# Preventing corrosion

*Building codes toughen requirements for corrosion protection of metals used in masonry walls*

By Mario J. Catani

Over the last 5 years, corrosion of ties, anchors, and joint reinforcement has become a main concern within the masonry industry. How much galvanizing is required to protect against corrosion? When should stainless steel be used?

## Zinc galvanizing

Galvanizing is the traditional way to protect metals from corroding inside masonry. Zinc galvanizing protects steel in two ways. It prevents moisture and oxygen from reaching the steel. Without moisture and oxygen the steel can't corrode. And by migrating to exposed steel areas, the zinc sacrifices itself, corroding before allowing the steel to corrode. This latter process is called galvanic protection.

How long does the zinc coating last before it's corroded away? There is no simple answer. Long-term exposure tests haven't been conclusive. And the actual exposure of metals in masonry walls varies so much it's difficult, if not impossible, to accurately predict the life of various zinc coating thicknesses. Table 1 shows how corrosion of zinc galvanizing varies with climate and location.

So exactly how much galvanized coating is needed? No one knows, and for each job the actual amount is sure to vary. However, because of concerns over corroding metals in masonry walls, the three model building codes and the new ACI 530.1/ASCE 5 *Specifications for Masonry Structures* have passed tougher corrosion protection requirements (see box). In general, metals embedded in exterior masonry walls must now be hot dipped galvanized *after fabrication* with 1.5 ounces of zinc per square foot. For interior work, only nominal galvanizing is required (between 0.10 to 0.40 ounce per square foot). Because the life of various zinc coatings can't be accurately predicted, for exterior walls, the codes chose to require 1.5 ounces of zinc per square foot—the most galvanizing that specifications traditionally had required.

## Stainless steel

Stainless steel isn't required but some designers prefer to use it because the life of galvanizing is unpredictable. Stainless steel costs 5 to 10 times more than zinc galvanizing but it can last much longer (Table 2).

### Table 1. How Corrosion of Zinc Galvanizing Varies With Location

| Location | Ounces of zinc lost after 2-year outdoor exposure* |
|---|---|
| Phoenix, AZ | 0.005 |
| Cape Kennedy, FL, ½ mile from ocean | 0.018 |
| Bethlehem, PA | 0.020 |
| Point Reyes, CA | 0.023 |
| East Chicago, IN | 0.028 |
| Columbus, OH | 0.033 |
| Pittsburgh, PA | 0.040 |
| Cleveland, OH | 0.042 |
| Newark, NJ | 0.057 |
| Cape Kennedy, FL | |
| 60 miles from ocean, elevation 3 feet | 0.062 |
| 60 miles from ocean, ground level | 0.064 |
| 60 miles from ocean, elevation 60 feet | 0.068 |
| Halifax, Nova Scotia | 0.114 |

*The weight loss shown here is for 4x6-inch test specimens fully exposed to weathering. Tests haven't been done on zinc lost from galvanized metals embedded in masonry walls at different locations.

Source: Adapted from *Hot Dip Galvanizing for Corrosion Protection of Steel Products,* American Galvanizers Association Inc., 1101 Connecticut Ave., NW, Suite 700, Washington, DC 20036.

### Table 2. Relative Cost of Corrosion Protection

| Type of Protection | Relative Cost Factor |
|---|---|
| Mill galvanized, ASTM A 641, 0.10 ounce per square foot | 1.00 |
| Mill galvanized, ASTM A 641, 0.40 ounce per square foot | 1.20 |
| Mill galvanized, ASTM A 641, 0.80 ounce per square foot | 1.30 |
| Hot dipped galvanized after fabrication, ASTM A 153, 1.50 ounces per square foot | 2.00 |
| Stainless steel, ASTM A 167 Type 304, austenitic | 10.00 |

**Stainless steel wall ties and joint reinforcement can cost 5 times the cost of hot dipped galvanized items and 10 times the cost of mill galvanized items.**

If not properly used, though, even stainless steel corrodes. The correct type of stainless steel must be used to avoid galvanic action between the stainless steel and any carbon steel that it touches. The correct type is the high nickel-chrome stainless steel conforming to ASTM A 167, Type 304. Classified as austenitic, this type of stainless steel has the best corrosion resistance and doesn't develop red rust.

Because austenitic stainless steel is soft, it can be used to make self-tapping screws but not self-drilling screws. To make a self-drilling screw, a carbon steel tip can be attached to a stainless steel threaded shaft. The carbon steel tip drills through steel, then the stainless steel threads tap the base metal.

## Avoid dissimilar metals

Using a stainless steel that isn't austenitic with carbon steel can result in corrosion of the carbon steel. When dissimilar metals, such as stainless steel and carbon steel, are used together, an electrical potential (voltage) is often created between them. Much like the situation within an electric storage battery, an electrical current flows from one metal to the other. The current flows from the more positively charged metal to the more negatively charged metal. The result is corrosion. The more positively charged metal (the anode) corrodes, sacrificing itself to the more negatively charged metal (the cathode).

This is how zinc galvanizing protects steel. Zinc, which becomes positive, sacrifices itself to carbon steel. The zinc corrodes and the carbon steel is protected. In the same way, carbon steel sacrifices itself to stainless steel. Carbon steel becomes more positive than stainless steel. In the former case, the carbon steel is protected; in the latter case, the carbon steel is in jeopardy.

Table 3 shows the galvanic potential of various metals. When any two of these metals are used together, the metal nearer the top

## New Corrosion Protection Requirements

### Standard Building Code

"Metal accessories (ties, anchors, joint reinforcement) for use in exterior wall construction shall be hot dipped galvanized after fabrication in accordance with ASTM A 153 Class B2. Metal accessories for use in interior wall construction shall be mill galvanized in accordance with ASTM A 641 Class 1."

—Section 1402.11.2
1989 Revisions to the 1988 *SBC*

### Basic Building Code

"Metal Accessories (ties, anchors, joint reinforcement) for use in exterior wall construction shall be hot dipped galvanized after fabrication with a minimum coating of 1.50 ounces per square foot in accordance with ASTM A 153 listed in Appendix A. Metal accessories for use in interior wall construction shall be mill galvanized with a minimum coating of 0.1 ounce per square foot in accordance with the standards listed in Appendix A as follows: ASTM A 641 for joint reinforcement, wire anchors and ties and ASTM A 525 Class G60 for sheet metal anchors and ties."

—Section 1401.10.1, Corrosion Protection
1989 Accumulative Supplement to the 1987 BOCA

### Uniform Building Code

"Joint reinforcement used in exterior walls and considered in the determination of shear strength of the wall shall be hot dipped galvanized in accordance with UBC Standard No. 24-15."

—Section 2407 (f) (ii), Reinforcement

"...anchors, supports and ties shall be noncombustible and corrosion resistant. When the terms 'corrosion resistant' or 'non-corrosive' are used in this chapter they shall mean having a corrosion resistance equal to or greater than a hot dipped coating of 1.5 ounces of zinc per square foot of surface area. When an element is required to be corrosion resistant or non-corrosive, all of the parts shall be corrosion resistant such as screws, nails, wire, dowels, bolts, nuts, washers, shims, anchors, ties, and attachments."

—Section 3003, Materials
1988 *UBC*

### Specifications for Masonry Structures

"Unless otherwise required, protect joint reinforcement, ties, and anchors not meeting the requirements of Article 3.2.1.3 [on stainless steel] by galvanizing in conformance with the following:

| | |
|---|---|
| Joint reinforcement interior walls | ASTM A 641 Class 1 (0.40 oz./ft.$^2$) |
| Wire ties or anchors in exterior walls completely embedded in mortar or grout | ASTM A 641 Class 3 (0.80 oz./ft.$^2$) |
| Wire ties or anchors in exterior walls not completely embedded in mortar or grout | ASTM A 153 Class B2 (1.50 oz./ft.$^2$) |
| Joint reinforcement in exterior walls or interior walls exposed to moist environments (e.g. [swimming pools] and food processing) | ASTM A 153 Class B2 (1.50 oz./ft.$^2$) |
| Sheet metal ties or anchors exposed to weather | ASTM A 153 Class B2 (1.50 oz./ft.$^2$) |
| Sheet metal ties or anchors completely embedded in mortar or grout | ASTM A 525 Class G60 (0.60 oz./ft.$^2$)" |

—Section 3.2.1.4, Coatings for Corrosion Protection
ACI 530.1-88/ASCE 6-88

of the list (more positive) will corrode and the metal nearer the bottom (more negative) will be protected.

The difference in electrical potential between metals is not the only factor that influences corrosion. Important also is the density of the corrosion current. If the surface area of the anode (the more positive metal) is much smaller than the surface area of the cathode (the more negative metal), the current density will be high and the anode will corrode rapidly.

Both electrical potential differences and density of corrosion current generally are reasons not to use dissimilar metals in contact with each other inside masonry walls. For example, don't form adjustable wall ties by welding stainless steel eyes to galvanized joint reinforcement. Welding two dissimilar metals with about the same surface areas encourages corrosion. On the other hand, using a Type 304 stainless steel screw in a carbon steel stud doesn't present as great a problem. Because the carbon steel stud (the anode) has a large surface area relative to the stainless steel screw, the current density is low. In fact, stainless steel screws have been used successfully in Europe to fasten sheet metal roof decking.

Also don't use dissimilar metals even in casual contact, such as installing stainless steel pintles with galvanized eyes in adjustable assemblies. The corrosion rate in such cases can't be accurately predicted.

### Epoxy coatings: Not yet

So far building codes and standards have not addressed the use of fusion-bonded epoxy coatings for metals in masonry. The behavior of this type of coating has not been demonstrated adequately in masonry. Steel ties, anchors, and joint reinforcement used in masonry are subject to different conditions than steel in concrete is. Hence, it's not appropriate to extrapolate data about the use of epoxy coated steel in concrete to its use in masonry. More research is needed before epoxy coated metals can be recommended for use in masonry.

### The last step

Providing adequate corrosion protection in masonry, is an art. The designer must balance the risk of corrosion with the cost of the corrosion protection. And he or she must be sure that the measures that are taken to prevent corrosion, such as specifying stainless steel, don't cause corrosion instead.

The first step to reducing corrosion problems have already been taken. Building codes have toughened requirements, making hot dipped galvanizing mandatory for exterior walls. Industry has invested in the equipment needed to make the hot dipped galvanized coatings readily available. Now the last step: designers and contractors must implement the new requirements.

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### Table 3. Corrosion of Dissimilar Metals

MORE POSITIVE

**Corroded End**
(anode)

Magnesium
Zinc
Cadmium
Aluminum
Steel or Iron
18-8 Chromium-nickel Iron
18-8-3 Chromium-nickel-molybdenum Iron
Lead
Tin
Brasses
Copper
Bronzes
Silver
Gold
Platinum

**Protected End**
(cathode)

MORE NEGATIVE

Source: Adapted from *Engineering Materials Handbook,* by Charles L. Mantel, McGraw-Hill Book Co., 1958

**When dissimilar metals are in contact inside a masonry wall, the more positive metal (nearer the top of this list) will corrode and the more negative metal (nearer the bottom of this list) will be protected.**

### U.K. Favors Stainless Steel

In the March 1990 issue of *Materials Performance,* published by the National Association of Corrosion Engineers (NACE), author David J. Cochrane reports that stainless steel masonry wall ties are rapidly becoming the norm in the United Kingdom. Stainless steel isn't required by British standards, but a new amendment to standard BS 1243 has substantially increased the amount of galvanizing required on carbon steel ties. Ties with less galvanizing had been found to cause early wall failures. This deterioration occurred with normal masonry mortars in normal, nonmarine environments. Galvanized ties investigated by the British Research Establishment (BRE) had lost 0.03 to 0.06 ounce of zinc per square foot per year.

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