C - 17: Concrete Corrosion & Cathodic Protection

Today, the serious and costly problem of spalling and deterioration in reinforced concrete structures, such as bridge decks, highways and parking garages, is due largely to the corrosion of the embedded steel bars in the concrete.

Corrosion is an electrolytic process. For corrosion to occur there needs to be a corrosion cell with an anode, a cathode, an electrical path connecting the anode and cathode, and an electrolyte. A section of reinforced concrete may have many corrosion cells within it.

In a typical concrete corrosion cell, the migration of chloride ions from deicing salts, marine salt water or chloride-based accelerators to an embedded steel bar creates anodic and cathodic areas on the bar. Initially the embedded steel bar is protected by a passive iron oxide layer over the bar due to the high concrete alkalinity.

Eventually chloride ions break down the passive layer over the steel bar by lowering the concrete alkalinity. An electrical path is created over the steel bar, and the concrete becomes an electrolyte. Oxygen and moisture must also be present for corrosion of the steel bar to occur. The anodic area of the steel bar in the concrete section discharges electrical current to the cathodic area. The problem is that the current leaving the steel at the anodic area carries corroded steel particles with it. The iron oxide formed on the corroded steel bar occupies a much greater volume than the original volume of the bar and, because of this, disruptive forces occur in the concrete surrounding the steel bar causing eventual concrete spalling and disintegration.

Cathodic protection is an electro-chemical process, which in simplest terms, reverses the natural corrosion process.

In a cathodic protection system, an external DC power source or rectifier is connected to the cathode or the embedded steel bar in the concrete, and to an external anode. External anodes can be coatings and are made of materials such as platinum or magnesium; however, platinum will last much longer.

Electrical current normally flows from the anode to the cathode and returns through the DC power source. Protection in concrete is achieved when a hydrogen layer is formed on the surface of the cathode or the embedded steel bar in this case. Electrical current cannot leave the cathode, so the external anode is sacrificed protecting the cathode or the embedded steel bar in the concrete from corroding. When the external anode is depleted it must be replaced with a new one.

Cathodic protection can stop or prevent corrosion but it cannot replace the steel or the structural integrity in concrete; therefore, the process should be applied as soon as possible to restrict the effects of corrosion on reinforced concrete. Cathodic protection is not recommended for post-tensioned or prestressed concrete since it has been found that the reinforcing steel bond strength is reduced due to hydrogen embrittlement at the steel surface.

The cathodic protection system is effective, but is not widely accepted since it is expensive to install and maintain. One must be selective when it is used; therefore, potential applications must be analyzed completely beforehand, including the overall cost of the system.

There are corrosion inhibiting chemical admixtures available that can be placed in fresh concrete and applied to in-place concrete that have been proven to prevent corrosion and also stop further corrosion once it has begun. For more information on corrosion inhibiting admixtures visit www.aximconcrete.com.