BLUEPRINTS

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Corrosion in Salt Air

Salt causes metal to rust or corrode faster than normal. But it is surprising to learn how fast deterioration occurs in coastal areas. The drastic increase is caused by the salt spray from breaking waves. The spray is blown inland by onshore coastal winds.

Corrosion variables

The primary variables affecting corrosion rates near the coast are the salt content in the air, the time of wetness of the metal surface, the temperature, and the level of other atmospheric pollutants. These variables are controlled by environmental factors: distance to the ocean, elevation, wind direction, wave action, rainfall, humidity, the degree of shelter and the level of industrial air pollution.

Corrosion rates vary from place to place and during different times at the same location. The corrosion rate of one metal versus another also can vary with differing environmental conditions. For instance, one material may corrode five times faster in one environment and 10 times faster in another. Such wide variability makes definitive conclusions difficult to determine. Instead, I will examine general trends and selected sites, realizing the corrosion rate will vary with time and location.

Test results

In the 1940s, Francis LaQue (for whom the LaQue Center for Corrosion Technology at Wrightsville Beach and Kure Beach is named) conducted a series of corrosion field tests. Steel plates were placed in a variety of configurations at an atmospheric test site in Kure Beach. The test results were based on a year or more of exposure.

One test examined the variability of the corrosion rate with distance from the ocean. Samples located 80 feet from the ocean corroded

Car shows effects of corrosive salt air

six times faster than a location 800 feet from the ocean (Fig. 1). The abundance of wave-supplied salt spray drastically increased corrosion close to shore.

The test also examined the variability of corrosion rate with elevation. On the oceanfront (80-foot) lot, the corrosion rate increased from ground level to a maximum at about 10 feet above grade and then decreased.

Other tests evaluated the direction of exposure relative to the ocean and various degrees of sheltering. A roof was constructed over the test plates (Fig. 2). Samples faced all compass directions, the east side facing the ocean. As expected, the east side had the highest corrosion rates—four times higher than the lowest rates on the west side.

LaQue tested the effects of sheltering by varying the height of the plates beneath the shelter. The highest plates were partially protected by the roof; the lowest samples received little protection. But the corrosion rate did not increase with exposure. The worst conditions occurred under partial shelter (Fig. 2). The corrosion rate was three times higher under partial shelter than full exposure. Two factors account for the increase. The salt on exposed surfaces is washed away by rainfall. Partial shelter allows almost as much incoming salt spray as full exposure, but the shielding from rainfall allows for a greater concentration of salt. A second factor is the time of surface dampness. Fully exposed surfaces are dried by the sun. Partial shelter allows the shaded surface to stay damp for longer periods, increasing the total amount of corrosion.

Typical corrosion problems

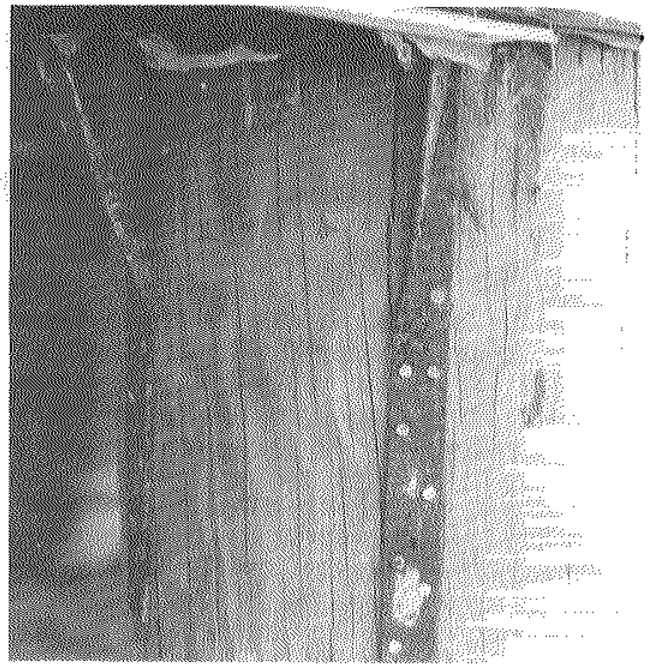
Rapid corrosion can be an expensive surprise to those living and working near the coast. Products and materials that might last many years five to 10 miles inland can deteriorate rapidly in salt air. Conditions are most severe around large bodies of salt water, sound or ocean, with regularly breaking waves and onshore breezes. But corrosion rates will be increased by salt air for several miles inland.

An oceanfront home or building on pilings stands in the shoreline's most corrosive zone, according to the LaQue tests. Its proximity to the ocean, elevation and open, partially sheltered lower level qualify it for this distinction.

Corrosion can be a problem even in wood-frame buildings. Although properly maintained wood is not affected, the metal fasteners and connectors holding it together are. Nails, screws, nuts and bolts require more frequent maintenance and/or periodic replacement. The need for replacement usually occurs gradually and is obvious during cleaning, painting or other regular maintenance.

Of particular concern is the corrosion of wind anchors or hurricane straps that hold the building together in extreme winds. These sheet-metal straps are recommended to resist hurricane-force winds and are widely used in North Carolina and other coastal regions. When new, the straps are effective and very inexpensive protection.

Unfortunately, the susceptibility of the straps to corrosion has been overlooked. In open, under-house exposures, the sheet-metal straps can lose all structural strength in five years. Since they are only needed in extreme winds and are cosmetically hidden from the owner's view, the straps are not readily maintained. Visibly rusted straps should be replaced before hurricane season. For more details on corrosion-resistant methods, send for UNC Sea Grant's *Blueprint*, "Wooden Wind Anchors for Hurricane Resistant Construction Near the Ocean" (UNC-SG-BP-84-3).



Metal wind anchors can corrode and lose strength

Corrosion problems also are common with heat exchangers used in air conditioners and heat pumps. Often the unit is placed under the building where corrosion is most severe. Almost all metal windows, doors, hinges, electrical fixtures and metal gutters will show the effects of corrosion. Window screens usually require frequent replacement. And cars in use near the coast inevitably show the effects of a salt-spray environment.

Living with corrosion: prevention

To cope with the problems of corrosion, the coastal property owner has several choices. The owner can use regular materials, expecting higher repair and replacement costs. Alternately, an owner can take preventive steps to extend the life of his metal products. Or, the owner can purchase corrosion-resistant products, anticipating any increase in initial cost may be offset by lower maintenance and replacement fees.

Galvanizing common steel can extend inexpensively the useful life of many products. Galvanizing coats steel with a layer of zinc. The high temperature process melts the boundary layer between the steel and zinc to form a tight bond. Tests show that zinc corrodes about 20 times slower in salt air than common steel alloys. The thicker the galvanizing coating, the longer lasting the protection.

The sacrificial ability of galvanizing sets it apart from other coatings and paints. When a scratch occurs, the zinc coating corrodes faster than steel and deposits material in the scratch to seal it. Galvanizing can be thought of as a self-healing coating. Most other coatings actually make the scratched area rust faster.

Two types of galvanizing exist. Using an electrical current, electroplating coats the object with a thin layer of zinc. The surface color is usually glossy gray. Electroplating is used frequently for nails and other small objects. Hurricane straps and other sheet metal connectors are electroplated.

Many steel objects can be galvanized by a chemical process that dips the object in hot molten zinc. A coating five or more times thicker is applied, leaving the surface duller and rougher than electroplating. The thicker the galvanizing the longer the material will be protected. Heavy hot-dipped galvanizing is preferred and can last 20 to 30 years in the worst atmospheric conditions. However, the galvanizing will not last as long as the useful life of a building constructed near the ocean. Maintenance and/or replacement will eventually be necessary.

Metal alloys have been developed for improved corrosion resistance. Although all stainless steel alloys are not suited for salt air, two widely distributed grades, identified by the numbers 304 and 316, have proved resistant. After 40 years of oceanfront exposure at Kure Beach, test samples lost their luster, but no rusting or loss of strength occurred. Stainless steel nails, nuts and bolts can be purchased at a premium cost. Wind anchors, hurricane straps and other sheet metal connectors may be ordered from stainless steel manufacturers. These may be worth the extra cost because connectors are difficult to maintain and replace. Nails are also available in Monel, a nickel-copper alloy that withstands salt air.

Aluminum, commonly used in buildings for such purposes as storm windows and doors, is relatively reactive in air, immediately forming a thin oxide layer over its surface. The oxide layer protects the metal from further corrosion. Any scratches are quickly oxidized again. Despite a protective coating, aluminum products corrode faster in salt air than in non-salt air. Excellent corrosion-resistant alloys have been developed for ship building and bulkheading but are not widely available in standard building products. Aluminum may be anodized, an electrochemical surface treatment, to reduce corrosion.

The combination of two different metals can sometimes cause rapid corrosion to occur. For instance, the use of brass screws to attach an aluminum frame results in rapid corrosion of the aluminum. Whenever possible, avoid the use of dissimilar metals together. In the example, aluminum screws are preferred. Stainless steel reacts less with aluminum than brass and would be an acceptable alternative. Monel should not be used with aluminum or galvanized steel.

Frequently corrosion problems with doors and windows are caused by hardware—hinges, locks and latches. Steel hardware is frequently bare or plated with brass or cadmium. These materials are highly corrosive in salt air. Solid brass hinges and other hardware are readily available and are more corrosion resistant. Stainless steel hardware also may be available. One manufacturer of sliding glass doors offers a kit with stainless steel rollers and other hardware that can be installed in their standard doors.

According to the LaQue Center tests, heat exchangers and air conditioning units would be better located on the landward side of the building. There, they would be sheltered from salt spray and exposed to rainfall. Periodic hosing with fresh water can help. When not used for extended periods, heat pumps and air conditioners under houses should be rinsed, coated with a light aerosol oil and protected with plastic cloth or other airtight barriers. Protecting the heat exchanger fins is particularly important. Corrosion by-products accumulate on the fins, reducing the efficiency of the unit and increasing your electric bill long before the equipment actually fails. Equipment maintenance agreements are always a better buy near the beach.

Metal chimneys for fireplaces and stoves are in wide use along the coast. Although some parts of the flues are made of stainless steel, most chimneys have galvanized or aluminized exteriors, internal spacers and caps. Complete stainless steel chimneys are desirable, but are not readily available to fit most fireplaces. If a metal chimney is used near the ocean, it will probably have corrosion-prone parts. Although the fireplaces and stoves may not be used frequently, it is important to inspect the chimney regularly, specifically looking for corrosion. Chimney sweeps and local fire departments are usually available for annual inspections.

Common window screen is galvanized steel. More corrosion-resistant alloys and fiberglass are available. Some alternative products may be harder to install or not as strong. For instance, fiberglass screen, although more corrosion-resistant, is not very strong. Check with your hardware dealer.

No cure exists for the rusting car. To delay rust, wash and wax the car regularly. Be sure to rinse the underside and other hard-to-reach surfaces where salt spray can accumulate. Park the car in an enclosed garage or keep it sheltered from salt spray as much as possible.

Corrosion and decay of products in marine environments is inevitable. But the problems created can be reduced by understanding the causes of corrosion, planning for preventive maintenance and spending extra money for more resistant materials.

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