INTERVENTIONS FOR CORRODED EXPOSED ARCHITECTURAL STEEL

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Introduction

Corrosion of exposed architectural steel features is a common and potentially costly problem for historic buildings. If no intervention is made, corroded steel continues to degrade, causing numerous problems, such as the disappearance of detail and craft, and structural deficiencies in the element. In addition, corrosion can cause damage to adjacent materials, through steel expansion forces as it oxidizes, or superficial staining. Pursuing an unsuitable intervention has the potential for severe consequences to the physical and historic integrity of the steel component. This poster covers methods of repairing, replacing, and maintaining exposed steel, and is intended as a quick reference to begin the selection of a treatment for corroded exposed architectural steel.

Before considering any interventions, these questions should be answered:

- *What **type** of steel or alloy is it?*
- *What is the existing or **original finish**?*
- *What is the **cause** of the corrosion?*
- *What is desired **finish after the treatment**?*

Types of Steel

In order for an iron alloy to be considered steel, it must contain roughly between 0.02% to 2% carbon. Cast iron contains more carbon, and wrought iron contains little to no carbon. Steel is further broken down into various types depending on their chemical composition and properties. Some basic classifications of steel are structural steel, carbon steel, alloy steel, stainless steel, and weathering steel. The latter two are both specific types of steel alloys. Stainless steel contains chromium and nickel, which adds corrosion resistance. Weathering steel, commonly known as Corten or Cor-Ten, develops a tightly-adhered oxide coating when exposed to the weather. The rust-like outer layer provides protection for its inner layer. Both of these alloys are often left unfinished or uncoated due to their increased corrosion-resistance.

Steel Finishes

Steel finishes are chosen for protection against corrosion and/or for appearance. The original finish is especially important to consider when determining which treatment to use. Finishes can be textures such as grinding, polishing, sandblasting, hammering, electropolishing, or other effects. Coatings of other metals can also be adhered to the surface of steel through processes like electroplating, galvanizing, and dipping. However, one of the most widespread and common methods of finishing steel is the application of alkyd primers, water-based acrylic paints, and high-performance coatings.

Causes of Corrosion

The cause of corrosion can be determined by conducting a condition assessment of the element itself and the surrounding materials. Steel corrosion is a cyclical process of the metal breaking down and reverting to a state similar to its original mineral compound, the natural iron ore. Air and water are major factors in corrosion. Electrolytes (water plus salts) enable ions to travel to different metals, or to different locations on a single surface. This action causes hard steel to break down and flake off. The product of this reaction is the corrosion, which is a form of iron oxide. The color of the corrosion varies slightly due to different chemical compositions.

- **Environmental Corrosion** - The presence of oxygen and water alone facilitates corrosion, but when chemicals such as sulfur dioxide and magnesium chlorides appear on a surface, corrosion can occur even when the environment has a low relative humidity. In some cases, the larger environment surrounding the steel can cause corrosion. For example, steel in salt water or close to the ocean is especially susceptible to corrosion. Even careful detailing may not guarantee that steel will not corrode in that sort of environment. Acid rain or other chemicals, pollution, and high humidity levels are common culprits of environmental corrosion.
- **Galvanic Corrosion** - Electrochemical corrosion or electrolysis occurs if there is a difference in electric potential between two adjacent metals. This can be prevented by separating two incompatible metals. A common sign of galvanic action within a piece of steel is pitting, or small grooves on the surface.
- **Improper Detailing or Maintenance** - Poor detailing and maintenance of steel can cause premature deterioration.

Desired Finish After Treatment

Guiding questions to ask when determining an appropriate finish for existing steel:

Is the building undergoing rehabilitation, preservation, restoration, or reconstruction? What is the significance of this particular piece of steel to the building? Is it mainly valued for its structural or aesthetic qualities? How will its continued performance or continued deterioration affect the surrounding materials?

Interventions

Choosing an intervention is a delicate balance between protection, aesthetics, and historic design intent. The feasibility of treatments and their success will also depend on the physical condition of the existing element. An attempt should be made to consider the most appropriate intervention to achieve a historically appropriate finish.

Redesigning Details

Redesigning details to prevent further damage to materials can be an effective technique for the preservation of steel when a systemic problem has been identified in a building assembly. Decisions to redesign a detail should be based on the historical significance of the particular building and element, the severity of the damage, and the extent of the problem. As always, the impact of the repair on the historical significance of the building should be considered. One example of a systemic problem is the buildup of water or moisture on a piece of steel or neighboring materials. Another example is when incompatible metals are too close to steel, and galvanic action has taken place.

Partial Replacement

In building preservation, repair of exposed architectural steel elements should always be considered first, and replacement should be avoided. However, sometimes replacement of steel is necessary if it cannot be adequately repaired, and/or if leaving the steel feature in situ will cause damage to other building features, as in the case of excessive expansion or rust jacking.

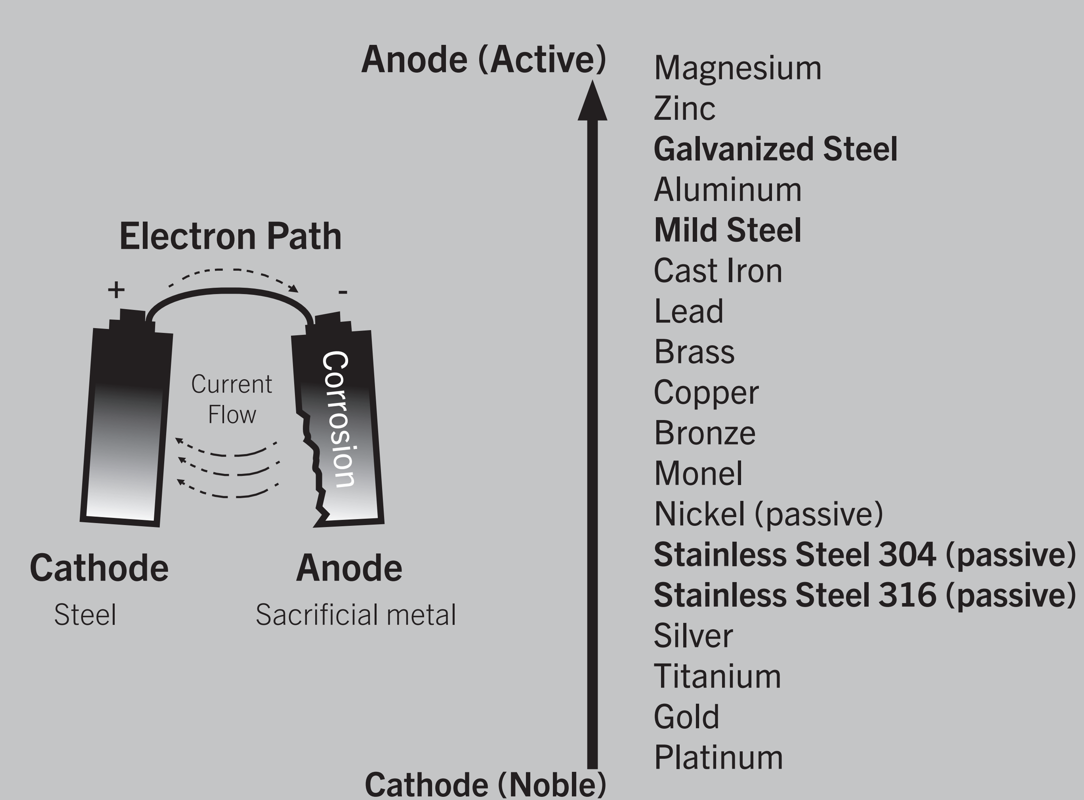
In certain cases, partial replacement of steel is possible. Methods of partial replacement are varied, and usually include cutting or grinding off pieces of the surface and welding a new piece in place. It is possible that a steel patch can be welded over an existing piece of steel, and compatible metal fasteners may also be used. However, partial replacement of steel is complicated due to the nature of the element. In most cases, steel is in a solid, continuous form. Partial replacement can create additional seams in steel features that were intended to be one piece. Therefore, the benefits of partial replacement of a feature must be weighed against full replacement to reduce the adverse effects to the building.

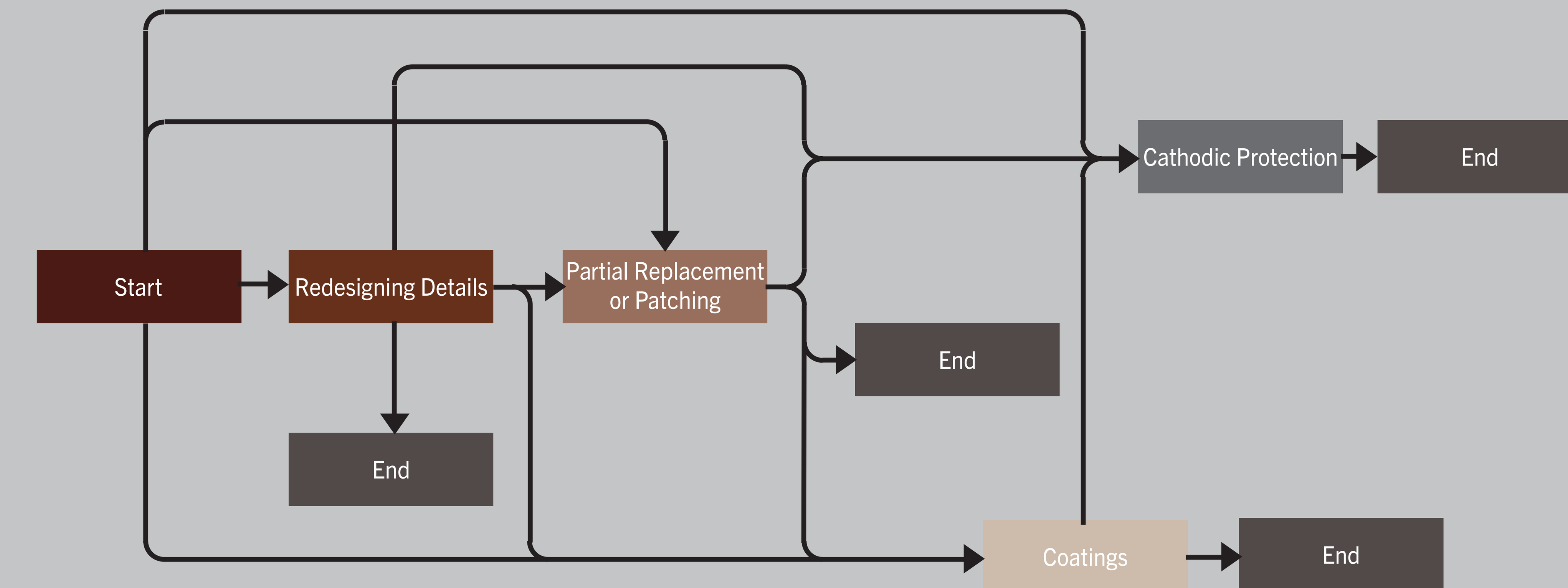
Cathodic Protection

Cathodic protection systems stifle the anodic process by causing electrons to build up on a steel surface, which forces it to act as a cathode. Although this cannot reverse corrosion, it helps prevent further degradation of the steel. Cathodic protection is challenging to incorporate into historic buildings, because limiting the adverse effects of the system often means redesigning elements to conceal it within walls. However, if feasible, it can facilitate in-place preservation of steel, when it might otherwise need to be replaced. There are two types of cathodic protection:

Sacrificial-Anode Cathodic Protection (SACP) – When a feature is protected by electrically connecting a less noble metal to it. Common sacrificial anodes used for steel are zinc, aluminum, magnesium, or alloys of these metals. The sacrificial metal must be close (usually within 30 ft) to the steel feature.

Impressed-Current Cathodic Protection (ICCP) – Involves a constant flow of electricity to the steel from an outside source. The opposite side of the circuit in the system must be of a less noble metal, which will corrode. These systems are stronger and can be used for larger pieces of steel. However, the systems often rely on conductive coating systems which are typically not appropriate for preservation of historic buildings.





Treatments are frequently used in combination with each other to make the most successful outcome. This graphic illustrates possible sequences.

Coatings

Before coatings are applied or reapplied, the surface must be adequately prepared to accept the new coating. This involves removing the existing rust and applying an adequate base coat, or primer. Sometimes grinding or other methods of achieving the proper surface texture is required.

Removal of Corrosion and Existing Coatings

Although it may seem straightforward, paint removal may be challenging in some instances. The application of lead-based oil paint was popular for modernist structures, and these paints were produced until 1978. When removing lead-based paint, it is necessary to take precautions. Dust caused by removal must be controlled in order to limit the amount of particles that make it into the air. The waste must also be handled with care and disposed of properly. The EPA's Steps to Lead Safe Renovation, Repair and Painting is a helpful resource for the proper actions that should be taken.

Another challenging condition is when rust gets into crevices at edges of materials or where materials join. Leaving corrosion in joints will cause improper adhesion of coatings, causing these areas to be left unprotected. Sometimes assemblies must be dismantled in order to properly address all surfaces of the steel.

Corrosion removal in and of itself is not considered an effective treatment for steel, because removing a layer of rust exposes a new surface of the steel which is then susceptible to corrosion. After removing rust, it is important to apply a new coating as soon as possible.

Corrosion Converter

As its name suggests, corrosion converters chemically change corrosion. Corrosion converters, such as Fertan, are based on tannin derivatives, phosphoric acid, and wetting agents. When these mixtures come into contact with iron oxides, or rust, they convert the brittle and powdery substance into strong ferric tannate. Since corrosion converter is activated by direct contact with corrosion, it may not be effective for certain surfaces that are hard to reach, such as joints between elements.

Corrosion converters are not suitable for every piece of steel because it changes the color and appearance of bare steel. The resulting insoluble complex organic compound turns surfaces a blueish-black color. Application of corrosion converter is most appropriate when the historic finish of the steel was painted or if the change in finish will not have an adverse effect on the building or individual feature. Some types of paints may be applied over corrosion converter, so the final finish may be any color.

The application of corrosion converters is especially effective in protecting steel in harsh environments such as places with volatile winter weather and places close to bodies of salt water.

Paint

When choosing a paint, consideration should be given to the type of environment in which the steel is, or will be located, the appearance of the paint (gloss level, color, etc.), the build of the paint, the application method and procedure, the life cycle cost, and the maintenance required. In many cases, the limitations of the site and position of the steel will dictate which types of paint can be used.

Paint analysis should be conducted to determine the makeup of the paint that was exposed during the desired time period for the treatment. It is important to consider what type of pigment was used, and recognize that the paint may have faded significantly due to sun exposure or dirt accumulation over time.

When any paint coating is selected, it is of vital importance that an appropriate primer is selected. The primer must be compatible with both the steel substrate and the paint selected for the top coat(s).

The paint build is the measure of the actual thickness of the paint, which adds depth to the exposed surfaces of the steel. Higher build paints may be more durable, but may not allow for touch-ups. On the other hand, low-build paints may not be as durable, and may require more coats of paint. Heavy-duty coatings are appropriate for conditions in which the paint will be subject to harsh conditions, such as areas with high average humidities, or areas subject to continuous changes in climate.

High-Performance Coatings

High-performance coatings are a relatively new product for coating steel. Types of high-performance coatings include fluoro-polymers, bitumastic coatings, epoxies, and polyurethane.

High-performance coatings are championed for providing excellent protection for steel, requiring minimal maintenance, and for being able to retain their pigments very well, without fading due to sun exposure.

However, the high upfront cost of these coatings is often a prohibitive factor for its use. The other potential challenges to using these coatings for historic buildings is the level of preparation required for them to adhere to steel that has corroded, and their high build. However, the life cycle cost is typically lower than other coatings, due to its durability. High-performance coatings can also offer enhanced protection against abrasion and chemical damage.

Conclusion

Regardless of which treatment is used, maintenance is vital to the successful protection of architectural exposed steel. As years go by, paint or other coating systems can fail, leaving areas of steel completely exposed to the elements. Many buildings with historic significance are subject to unnecessary damage due to lack of maintenance. If a building is properly cared for and maintained, large stabilization and preservation interventions can in many cases be avoided.

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