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Construction Concern: Corrosion
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Corrosion of a metal can be defined as its degrading from a reaction with its environment. This degradation can cause weakening of the metal by reducing its cross section, by changing its crystalline structure, or by a gradual chemical reaction converting the metal to a compound with less strength.

Environmental concerns include the presence of oxygen, moisture (water), contact with dissimilar metals, and chemicals.

The National Aeronautics and Space Administration (NASA) suggests that most corrosion is electrochemical, taking place at the atomic and molecular level; and estimates that 90 percent of corrosion is caused by oxidation. Most of the remaining corrosion is galvanic, taking place between two dissimilar metals in contact with each other in the presence of an electrolyte, which forms a weak battery; a topic for another time.

(1)

One of the most common and most destructive electrochemical oxidation reactions is one that occurs between iron or steel and oxygen, commonly called “rust.” In a simplified description of this reaction, iron atoms lose electrons, becoming positively charged iron ions. Oxygen atoms gain the electrons, becoming negatively charged oxygen ions; which combination forms iron oxide. Iron oxide has different chemical and physical properties than pure iron, including a great reduction of tensile and compressive strength. This process occurs most quickly in the presence of moisture with dissolved oxygen. Photo 1 shows the remains of the reinforcing steel (rebar) in a structural concrete slab that was corroded from years of rainwater and salty snow-melt finding its way through the cracks and fissures in the concrete, until the pressure exerted by the increased volume of the iron oxide (compared to the volume of the original steel) spalled a large area of the under-side of the concrete.

(2)

Photo 2 shows part of the steel frame of a truck that has been severely corroded and weakened by years of exposure to weather and salty snow-melt. This steel has been so weakened by corrosion that it is no longer structurally sound and needs to be replaced.

In piping systems, the most destructive oxidation in iron or steel is the localized one resulting in pits (thin spots in the steel) and deposits of iron oxide and other minerals above them which maintain a localized environment that is especially conducive to corrosion, and which can obstruct flow of fluids through pipes.

(3)

Widespread or general corrosion on the surface of a metal changes its appearance but does not affect its strength. Photo 3 shows rebar stirrups with surface rust, which will become part of the rebar assembly inside reinforced concrete columns. In this instance, this mild corrosion lifts any remaining oil from the steel mill from the surface of the rebar and roughens it slightly to provide a better bond for the concrete.

In some cases, like the formation of copper oxides and aluminum oxides on the surfaces of these metals, oxidation forms a film that prevents further oxidation by preventing contact with oxygen.

(4)

In other cases, general corrosion and further degradation of the metal are combated by applying coatings to the metal, to isolate the metal from the oxygen in the air, moisture, and soil. Photo 4 shows rebar stirrups that have been coated with an epoxy compound for this purpose. Photo 5 shows epoxy-coated rebar that has been assembled to join a column with a structural concrete deck that will be exposed to the weather. This epoxy-coated rebar is often used today in bridges, underground structures with high water tables, and anywhere that the completed structure needs a long life expectancy and will be exposed to the extremes of weather.

(5)

(6)

The lead-based, chromate-based, and polymer film-forming primers and paints (Photo 6) used on structural steel and bridges are examples of these coatings on structural steel.

Combining a metal with a less reactive metal can result in an alloy that does not oxidize as easily as the original metal. The addition of copper, nickel, chromium, and other metals to steel to form stainless steel of different grades is an example of this. Another example is the patented formula for alloy structural steel which forms an oxide coating on the surface that protects the rest of the steel structure.

Plating one metal with another can also prevent the oxidation reaction, as in the plating of steel with chromium in exposed components like automobile bumpers and hardware.

(7)

Coating one metal with another that is more reactive in oxidation can protect the base metal from corrosion, as in coating steel with zinc, which sacrifices the zinc by corrosion rather than the steel. Photo 7 shows galvanized (zinc-coated) steel electrical conduit in a wall framed with galvanized steel studs. This is the same principle used in galvanizing (zinc-coating) steel pipes and ducts; in the "sacrificial anodes" that are used in water heaters to protect the heating elements and the tank; and the "sacrificial anodes" that are used with protective coatings to prevent corrosion of steel gas and oil pipelines from soil contact.

Uncontrolled corrosion in a building and its systems can lead to early failure of pipe and duct systems, as well as to structural collapse when the corrosion sufficiently weakens the structural steel. These potential failures may not be noticeable under normal conditions, until an abnormal even like a fire, tornado, or earthquake add stress to these already stressed systems.

For more information on the electrochemical and galvanic reactions involved in corrosion, search the Internet for

- Corrosion
- Corrosion types
- Galvanic corrosion
- Corrosion prevention
- Corrosion protection

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