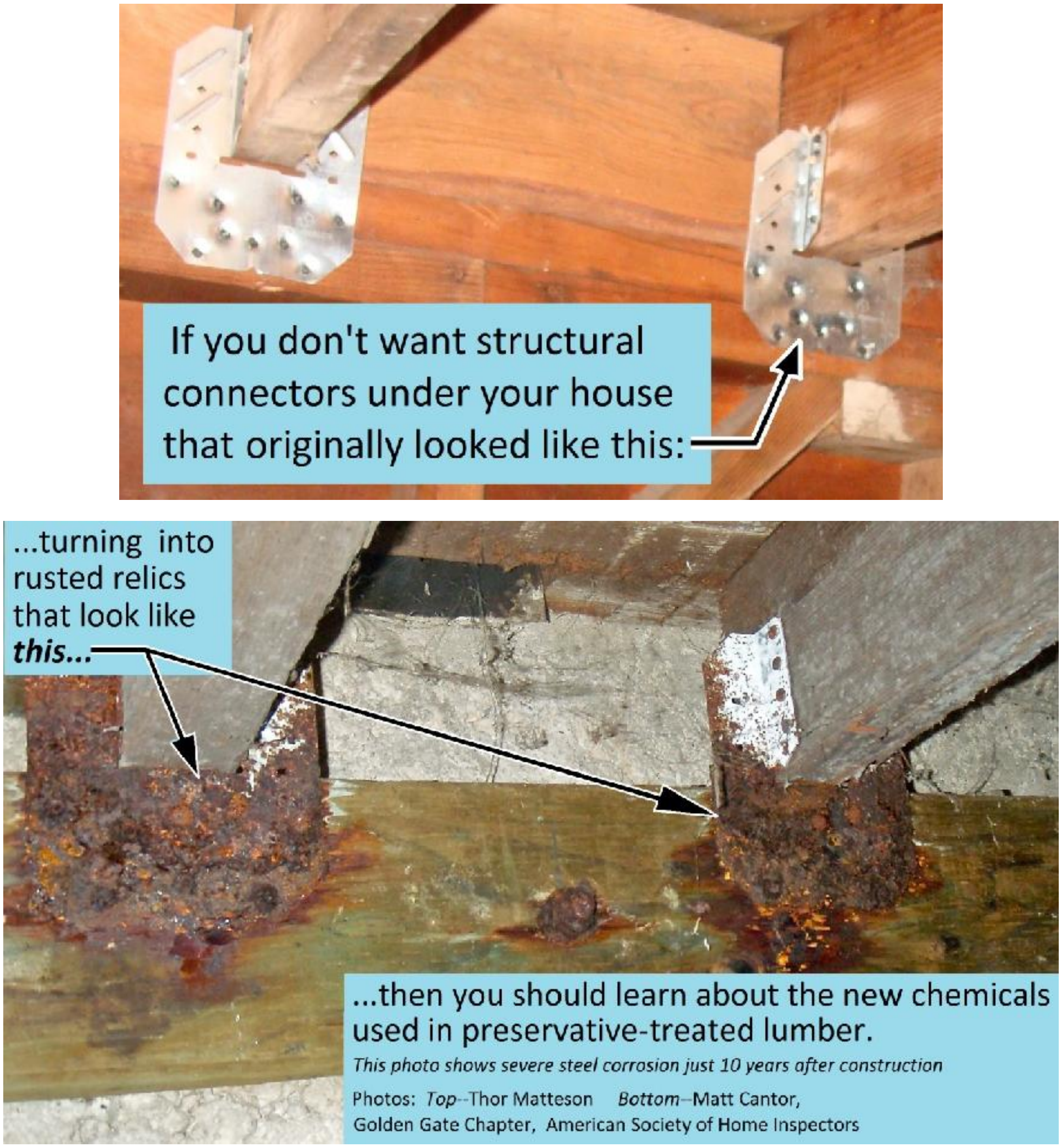
# Corrosion of Steel Hardware Caused by Pressure-Treated Lumber




This handout is part of an upcoming book on earthquake retrofits by Thor Matteson, Structural Engineer. Mr. Matteson has been concerned with fastener corrosion since 2004, when the wood-treating industry began using new preservative formulations that aggressively attack steel hardware. Mr. Matteson is the author of "*Wood-Framed Shear Wall Construction—an Illustrated Guide*"

Rev 9/23/14

## 8.5 Pressure-treated lumber: a ticking time-bomb since... 2004?

Alert: This section is *long*; there is a great deal of misinformation to address, and the subject involves some technical information that needs explanation.

**Figure 8-45 Most wood now sold to resist decay also attacks steel connectors. The red circle shows a rusted concrete anchor. At center is an H10 (compare to Figure 6-34). This installation was about 10 years old. Photo: Matt Cantor, GGASHI**

Imagine constructing a house using building materials that will quietly destroy each other. Millions of homes have been built using such materials; the hardware pictured in Figure 8-45 shows severe corrosion of steel connectors in contact with chemically treated lumber. Future failures of structural connections will surprise a lot of building professionals and homeowners; if you have this material in your home you still have time to avert disaster.

### 8.5.1 Background information

Ever since the first building code there has been a requirement for mudsills or other wood members in contact with earth or footings to be decay-resistant. The codes allow foundation-grade redwood or cypress, or preservative-treated wood. "*PT lumber*", or even just "PT" is the term used for wood that has been made artificially decay-resistant by the addition of preservatives. Technically the proper term is "*preservative pressure-treated*" lumber, as wood can also be pressure-treated with chemicals to make it fire-resistant (and possibly for other traits). I will stick with the term PT lumber here.

### 8.5.2 Alphabet soup—and unintended consequences

**The chemicals:** Until 2004, the most common treatment chemical used in PT lumber intended for residential construction was chromated copper arsenate, or "CCA." You may find PT lumber stamped with "CCA" or "CCA-C," (or some other suffix letter; the trailing "C" is the third formulation they came up with, after A and B). Arsenate is a chemical compound that includes arsenic, which has been a known human poison for centuries. The chromate is probably not good for us either. Thankfully the CCA binds with the lumber and the toxins pretty much stay in the wood.

Since 2004, CCA has not been allowed as a treatment for wood used in residential construction in the US. Some of the more common new chemicals used for preservatives include CA (Copper Azole), ACZA (Ammoniacal Copper Zinc Arsenate), CC (Copper Citrate), ACQ (Ammoniacal Copper Quaternary). All of the preceding chemicals bond with the wood cells, giving a "waterproof" treatment suitable for fence-posts, decks, etc. Figure 8-46 shows several labels from PT lumber.


**Micron-ized CA**


**ACZA**


**CA-C**



**ACQ-D**


**ACQ & instruct-tions**

**Figure 8-46 Tags from several varieties of pressure-treated lumber found on jobsites; all of them are rated "ground-contact," which has higher chemical content than the minimum needed to protect lumber used as mudsills.**

All of the preceding treatment compounds contain copper. Copper and steel, in the presence of water and oxygen, create a "galvanic reaction" (*galvanic* and *"galvanized"* both give tribute to Italian scientist Luigi Galvani). This reaction occurs even with very small amounts of water, such as from humid air in a crawlspace. Oxygen molecules will travel through wood, so embedding nails or other fasteners into wood does not protect them. The steel corrodes as a result of this reaction. Corrosion is the chemical term for "rust." Figure 8-47 shows some very disturbing examples of rapid corrosion.

The "white rust" often seen on galvanized steel connectors is the first corrosion by-product: zinc oxide. After the zinc corrodes away, the underlying steel is no longer protected and it begins

### Why the "teeth-marks" in PT lumber?

To speed up the process of getting the preservatives into the wood, the wood is immersed in chemicals inside huge vessels that are then pressurized to force the mixture into the wood cells.

Some species of wood will accept the chemical treatments more easily than others; wood that is difficult to treat otherwise is usually "incised" by sending the lumber through rollers studded with miniature knife-blades. Douglas fir is difficult to treat and needs to be incised for most chemicals. The "hem-fir" species group is also easier to treat, but woods in this group are softer and do not provide the same connection capacity as Douglas fir. (Since mudsills are not high-demand members, the reduced capacity can be addressed easily by using more edge-nails when connecting bracing panels.) Southern yellow pine accepts treatment readily and does not require incising.

to rust. ***This process continues until all the steel has corroded away. ALL of it***. The time it takes depends on many variables—so: do you feel lucky? Note that hardware manufacturers advise if you see *any* "red rust" on a connector then it should be replaced.


**Figure 8-47 Photos show severe corrosion that occurred within five years of construction.**
***Left*: "White rust" turning to red rust. Photo: John McComas, GGASHI**
***Center:* Remains of nails used to fasten PT plywood. Photo: Keith Tarkington, GGASHI**
***Right:* Mudsill anchor photographed by author in May, 2014.**

Compare the photos above with the anchor bolts shown in Figure 8-48, which were installed in either CCA or redwood mudsill material. The threads on the anchors are still well-defined, whereas the threads shown in Figure 8-47 are rusted badly enough that removing the nut would be impossible.

**Figure 8-48 Bolts shown above were installed before PT chemical reformulation and show minimal corrosion.**
***Left*: In a CCA mudsill, approx. 35 years old; *Right*: In a redwood mudsill, approximately 80 years old.**

## The Chemistry of Corrosion

The reaction between different metals is an electro-chemical process where electrons flow from one of the metals toward the other one. Chemists refer to one metal (the one that corrodes) as the "anode" and the other as the "cathode."

Any particular metal will act as either the anode or the cathode depending on what other metal is present. Chemists rank metals on the "Galvanic scale." Metals that corrode easily (magnesium, zinc, aluminum) are at one end of the scale. Metals toward the other end of the scale include gold and platinum. Metals that do not corrode easily are called "noble" metals. You can find pure gold nuggets in nature because gold lasts millions of years without corroding. Metals that corrode easily are almost impossible to find in pure form in rock formations—they exist almost exclusively as oxides.

Iron (the main ingredient in steel) is near the middle of the Galvanic scale; if it is paired with zinc, it remains stable. When paired with copper, it corrodes.

*(continued next page)*

### How much copper is in the wood?

The American Wood Protection Association (AWPA) generates specifications for various "use categories" for lumber and minimum treatment levels. Most PT lumber used in construction comes in one of two "retention levels" (the amount of chemical retained in the wood after the treatment process). The lowest level is "above ground," followed by "ground contact." Higher retention levels are available for marine use or wood pilings.

The amount of preservative remaining in the wood is measured in pounds of chemical per cubic foot of lumber. The amount required depends on the type of chemical, since some are more effective at protecting against decay. For ACQ and CA to meet the minimum "above ground" use category, each cubic foot of treated wood must contain 0.25 pounds of chemical. For "ground contact" the minimum retention level is 0.40 pounds of chemical per cubic foot of wood.

### 8.5.3 Most suppliers stock only the most corrosive wood

People use PT lumber for mudsills, fences, planters, retaining walls, play sets, decks and so forth. Some of these uses require the "ground contact" level of chemical treatment. Lumber suppliers have apparently gotten blamed when a contractor or homeowner installed "above-ground" rated wood in such cases, and chose to stock only the "best" grade of lumber. Between the desire to avoid confusion and save space that would be needed to stock two different sorts of lumber in many sizes and lengths, most suppliers only carry lumber treated with higher preservative levels. Unfortunately this means the PT lumber you buy for a mudsill

### The Chemistry of Corrosion

*(continued from previous page)*

You may wonder why steel rusts when it is not in contact with another metal; there is enough physical difference in the steel that small regions will act as anodes and other regions act as cathodes. In the photo below, simply bending the reinforcing bars changed the steel properties enough that the bent regions of the bars became anodic relative to the straight sections, causing them to rust first.

When the initial anodic regions rust away, other regions are next in line. Thus if we have metal items that we want to keep from corroding, we need to protect them somehow. One way to protect them is to coat them with paint to keep the moisture and oxygen away. Another method is "*cathodic protection*," i.e., protecting the cathode from corrosion.

Cathodic protection uses "sacrificial anodes." The sacrificial anodes give their lives to save the more noble metal you want to protect. Boat owners may be aware of zinc anodes used to protect their steel boat hulls. *(continued next page)*

has 60% more copper in it than necessary. More copper means faster corrosion of steel fasteners.

### 8.5.4 Bolts versus nails

Most bolts shown in the accompanying photos probably still have almost their full strength. I am much more concerned about nails driven into PT lumber. The nails are much smaller than bolts and would corrode faster. I would photograph nails if I could—in most cases they are covered with siding or stucco. You will never know the nails have failed until sheets of plywood or stucco peel away from the mudsill during an earthquake.

### 8.5.5 One solution: use Stainless Steel hardware and fasteners

Stainless steel contains chromium and nickel, which make it more corrosion resistant than copper. You may be stuck with nasty PT lumber that someone else installed when they replaced your foundation. In this case the only way to assure long-term performance of connections to the treated lumber is to use stainless steel fasteners and connectors. ***Every*** metal component that connects to, or passes through the treated lumber should be stainless steel. Stainless steel nails should be available at most local lumber yards, but you may have to special-order other components. The Maze Nail Company makes stainless steel nails. GRK Fasteners makes self-drilling structural screws. Note that Simpson Strong-Tie and other companies offer some of their connectors in stainless steel, but the cost of stainless is about *ten times* that of their regular connector line. Clearly you want to avoid the need for stainless steel fasteners.

**The Chemistry of Corrosion**

*(continued from previous page)*

Aluminum or zinc anodes are commonly used to protect steel. Magnesium anodes are used to protect aluminum (magnesium could also protect steel, or any other metal more noble than it is; but magnesium is more expensive than aluminum).

Galvanic corrosion occurs because our metal parts create a crude battery. Since the process involves very weak electrical current, the anode (metal that corrodes) does not have to be in contact with the cathode—just joined to it by a wire or other metal part. The photo at left below shows a concrete anchor with significant corrosion only three months after installation, and it was not even touching the ACQ-treated lumber; it was connected to a UFP10, which was in turn attached to the ACQ lumber. Most importantly, *the process does not stop until all of the anode material has corroded.* Sacrificial anodes must be replaced periodically, or protection is lost for the boat hull, oil pipeline, or structural framing connector. The photo below right shows a sidewalk access cover for Pacific Gas & Electric Company to replace an anode that is protecting an underground pipeline from corroding; if they do not replace the anodes regularly, the pipelines would corrode and eventually leak.

### 8.5.6 Addressing the problem, or ignoring it?

The wood-treating industry and the hardware manufacturers really don't want to tell contractors that durable fasteners and connectors will cost ten times as much as what they were accustomed to paying before the switch to new PT formulations. The industries use a few ways to avoid telling you straight out that you should use stainless steel connectors with treated wood.

**Tactic #1: Misdirection & denial:** One of the early "answers" from industry was to deny that there was a problem. The following is a quote from a preservative industry document dated 2004 (still at large on the internet as of September, 2014) regarding corrosion:

> *"It is generally recognized that the potential for fastener corrosion in forest products based building materials used in an interior exposure environment is minimal because the equilibrium moisture content of the wood is maintained at a level that does not support corrosion reactions."*

**Figure 8-49 This installation was four years old when photographed. Note the red circle at the top of the picture, which shows a rusted nail that is just barely touching the PT ledger.**
**Also note that the PT ledger is separated from a concrete foundation wall with tarpaper, which reduces the moisture that would wick into the wood from the concrete.**
**The manufacturer of the joist hanger shown recommends replacing hardware that has any "red rust" on it. *Hint: Replace with stainless steel if you do not want to repeat this process every four years.***
**Photo by John Fryer, GGASHI**

The above quote is generally recognized as the sort of statement intended to be as confusing, vague, and misleading as possible. What they mean is, "it is generally recognized that lumber used indoors will probably be too dry to allow steel to rust." The most misleading term is "*it is generally recognized*." Who recognizes this? And based on what? Testing? Hope? Unrelated studies? The document asserting this "fact" quotes a study of moisture levels in wood, dated 1988. When we are talking about corrosion caused by chemicals that were not even *invented* in 1988, this reference by someone who wants to sell me their product seems unhelpful at best. The second-most misleading term is "*interior exposure environment.*" Does this mean inside the heated or air-conditioned part of your home, or the damp crawlspace beneath it? One reason that PT lumber is used in contact with concrete is that the concrete wicks moisture up out of the ground, resulting in elevated moisture levels in the mudsill. Considering the severe corrosion of steel connectors seen in the last few years, as shown in Figure 8-50 through Figure 8-53, I am not reassured by this pitch from the wood-treating industry.

**Figure 8-50 Six-year old installation in a mechanically vented crawlspace, where air circulation was provided by a fan to provide reliable ventilation. It would take a fairly long time—maybe decades—for this bolt to corrode to the point it lost significant strength. Nails are a different matter; see below.**

**Figure 8-51 Rusty edge nailing of a shear panel, approximately five years after construction. Contractors have reported almost total corrosion of nails in just a few years. Photo by Skip Walker, Silicon Valley ASHI/CREIA**

**Tactic #2: Minimize the problem:** After the new treatment chemicals had been corroding fasteners in the real world for a few years, manufacturers started including warnings in the fine print on their labels. One suggestion is that regular inspection and maintenance of the hardware will allow you to use the less-expensive fasteners they sell. "Regular inspection and maintenance" is possible—but, let's face it, highly unlikely—on a deck or a fence. For most connections that are crucial to your house's integrity, inspection & maintenance is completely impossible: how do you inspect or maintain the nails driven into a PT mudsill to attach the bottom edge of the exterior sheathing on your house if the nails are covered by siding or stucco?

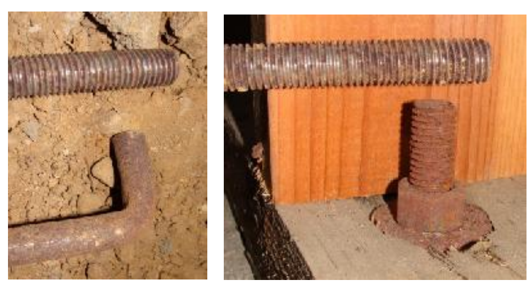


**Figure 8-52 Accidental experiment—the builder left a couple of foundation anchors lying on the dirt under a house (photo above left). Photo above right compares one of them to an anchor installed in PT lumber nearby. The anchor that had been left on the bare ground still has shiny portions, whereas rust completely covers the anchor installed in the PT lumber.**

### Tactic #3: Pass the buck:

Fine print on PT lumber labels and hardware manufacturer's brochures tosses all the responsibility for corrosion to the consumer, just saying to make sure you select the appropriate fasteners to use with the chemicals in question. One hardware manufacturer states that their products perform well under controlled tests, but also notes that the test results may not apply to actual field conditions and suggest using stainless steel if you are unsure about the specific installation. If *they* are not sure, how can *you* be sure? Unless you have a degree in metallurgy and a laboratory to do your own tests, the hardware manufacturers are essentially recommending stainless steel.

One hardware maker's catalog indicates what type of fastener material is recommended for connecting to treated lumber, based on the treatment level, type of chemical, and whether the installation will be dry or wet. For *any* of the copper-containing wood treatments at "higher chemical content" levels they recommend using stainless steel, copper, or silicon bronze fasteners. They define "higher chemical content" as the levels required

### All Galvanizing is not Equal

"Galvanizing" generally means to coat a metallic item with zinc. The zinc is applied in one of three ways: Electro-plating, mechanically, or by dipping the item into a bath of molten zinc. Each method has advantages and disadvantages.

**Electroplating** uses an electric current to deposit a metal (in this case, zinc) onto the base metal being plated. The plating is deposited one atom at a time from a bath containing a solution of a zinc salt. Electroplating deposits a fairly uniform layer of zinc, and gives parts a somewhat shiny, silvery appearance. This method is also called "electro-galvanizing." For something as crucial as an earthquake retrofit system, electroplating does not deposit enough zinc onto the base metal to offer adequate protection from corrosion. That leaves mechanical or hot-dip galvanizing.

**Mechanical galvanizing** is done by tumbling a bunch of metal parts in a rotating drum with powdered zinc. Enough zinc is pounded onto the surface of the metal to offer protection. This method is used to coat threaded parts that might otherwise turn to blobs if they were dipped into molten zinc. This method is sometimes referred to as "tumbling." Mechanically galvanized parts have a dull-gray finish. Simpson "SDS" screws are currently supplied with mechanical galvanizing.

**Hot-dip galvanized** ("HDG" for short) parts are dipped into a kettle of 900-degree molten zinc. Many galvanizers have kettles big enough to dip 60-foot street-light poles. The molten zinc heats the base steel to the point where four different iron-zinc alloy layers are formed. Two of these alloy layers are actually harder than plain steel. HDG material has a spangled appearance. Most sheet-metal framing connectors are hot-dip galvanized.

Hot-dip galvanizing can coat the entire surface of a part with zinc, which offers the best protection from corrosion—however, see the sidebar on the following page for some bad news.

for wood to be rated as "ground-contact"—the only PT lumber sold at most lumber yards. Since the building code only allows steel or stainless steel connectors for structural purposes, this rules out copper and silicon bronze (although at twice the cost of stainless steel, nobody is likely to use copper or silicon bronze anyway).

### 8.5.7 Why is this still a secret after 10 years?

Many reputable contractors and engineers are not aware of the problem with copper-containing wood treatments. Most likely this is because they rarely get a chance to see connectors and fasteners after nature has taken its toll.

Members of the American Society of Home Inspectors have shared many of the photos included here that show extremely severe corrosion due to copper-based lumber treatments. ASHI members are on the forefront of seeing early failures of many different products. Lead paint and asbestos were used on millions of houses, but that does make them any less bad now that we finally acknowledged they are harmful. I expect that copper-treated lumber will eventually be viewed in a similar way—and I hope it's sooner rather than later.

**Figure 8-53 Anchor bolt on left is from original 90-year-old construction. Anchor on right was installed in PT lumber for an eight-year old remodel in the same crawlspace. The anchor in the PT material looks worse than the older one. Photos: Justin Brodowski**

**Not even all *Hot-Dip* Galvanizing is Equal!**

Most framing connectors are made from sheet steel that was galvanized before the steel was shipped to the hardware manufacturer.

Sheet metal parts are cut from huge rolls of HDG steel sheet. The cut edges of the parts are bare steel. Since the steel will not corrode if there is an anode in contact with it, the bare edge is protected—for a while. In the photos of corroded connectors, though, you will notice the red rust almost always begins to form near a cut edge of the material.

Many galvanized nails are made similarly—the nail manufacturer buys spools of HDG wire from a steel mill, then cuts the wire into short pieces to make the nails. The points and heads of the nails are not coated with zinc. Worse, the nail heads are formed by stamping the wire into a die so it flares out. In the sidebar explaining the chemistry of corrosion we saw that steel begins to corrode where it has been bent or deformed. Now we have a deformed area of the steel nail that also has no zinc coating on it—thus the nail head is usually the first place you see rust.

Other than stainless steel, the best readily-available finish to resist corrosion is hot-dip galvanized material. **The best HDG protection is provided by hot-dip galvanizing after fabrication.**

### 8.5.8 Solutions—or experiments?

Two methods to reduce corrosion without using all stainless steel connectors are fairly common, but not proven over the long term.

#### 8.5.8.1 Mixing stainless steel and galvanized connectors does not solve the problem

For steel connectors and fasteners, copper is the enemy in PT lumber. But copper is not the only metal that will react with steel to cause fastener corrosion. You do not want to introduce another metal that begins to attack your connectors—yet combining stainless steel and galvanized fasteners has this result. Stainless steel is more noble than plain steel (see "The Chemistry of Corrosion" sidebar). If you use stainless steel together with plain or galvanized steel, the plain steel becomes the anode in the galvanic reaction. Now the plain steel corrodes because it is in contact with stainless steel; you could take the copper-treated wood completely away and the plain steel would still corrode.

Sometimes fasteners are mixed intentionally, sometimes accidentally. Installers may think that using stainless steel nails will improve the connection performance of galvanized framing connectors or foundation plates. The cost of mixing the two materials is certainly less than going all stainless steel.

Manufacturers clearly state that you should not mix different materials in the same connection.

#### 8.5.8.2 Isolation membranes do not isolate the nails

For corrosion to occur, the two metals in question must either be in contact or at least have a way for small electrical charges to flow between them

**Relative size of different metal parts affects corrosion rates**

We know that whenever two different metals are joined, one of them will corrode—but how quickly? It depends on how much of which metal is present.

Say you have a two-pound steel foundation plate joined to *un*treated wood with stainless steel nails (adding another PT metal is more complication than we need). The foundation plate is the anode in this case, and will corrode until it is gone. Compared to the nails, the plate has a large surface area. If iron atoms in the steel plate are lost from the whole surface of the plate, it would take a long time for the plate to lose significant strength.

If we switch the metals so we have a stainless steel plate secured with steel nails, things get scary. Now we have relatively small steel nails acting as anodes that need to protect the much larger stainless steel plate; the nails will corrode very quickly. It could be that the same amount of steel is lost over the same time-span in this case or the one described in the preceding paragraph—but when the loss of a few small nails means a failed connection, the second installation is much more dangerous.

In the first case above, we cannot count on losing a thin layer from the whole surface of the steel plate. Likely some concentration of corrosion will occur right around the stainless steel nail.

(water or moisture provides such a way). If the two metals are kept physically separated, corrosion will not occur. So why don't we just wrap the evil PT lumber with a water-proof membrane to separate it from the metal parts? There are products that attempt to do this—but I do not see how they can actually work. This is because you cannot isolate the *nails* from the PT lumber. If only the nails corrode, you still lose connection capacity—but the nails provide a path for the electrical charges to flow, leading to possible corrosion of the "isolated" metal.

The membrane shown in Figure 8-54 is marketed specifically for decks, which are one of the main uses of PT lumber. At least you can usually access connections under decks to monitor the condition of the steel now and then.


**Figure 8-54 PT lumber separated from a sheet metal connector with a self-adhered membrane. The nails still penetrate the PT lumber. This method may delay corrosion in the connector, but the membrane does not offer any improved protection for the nails.**

#### 8.5.8.3 Proprietary coatings

Major hardware manufacturers offer thicker zinc coatings on some of their products (for example, Simpson's "Z-Max" and USP's "Triple Zinc"). These coatings just provide a thicker layer of zinc (and since the parts are not galvanized after fabrication, all the cut edges are left uncoated). The thicker zinc buys some time—but the corrosion reaction is patient and unrelenting, so I do not trust a mere delay in connector death.

USP supplies *some* of their connectors with their "Gold Coat" finish. Gold Coat is "an organic top coat barrier layer" over galvanized steel. Coatings can get scratched during installation or handling; I simply would not want to trust my house to a thin coating separating essential connectors from corrosion doom. But I may change my mind after 50 years if actual field installations show good performance…

### 8.5.9 How long a time is "long enough"?

Many of the coatings and other protection methods and materials listed in the previous section were developed for outdoor decks. Compared to a house, the expected life of a deck is much less (as short as 10 or 15 years). What may be a satisfactory lifespan for a deck fastener would not meet most homeowners' expectations for the lifespan of their homes.

When a client with a 100-year-old house asks me to design an earthquake retrofit, I want to design a system that will last another 100 years. Copper-containing PT lumber poses a severe threat to that goal; I don't even want to rely on stainless steel, much less some unproven system—some of which have obvious flaws.

### 8.5.10 A better alternative: Borate-treated lumber

Another class of preservative treatment chemicals includes *borates*. The two common formulations are Disodium Octaborate Tetrahydrate ("DOT") and Sodium Octa-Borate ("SBx"). Borate treatments do not corrode fasteners even as much as CCA did, and therefore do not require special fasteners. Borates are not toxic to humans (this is the same class of chemicals as borax that you use to wash your clothes or hands, and is a major ingredient in dishwasher detergent). Borates are much less harmful to the environment than copper and arsenic-containing wood treatments.

Unlike copper-based treatments, borates are colorless. Since carpenters are used to PT lumber having a green color to it, most borate-treated lumber is dyed light green or light blue. Figure 8-55 shows two samples of lumber treated with the same brand of borate.

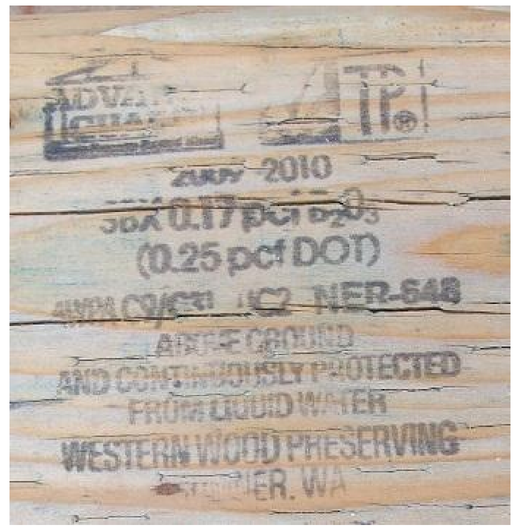




**Figure 8-55 Borate-treated lumber does not corrode fasteners; it is also not toxic to mammals. Borate-treated lumber cannot be exposed to liquid water, but is appropriate for most retrofit applications. It is also usually less expensive than wood treated with toxic chemicals. California Cascade Industries (phone 800-339-6480) supplies borate-treated lumber throughout the state. A few lumber yards in the SF Bay Area [Osborne Lumber (in Newark), Sierra Point Lumber (Brisbane) and Golden State Lumber (several locations)] carry borate PT lumber as a regular stock item in limited sizes and lengths. Special-ordering from other yards is very worthwhile—but see the warning in the sidebar, next page.**

> **Borates do not kill termites directly**
>
> Termites do not actually digest wood—they only chew it up and swallow it. A variety of fungus that inhabits termite stomachs breaks down the wood. The termites get their energy from the fungus. Borates kill the fungus—thus the termites die of starvation.

#### 8.5.10.1 Limitations for borates

Borates will dissolve in water, so borate-treated wood must be protected from liquid water—this rules it out for building decks or fences. Borate-treated wood is perfectly acceptable for use in foundation sills.

Borate-treated lumber is also not allowed in areas where Formosan termites are present (Hawaii and Florida, possibly other Gulf-coast areas).

### 8.5.10.2 Why don't more lumber yards stock Borate-treated lumber?

As with the two treatment levels used for copper-containing PT lumber, suppliers do not have space for yet another type of material. In most suppliers' minds, there is no advantage to borate treatments—borates are not water-proof, and the suppliers assume the products they already stock will work in all situations. Some people in the construction industry are also under the false impression that borate-treated wood cannot be used for mudsills because borates are not waterproof.

### 8.5.10.3 Other benefits of borate-treated lumber

One advantage of borate-based treatments is that they will travel toward moisture in the wood, which is exactly where you need them. In log cabin construction, large borate crystals are placed in holes bored in the logs. If moisture reaches the crystal it begins to dissolve. The borate moves through the moist wood, spreading out away from the crystal. In this case the fact that borates will move through the wood is helpful.

According to the borate-treating companies, incising is not required for the treatment to adequately penetrate the wood. If true, this means you do not need to spot-treat cut ends of boards.

**For more information on borate treatments, search for:**
"Timbor" by US Borax
"Sillbor" by Arch Chemicals
"Advance Guard" by Osmose

**Warning: check the lumber yourself!**

In 2005 I hired a contractor to build an addition on my house. I told him to make sure he put in a special order well in advance for borate-treated lumber to use for the mudsills. The contractor and his crew arrived to lay out walls the day before the lumber yard was to deliver all the framing lumber—he assured me that the yard had ordered borate-treated stock for the mudsills.
A delivery truck arrived the next morning, including a dozen or so dark green boards for mudsills. I checked the tags on the ends: ACQ. Those boards went back to the yard.
I took the morning off, drove an hour to the nearest yard that had borate-treated lumber in stock, and returned with what was needed so the crew could begin building a structure that would not self-destruct.

Onward to 2014; I designed a foundation replacement and earthquake retrofit for a 1915 bungalow. I referred the owner to a premier foundation contractor. The references on the drawings to borate-treated lumber got their attention and they special-ordered borate-treated mudsill stock. When I went to crawl under the house to observe the work before concrete was poured I immediately noticed dark green mudsills; no end-tags were visible, so I went to the lumber yard the next day. The only PT lumber they carried was ACQ, and they told me their supplier filled the "special order" with ACQ.

Moral: If you've read this far, you know more about PT lumber than most lumber suppliers, engineers, contractors and building inspectors. Don't rely on them.

### 8.5.11 Another alternative: Isolate untreated wood with water-proof membrane

The building codes generally call for foundation sills and posts resting on concrete to be of PT lumber or decay-resistant wood (IBC/CBC Section 2304.11). In some specific cases, untreated lumber is allowed if an "impervious moisture barrier" is used between the wood and concrete (such as posts in metal post-base connectors). The spirit of the code seems to allow use of untreated wood if it is separated from concrete by a moisture barrier. If separating untreated mudsills or other members from concrete was more common, the code would probably include a specific provision allowing this practice. The absence of such a provision does not mean a membrane would not protect the wood.

**Figure 8-56 Untreated lumber shown here is protected from moisture wicking through the concrete foundation wall by "peel-and-stick" membrane (also called self-adhered flashing, commonly used to waterproof around window and door openings).**

Figure 8-56 shows the beginning of a wall frame isolated from a concrete stemwall by self-adhered flashing. The flashing should block moisture from the concrete, thus protecting the wood from decay. Note that "tar-paper" does not block water vapor effectively and should not be used.

I not like to give termites a path from the ground to untreated wood without crossing borate-treated lumber somewhere. However, I would take my chances with the system shown rather than use copper-containing treatments that I know will corrode fasteners

### 8.5.12 Recommended best practice for known damp areas: All of the above, short of stainless steel

For the amount of trouble it is to install most earthquake retrofits, you may as well spend more on good materials to provide a superior system. Use borate-treated lumber, hot-dip galvanized connectors (if nothing else, at least the nails should be hot-dipped after fabrication), and an isolation membrane. The membrane will keep moisture from wicking into the wood structure. Even foundation grade redwood decays after decades of contact with damp concrete; the borate-treated material may not decay, but it could transmit moisture to other wood components.