Fire Towers, Lumber, and Corrosion - Should We Be Concerned?

Ed Engelman, December 3, 2020
engelman.ed@gmail.com

Pieces of the 100-year-old cross braces from the St. Regis Fire Tower were used in this investigation. The old braces were replaced by the Friends of St. Regis Fire Tower with newly manufactured hot dipped galvanized braces in 2018 and 2019	The Rock Rift Fire Observation Tower is located on Tower Mountain above the Cannonsville Reservoir in the Town of Tompkins, Delaware County, New York. This investigation will inform decisions to be made regarding its restoration.

Special Thanks Special thanks to the Friends of St. Regis Mountain Fire Tower and the NYS Department of Environmental Conservation for supplying the samples of steel cross brace material removed from the St. Regis Mountain Fire Tower. Special thanks also to Wagner Lumber and Quality Hardwoods for the donation of white oak lumber.

I recently completed a study of the potential for corrosion between lumber and galvanized steel. Four types of lumber were paired with old galvanized steel from the St. Regis fire tower and set outdoors for one year. The purpose of this study was to help inform the future renovation of the Rock Rift Fire Tower in the Town of Tompkins, Delaware County, NY as well as renovations of other towers.

Hot dipped galvanizing (HDG) is the process of coating steel with a layer of molten zinc. While galvanizing is a protective measure, it does erode and weather. It also takes part in a galvanic chemical-electrical reaction with other metals, including the copper that is a component of many wood preservative formulations used in the pressure treating of lumber for decking and stair treads. (Pressure treating chemicals that are less corrosive to galvanized materials such as Copper Chromium Arsenic (CCA), creosote, and penta-chlorophenol have been used in the past. However, their toxicity to people and wildlife as well as their mutagenic and carcinogenic effects have curtailed their use today.) Repeated wetting of the lumber in contact with galvanized steel increases the rate of corrosion vs a dry condition.

The Study

Four lumbers were examined:

- Rough-sawn white oak (WO)
- Alkaline Copper Quaternary pressure treated lumber (ACQ)
- Micronized Copper Azole pressure treated lumber (MCA)
- Ecolife II treated lumber (EL2)

Study in-progress November 2019

Six samples of each lumber were attached to the old, galvanized steel from the St. Regis tower without any barrier materials placed between the lumber and the steel. Two samples of each lumber were attached to steel with Rust-oleum® 5200 System DTM Acrylic paint. Two samples of each lumber were attached to steel pieces with Grace® Water and Ice Shield as a barrier between them. This material is a membrane of rubberized asphalt adhesive backed by a layer of high density cross laminated polyethylene film. The samples were attached to frames and were set outdoors in the Town of Bainbridge, Chenango County, NY from November 3, 2019 to November 3, 2020.

The steel that was in direct contact with white oak lumber rusted. This was readily evident on each sample. White oak lumber is quite acidic, and this result was not unexpected. The samples with the Grace® water and ice shield and the Rust-oleum® painted barrier did not show any rusting.

White oak lumber has several excellent qualities. It is strong, decay resistant, and a local woods product. This study shows that if white oak is attached to a galvanized steel surface that a barrier is needed to minimize corrosion. The ice and water shield is quick and easy to apply and does not require the drying time of a paint. The Grace® Ice and Water Shield stood up to removal of the lumber and maintained its integrity. The Rust-oleum® 5200 System DTM Acrylic paint also protected the steel. Portions of the paint pulled away from the steel upon disassembly.

	
The upper portion of this image shows steel sample # 06 A with rust on the leg of the angle iron. The lower portion shows the piece of rough sawn white oak lumber that was attached to this piece of steel. It shows a transfer of rust from the steel angle iron.	Sample of bolts that connected wood to steel for 1 year. Bolt through ACQ # (Top Left), Bolt through white oak (Top Right), EL2 (Bottom Left), and Bolt through MCA (Bottom Right)

The bolts through the white oak lumber showed the most corrosion (WO). Moderate corrosion is seen along the threads of the bolts from the Alkaline Copper Quaternary (ACQ) pressure treated lumber samples. Light corrosion is seen along the bolts that were imbedded in the Micronized Copper Azole (MCA) pressure treated lumber. MCA lumber was developed to be less corrosive than ACQ. This demonstration supports that claim. Of the four lumbers used the MCA formulation used in this investigation is the only one recommended for ground contact. The others are only for non-contact or above ground use. Corrosion is not evident on the bolts in the Ecolife II treated lumber (EL2).

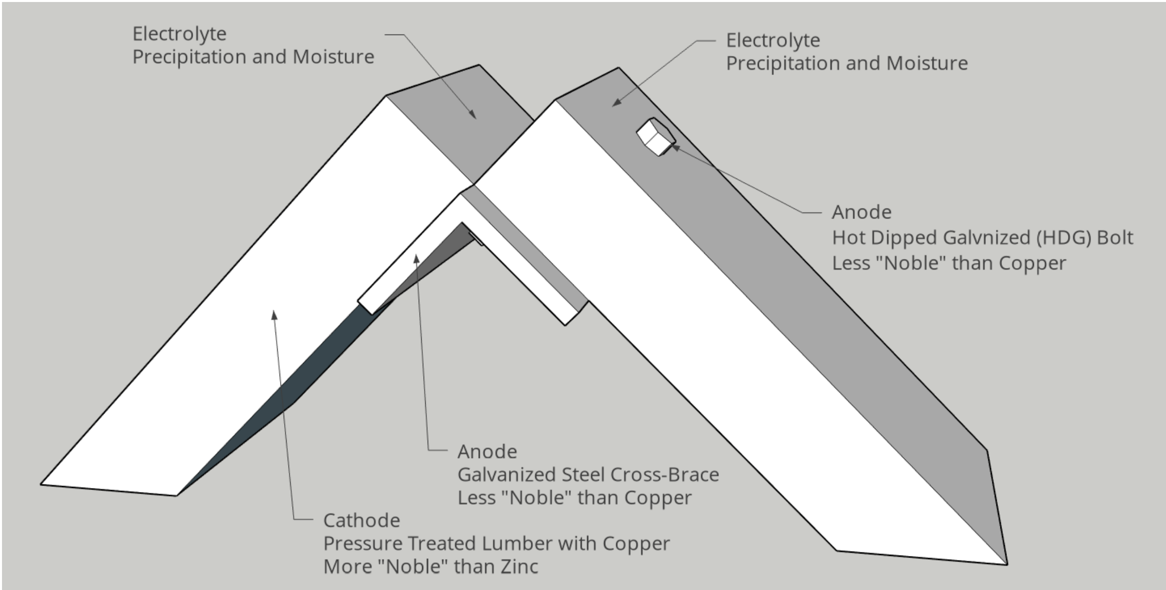
	The bolt on the left was imbedded in ACQ lumber. In addition to surface corrosion this close-up image shows pitting on the crest of the thread and along the thicker flank portion of the thread.
	The bolt on the left was imbedded in MCA lumber. It shows corrosion mostly on the crest of the thread.

No visible corrosion was seen on the galvanized steel angle iron connected to the Alkaline Copper Quaternary Pressure treated lumber (ACQ) or the Micronized Copper Azole Pressure treated lumber (MCA). Minor rust stains were found on the steel along the margins of samples of the EL2 – Ecolife II lumber.

This study found little or no visible corrosion of the angle iron from the various pressure treated lumber. It was anticipated that the effect would be significant. So, what may explain this? Much of the literature concerning the corrosive effect of pressure treated lumber was performed on nails and other fasteners inserted into the treated lumber.

Requirements for Galvanic Corrosion

- Two or more metals with different corrosion potentials
- Contact between the two metals or metal bearing substances
- A conductive electrolyte solution such as water that creates a path for electrical conduction



However, size matters as to the amount of current generated by a galvanic reaction. The relative surface area (not mass) of each of the exposed metals is an important factor. If the area of the cathode (the noble metal – The copper in pressure treated lumber is noble relative to zinc) is very large, and the anode (The less noble zinc in the galvanized coating of the steel) is very small, the current produced is likely to be very high and the anode will corrode quickly. That is not the situation in this experiment with the angle iron. The surface area of the pressure treated lumber was approximately 460 sq. cm and the steel was approximately 219 sq. cm. This is a ratio of 2.1:1. Thus, we can expect that there is less of a galvanic current flowing and that it will not be as corrosive as many of the published laboratory test conditions. However, it is evident that the bolts with their much smaller area that are imbedded through the ACQ and MCA lumber are visibly corroding more than the angle iron attached to the lumber.

Perhaps the corrosion of the bolts in the white oak, ACQ, and MCA lumber is acceptable. Bolts can be viewed as an acceptable sacrifice as compared to the cleats of the stairs or the angle iron supporting the landings. Bolts can be replaced more easily than the steel structure of the fire tower.

We know that there will be a galvanic reaction between most available formulations of pressure treated lumber and galvanized steel. We know that there is corrosion from this reaction. We are not restoring the fire towers for the next 10 or 20 years. We are restoring them so that their structures and legacies are preserved far into the future. Perhaps it is prudent to install a barrier system during fire tower renovation between all lumber and galvanized steel.

This article is a shortened from the full write-up of this investigation. The original report and the appendix may be downloaded from:

https://www.dropbox.com/sh/3a7k8gr79ah5l9k/AACAUmyNv7xbDrTbY8_o9BSca?dl=0