CORROSION OF STEEL IN REINFORCED CONCRETE

Reinforced concrete is widely used around the world. Steel bars are used to strengthen a material that would otherwise be brittle. Corrosion of steel bars can reduce a structures mean time before failure. An adequate corrosion control method must be applied for the steel in concrete.[1]

The principal cause of steel corrosion is the presence of chlorides during the preparation of the concrete. In several places close to shore, even sea sand is used as an aggregate. Some chemical admixtures, as accelerators, can contain high percentage of chlorides. De-icing salts used during winter time can introduce chlorides to the reinforced steel. The corrosion process caused by chlorides in steel is shown below in figure 1.

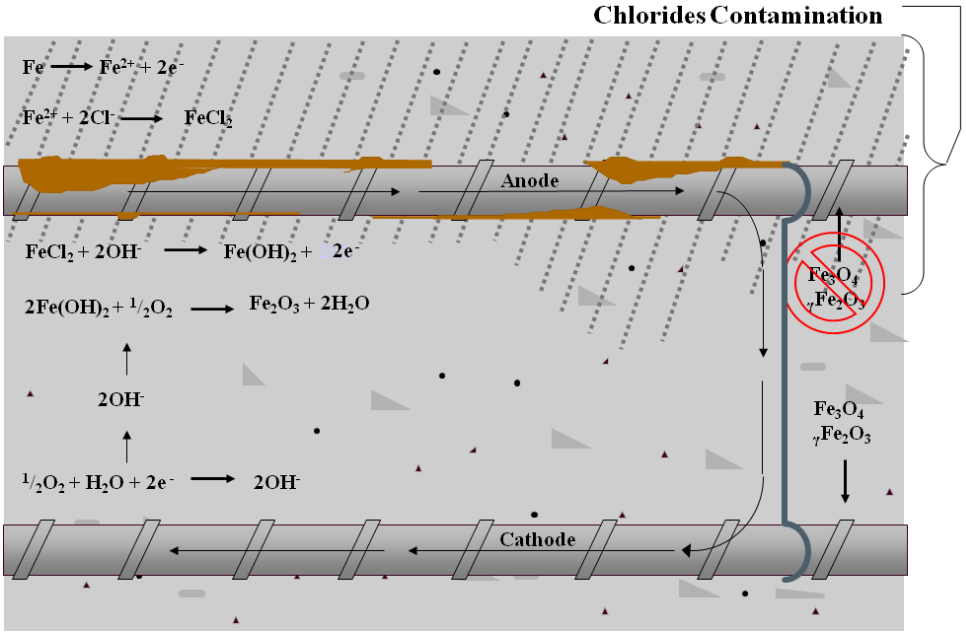

Figure 1. Chlorides Reinforced Steel Corrosion[2]

[1] http://en.wikipedia.org/wiki/Reinforced_concrete
[2] Vector-Corrosion Conference

As well as the chlorides the carbonation is a cause for the corrosion of the steel bars. The carbonation reduces the alkalinity of the concrete. Carbonation is a reaction of atmospheric carbon dioxide with calcium hydroxide (in the cement paste). As it is shown on Equation 1, the result of carbonation is a reversion of the calcium hydroxide to calcium carbonate (limestone) which has insufficient alkalinity to support the passive oxide layer. The amount of time for the carbonated zone to reach the level of the reinforcing is a function of the amount of concrete cover, concrete porosity, humidity levels, and the level of exposure to carbon dioxide gas[3].

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$ [4]

Equation 1. Carbonation Reaction

As we can see there are two main causes of corrosion of reinforcing steel in concrete (chlorines and carbonation). Chlorides contamination must be minimized or avoided during fabrication and operation of reinforced concrete structures. An adequate concrete cover must be installed over the reinforcing in order to reduce the carbonation risk. Finally, adequate corrosion control methods must be applied to protect the steel. Some of those are shown below:

1. Use of epoxy-coated, hot dip galvanized or stainless steel rebar.
2. Cathodic Protection.
3. Corrosion Passivation.[5]
4. Inhibitors.

[3] http://www.vector-corrosion.com/corr_basics.html. **Corrosion Basics: Understanding the Different Types of Corrosion that Affect Concrete.**
[4] http://en.wikipedia.org/wiki/Carbonatation.
[5] http://www.vector-corrosion.com/pdf/SEC_0003/COR_0002.PDF.

CATHODIC PROTECTION FOR STEEL IN REINFORCED CONCRETE

Corrosion causes damages to several structures around the word. Corrosion seriously affects the steel in reinforced concrete. Cathodic protection is a solution for preventing and controlling corrosion in reinforced steel concrete structures. Cathodic protection must be used in reinforced concrete structures in order to assure a significant mean time before failure.

Cement aggregates with a minimum content of contaminants such as chlorides can introduce leading conditions to corrosion. “Once corrosion is initiated, it is only a matter of time before the expansive pressures from steel oxidation causes concrete cracking, spalling and delaminations. If the on-going corrosion activity is not addressed, section loss of the reinforcing will occur and significant structure repair or replacement may eventually be required”6. Adequate cathodic protection is able either to control corrosion activity or reduce the corrosion rate even with the presence of contaminants in the concrete. The use of cathodic protection can increase the service life of new and rehabilitated structures.

Although there are several methods of corrosion control of steel in reinforced concrete, cathodic protection provides the highest level of protection7. For structures built close to shore, because of the marine environment, cathodic protection must be a construction requirement. Concrete structures reparations can introduce potential differences between the new concrete and the surrounding contaminated concrete. This difference in corrosion potential (voltage) is the driving force for new corrosion sites8. Cathodic protection is also an alternative for controlling corrosion in rehabilitated structures.

[6] http://www.vector-corrosion.com/corr_basics.html
[7] http://www.vector-corrosion.com/corr_mgmt.html
[8] http://www.vector-corrosion.com/corr_basics.html

As we can see corrosion is a critical problem that can affect the service life of reinforced concrete structures. The best solution for controling corrosion in reinforced concrete structures is cathodic protection. Contractors must evaluate the cost benefits and impacts of including cathodic protection systems in new structures. In conclusion, cathodic protection is an effective and adequate method to control corrosion of reinforced steel and extend the service life of structures.

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