Corrosion Avoidance with New Wood Preservatives

By Samuel L. Zelinka and Douglas R. Rammer

Corrosion of galvanized bridge hardware in contact with alkaline copper quaternary (ACQ) after 3 years of service.

The increased use of Alkaline Copper Quaternary (ACQ) and Copper Azole (CuAz) as preservatives for wood used in residential construction has led to concerns about the corrosion performance of fasteners. Information on the effects of these preservatives on fastener corrosion rate is limited, although Simpson Strong Tie has published a technical bulletin indicating that both ACQ and CuAz are roughly twice as corrosive as Chromate Copper Arsenate (CCA) and recommends fastener types for a given environment and preservative (Simpson Strong Tie, 2005). It is believed that ACQ and CuAz are more corrosive than CCA due to the higher percentage of copper in these preservatives, and absence of chromium and arsenic; both are known as corrosion inhibitors. While accelerated tests exist for estimating the corrosiveness of new wood preservatives, currently there is no consensus on how to relate the results of these tests to in-service performance. For information about the effect of new wood preservatives on corrosion, and a critical review of test methods used to measure corrosion in wood, see Zelinka and Rammer (2005) (references available in the online version of this article, **www.STRUCTUREmag.org**).

This article focuses on considerations that need to be made when choosing products, other than stainless steel, to minimize corrosion of metals in contact with treated wood. With so many "corrosion-resistant" alternative products on the market, it is important to know the fundamental principles of corrosion protection to make informed decisions when designing structures.

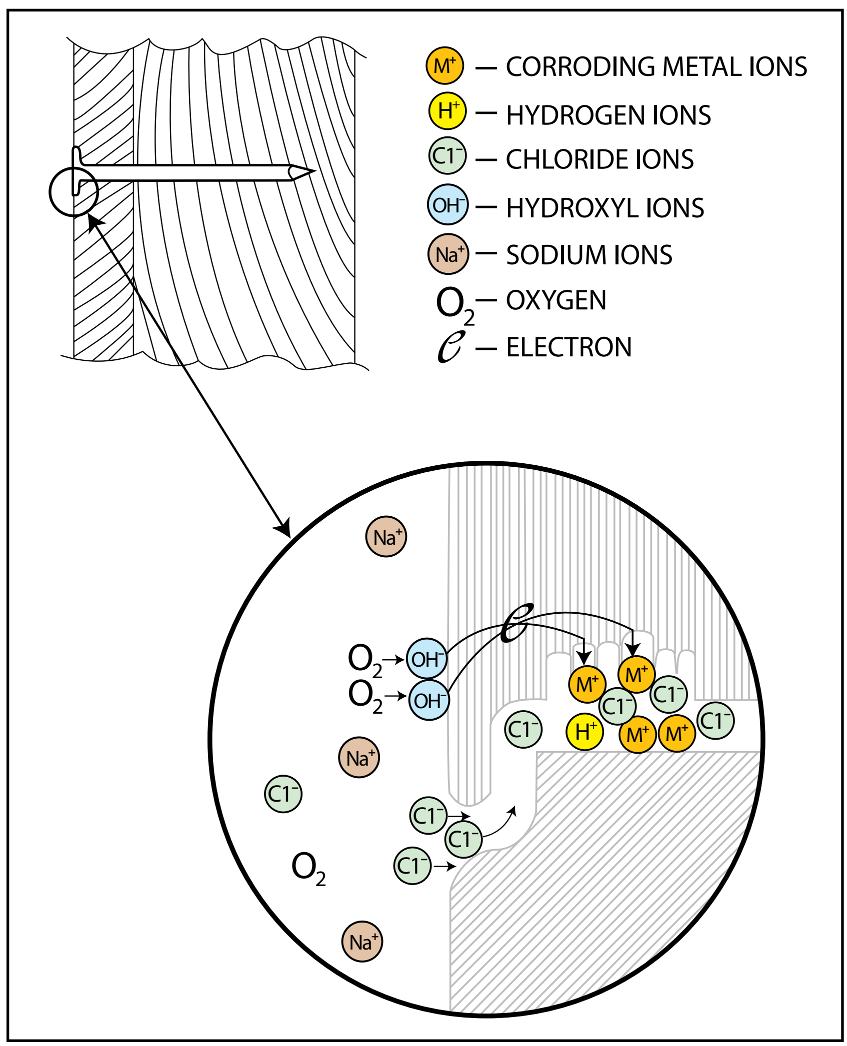
Protective Coatings

For steel fasteners, one of the most popular approaches is coating the fastener with either zinc galvanizing or a non-metallic coating. Although coatings are a cost effective way of increasing the corrosion resistance of fasteners in treated wood, caution is still needed when specifying their use. The overall corrosion performance of a coated fastener is dependent on properties and thickness of the coating, the size and quantity of defects in the coating, and the adhesion between the coating and fastener. Furthermore, coatings that perform well in certain environments perform poorly in other environments. For example, zinc coatings perform better than cadmium coatings in industrial environments, while the reverse is true in marine environments (Mooney 2003). It is imperative that fasteners be tested in treated wood so that test results are not erroneously applied.

Metallic/Galvanized Coatings

Metallic coatings, such as galvanizing (zinc plating), work by applying an envelope layer of metal that corrodes at a slower rate in a certain environment over the substrate metal that corrodes faster. It is important to stress that the lower corrosion rate of the coating gives it improved service life, which is independent of its ranking on the galvanic series for the specific environment.

Metallic coatings can be further sub-divided into two categories, depending on the relative positions on the galvanic series of the coating and the substrate metal. If the coating is more anodic on the galvanic series than the substrate, the coating will corrode to the benefit of the substrate; that is, the coating galvanically protects the substrate. The advantage of theseanodic coatings is that the substrate is protected from defects in the coating (such as pores and cracks) because of the galvanic protection.However, the anodic coating is only beneficial if the corrosion rate of the coating material is slower than that of the substrate. Common anodic coatings



Mechanism of crevice corrosion of fasteners in wood, originally proposed by A.J. Baker of the USDA Forest Products Laboratory (FPL) in 1978.

Typical electrochemical test set up for rapidly measuring corrosion rate. These methods are being developed at FPL for use on perservative treated wood.

for steel are zinc or cadmium. For galvanized coatings, the thickness is specified by several ASTM standards; fasteners are governed by ASTM A153, and sheet metal products by ASTM A653.

Cathodic (noble) coatings, on the other hand, solely act as a barrier between the substrate and the environment. In this respect, cathodic coatings are similar to ceramic or organic coatings because they are susceptible to pitting corrosion at defects in the coating. Common examples of cathodic coatings are chromium, nickel, and tin. Increasing the thickness of cathodic coatings should increase corrosion resistance because a thicker barrier results in a lower chance of coating defects reaching the substrate.

Ceramic/Organic Coatings

Ceramic and organic coatings try to completely isolate the substrate from the corrosive environment. The effectiveness of these coatings depends on their ability to provide and maintain a defect free, dry environment on the surface of the fastener after insertion in the wood member or metal connector. Organic coatings vary from common alkyd paints to epoxy resins to various rubbers, and all work based on the principle of isolation. This wide range of materials allows for a certain degree of optimization of the coating for its intended environment and purpose. Ceramic linings, while more porous than their organic counterparts, have a greater hardness, which is important as fasteners are inserted into the wood or connector. Any damage that occurs to the coating during insertion can give the corrosive environment a path to the substrate, and pitting or crevice corrosion will occur at these sites.

Barriers

Currently, there is at least one manufacturer who is marketing a barrier intended to go between treated wood and deck hangers to prevent corrosion. Similar to ceramic and organic coatings, barriers try to isolate the metal from the corrosive environment, and are only as effective as the number and type of defects they contain. Fasteners inserted through the barrier into the wood penetrate the barrier, and corrosion can occur in this area.

Dissimilar Metals

A condition that is sometimes overlooked is the combination of different metals; for example, using a stainless steel fastener to connect a hot-dip galvanized joist hanger to a deck. Galvanic corrosion occurs when dissimilar metals are placed in "electrical contact" in a corrosive environment, and the less noble metal corrodes at the expense of the more noble metal. Even if metals are protected by paint or another barrier, galvanic corrosion can still occur through defects in the barrier. The anodic (less noble) metal should never be coated since defects in the coating exacerbate the effect of galvanic corrosion by localizing it to a small surface area (Elliott 2003).

Conclusions

With the introduction of new wood preservatives, the concern for corrosion protection has increased. When considering alternatives to stainless steel for fasteners and connectors, the designer should understand the methods by which these alternatives work. Coatings inhibit corrosion by isolating the metal from corrosive conditions. For isolation to be successful, the barrier or coating must not be compromised, with the exception of metallic anodic coatings. Finally, combining dissimilar metals can increase the corrosion rate because of galvanic action. This information is summarized in *Table I*.▪

Samuel L. Zelinka is a Materials Engineer with the USDA Forest Products Laboratory in Madison, WI. Sam is currently working on developing electrochemical methods to evaluate the corrosion rate of fasteners in treated wood. He can be reached via e-mail at ***szelinka@fs.fed.us.***

Douglas R. Rammer is a Research Engineer with the USDA Forest Products Laboratory in Madison, WI. Doug's work focuses on issues dealing with the design criteria for wood structures, especially items related to fasteners. He can be reached via e-mail at ***drammer@fs.fed.us.***

Reprinted with permission by Wood Design Focus (Vol. 16, No. 2), Summer 2006

Product	Design Concern
Stainless Steel	Combining with a different metal
Metallic Coatings (anodic)	Combining with a different metal Corrosion rate of coating
Metallic Coatings (cathodic)	Combining with a different metal Defects in coating Construction damage to coatings
Organic/Ceramic Coatings	Defects in coating Construction damage to coatings
Barriers	Defects in barrier Damage to barrier during construction

Table I: Products available for use with treated wood, and possible design concerns

References

Elliott, P. Designing to Minimize Corrosion. A*SM Handbook Volume 13A Corrosion: Fundamentals, Testing, and Protection*. Materials Park, OH. ASM International

Mooney, T. 2003. Electroplated Coatings. *ASM Handbook Volume 13A Corrosion: Fundamentals, Testing, and Protection*. Materials Park, OH. ASM International

Simpson Strong Tie. 2006. Corrosion Fact Sheet. *Simpson Strong Tie Technical Bulletin T-PTWOOD06*. Available electronically at **http://www.strongtie.com/ftp/bulletins/T-PTWOOD06.pdf**

Zelinka, S., Rammer, D. 2005. Review of Test Methods Used to Determine the Corrosion Rate of Metals in Contact With Treated Wood. Gen. Tech. Rep. FPL-156. Madison, WI: U.S.D.A. Forest Service, Forest Products Laboratory.