimum.
- Traffic is hardly influenced (no jams, no diversions, etc.).

The V&C-CCP-Controller

For the control and monitoring of the effectiveness of a cathodic corrosion protection system the V&C-CCP-Controller is used.

Due to the experiences and findings about developments on the field of cathodic corrosion protection of steel reinforced concrete structures V&C has developed a special control system for the protection of reinforced concrete constructions. The V&C-CCP-Controller delivers not only the required protective current but is also responsible for a current and voltage constant operation, automatically measuring routines, regular data recording as well as remote control and wireless data transmission.

The V&C Service Package

- Inspection of Building Structures in cooperation with Concrete Specialists
- Evaluation of the CCP-System

The status of the building and the effectiveness of the CCP-system is permanently monitored.
- Corrective interventions in the system can be done at any time.
- No necessity for rehabilitation over the next 30 to 40 years.
- The required current to operate a CCP-system is an insignificant factor. The power of a light bulb (100 Watt) can protect about 5,000 m² cathodically.
Data Recording and Remote Control of a CCP-Plant

Provider of Protective Current

In each V&C-CCP-Controller an individual amount of voltage modules can be integrated. The voltage modules deliver the required protective current. The modules are mounted in a control cabinet in 19" modular system and are connected to the control module.

Current and voltage constant operation

The control module is responsible for the control of the plant. Each voltage module can be individually operated current or voltage constant. Depending on the mode of operation a current or voltage limitation can additionally be adjusted in order to guarantee safeness in the case of an error.

Automatic Measuring Routine for the Control of Effectiveness of the CCP-System

The control module runs periodically measuring routines. Depending on the adjustment an automatic depolarisation of 4 or 24 hours is executed in a 1 to 8 week cycle. The measuring results are saved and shown in a control chart at the end of the measuring routine. In this way the plant can be easily checked for proper operation.

Data Recording

The control module also controls the whole measuring data recording. The current, voltage and potential data are recorded and saved in a database. The measuring data are even kept in the case of power breakdown.

For registration of the measuring data a recording rate of up to 100 ms in a daily rhythm can be ad-
justed. The collection of the first measuring data after leading-in an automatic depolarisation can also be adjusted accurate to 100 ms.

**Remote Control and Data Transmission**

Due to an user-friendly software the measuring data are transmitted via modem or GSM network and can be easily evaluated in the office. Furthermore eventual readjustments can be done from any place.
Lückenlose Kontrolle und Überwachung


V&C verfügt außerdem über einen bestens geschulten und langjährig erfahrenen Mitarbeiterstamm an Messtechnikern, welcher vor Ort
Contact:

V&C Kathodischer Korrosionsschutz Ges.m.b.H.
Josef Perger-Str. 2/A-05
A-3031 Pressbaum

Phone: +43 (0)2233 57 771
Fax: +43 (0)2233 57 771 -15

office.engineering@vc-austria.com
www.vc-austria.com