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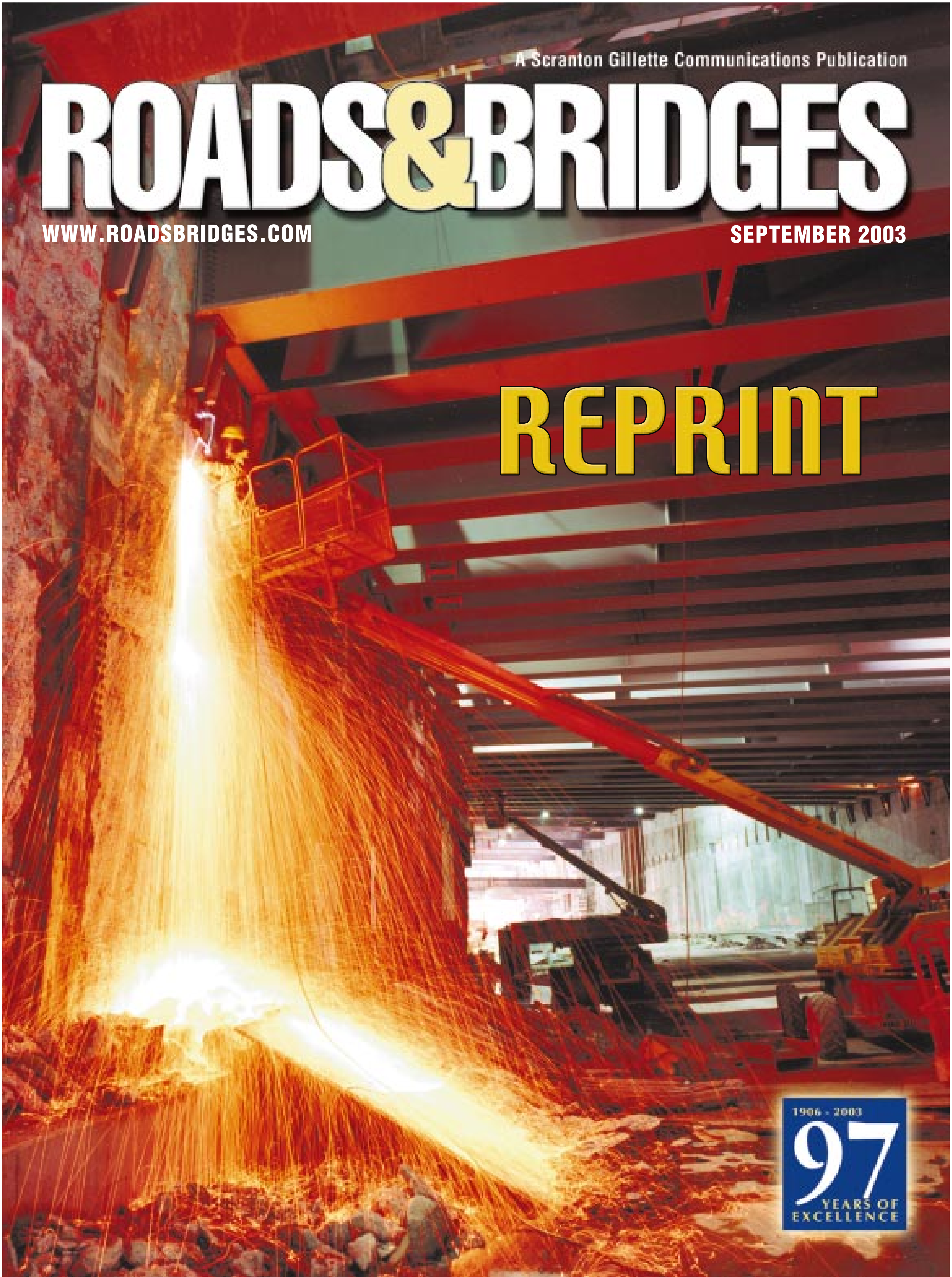

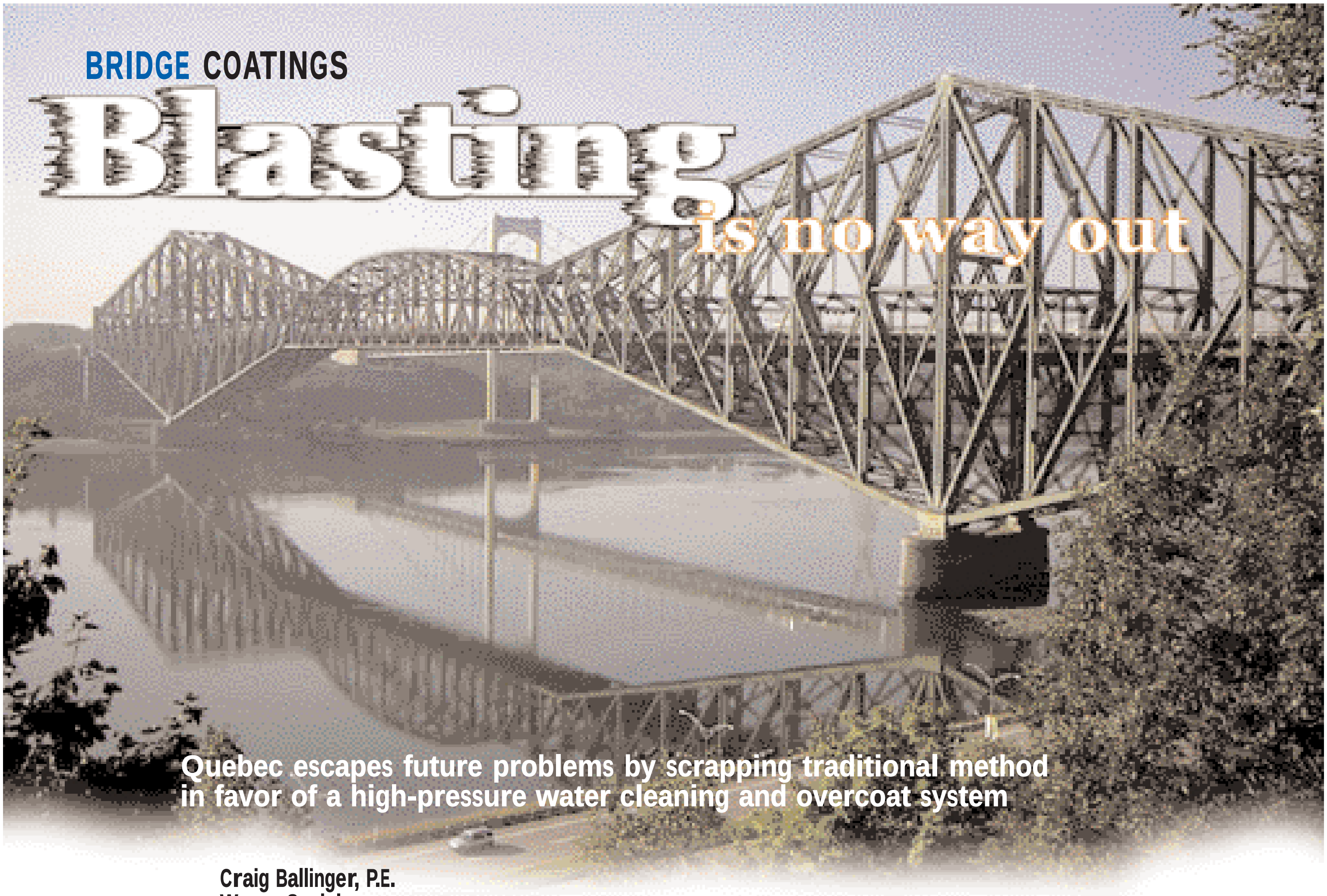

Blasting is no way out

Quebec escapes future problems by scrapping traditional method in favor of a high-pressure water cleaning and overcoat system

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For more than 100 years steel bridges have been erected throughout the world—fascinating structures with wonderful histories like the Brooklyn Bridge in New York and the Golden Gate Bridge in San Francisco. Structures that families put their blood, sweat and tears to erect, and states and cites have used to develop reputations.

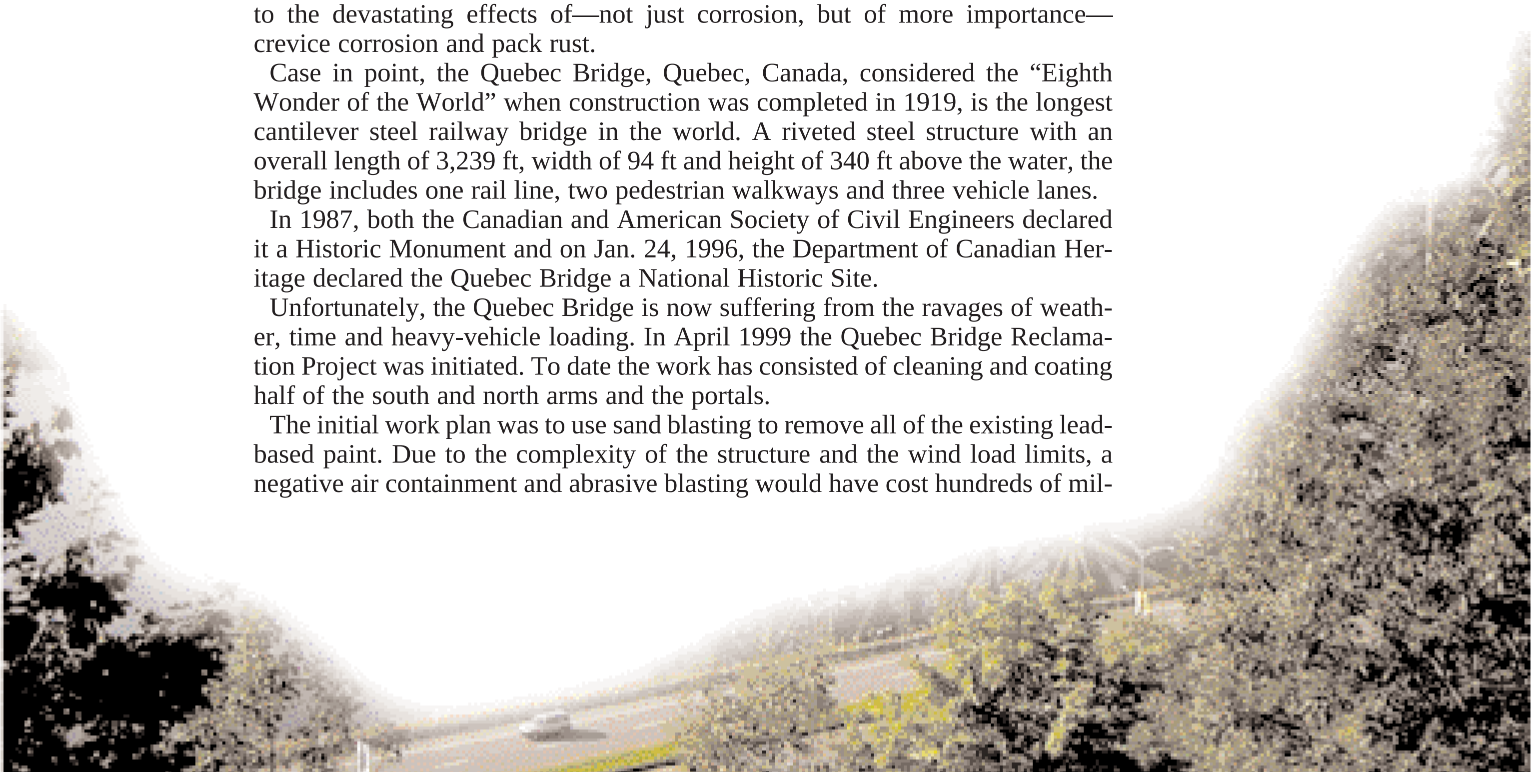
However, these incredible structures are deteriorating in front of our eyes due to the devastating effects of—not just corrosion, but of more importance—crevice corrosion and pack rust.

Case in point, the Quebec Bridge, Quebec, Canada, considered the "Eighth Wonder of the World" when construction was completed in 1919, is the longest cantilever steel railway bridge in the world. A riveted steel structure with an overall length of 3,239 ft, width of 94 ft and height of 340 ft above the water, the bridge includes one rail line, two pedestrian walkways and three vehicle lanes.

In 1987, both the Canadian and American Society of Civil Engineers declared it a Historic Monument and on Jan. 24, 1996, the Department of Canadian Heritage declared the Quebec Bridge a National Historic Site.

Unfortunately, the Quebec Bridge is now suffering from the ravages of weather, time and heavy-vehicle loading. In April 1999 the Quebec Bridge Reclamation Project was initiated. To date the work has consisted of cleaning and coating half of the south and north arms and the portals.

The initial work plan was to use sand blasting to remove all of the existing lead-based paint. Due to the complexity of the structure and the wind load limits, a negative air containment and abrasive blasting would have cost hundreds of mil-



lions of dollars. By using high-pressure water cleaning and selective UHP water jetting followed by an overcoat system supplied by Termarust Technologies, the owner was able to substantially reduce the cost of cleaning and coating the historic Quebec Bridge.

Breaking through paint

Crevice corrosion and pack rust create serious structural problems and can seriously affect the load capacity and structural stability of bridges. The rate of corrosion within crevices can be 400 times greater than corrosion on flat surfaces that are open to the ambient atmospheric conditions. Research on reinforcing bars in concrete bridge decks has found that for every mil loss of steel cross section there is 10 mil (i.e., 10x) increase in corrosion product. This is why pack rust can rapidly develop and cause considerable forces to be exerted against adjacent steel members and their rivet or bolt fasteners.

Metallic corrosion can produce very corrosive environments through the chemical change of water into acid, called hydrolysis. This phenomenon is particularly noticeable when the environment is confined, such as in most forms of localized corrosion (pitting, crevice, environmental cracking).

As in a pitting corrosion attack, coating systems which rely on passive surface films for corrosion resistance can be particularly vulnerable to this mode of corrosion. The highly corrosive micro environment of crevices tends to be similar to the micro environment which exists at the base of corrosion pits. Crevice corrosion is usually a result of a differential oxygen concentration cell in which the mouth of the crevice is richer in oxygen than the metal interface within the crevice. It then becomes anodic and dissolves. Subsequent pH shifts within the crevice may lead to an even more intensified attack associated with the induction (initiation) and propagation phases of the corrosion cycle.

The chemical change in question is true of most metals since the metallic ions produced by the corrosion process are not soluble in their ionic forms. The ions will then react and form more stable species such as oxides and hydroxides. In aerated environments iron oxidizes to ferric ions that subsequently react with water.

Many of our older (especially truss) bridges have not been painted for many years, specifically because painting does not stop the development of crevice corrosion and pack rust in inaccessible places, such as between steel members that are connected with bolts or rivets.

Pack rust can rapidly develop and cause considerable forces to be exerted against adjacent steel members.

A little history of the Quebec Bridge:

- Initial construction commenced in 1900;
- Aug. 29, 1907: Due to design changes during construction that significantly increased the weight of the structure, the south anchor arm and a portion of the center span failed catastrophically;
- September 1916: While being raised into position, the prefabricated center span fell into the St. Laurence River;
- September 1917: The second Quebec Bridge was completed at a total cost of $25 million; and
- 1919: Structure was completed and considered the “Eighth Wonder of the World.”

Could pack rust contribute to the collapse of a bridge? The answer is yes. From the analysis of structural failures it has been found that in almost all cases failures are the result of a combination of effects. There is no question that pack rust can severely distort steel members and overstress fasteners—to the point that a combination of load effects can be critical (e.g., overweight vehicles, wind loads, cold temperatures and earthquakes).

The old National Bridge Inventory System (NBIS) bridge inspection criteria did not include an assessment of the level and severity of crevice corrosion and pack rust, and thus its ramification as a structural problem was often not recognized as being important.

The fact that pack rust can be a structural problem is highlighted by the new PONTIS bridge evaluation criteria, which included a ‘Smart Flag’ for pack rust. Now, when severe pack rust is found there is a requirement that the bride be analyzed to determine the effect of pack rust on the load capacity and structural stability.

Lots of connections, and rust

It is important to recognize why crevice corrosion and pack rust cannot be stopped by sand blasting to remove existing paint and cleaning the steel members before using inactive film forming coatings or sealants on the connections.

First, sand blasting will not remove the corrosion products in inaccessible areas. Second, the active corrosion cells (within crevices) include water, oxygen and hydrochloric acid (and sometimes also nitric and sulfuric acids). The corrosion process will not be stopped by caulking or sealing up of the exterior edges of the connections. In fact, within the connections there are oxygen concentration cells, which are created when sealing up connections. If connections are sealed up without treating them with an active chemistry to neutralize the acids, displace the moisture and scavenge the oxygen it will actually accelerate the development of protons which in turn creates more acid, thereby driving the corrosion process within the space between the steel members. Sealing up the joint without

members. Sealing up the joint without doing something to neutralize the active corrosion product in the joint actually accelerates the corrosion.

This is why meticulous cleaning of the outer steel surfaces of bridges then painting them with a three-coat zinc-based coating system does not work for maintenance painting of crevice corroded bridges. The three-coat zinc-based type of coating system does not chemically deal with the corrosion process that exists within connections, and this type of coating system frequently fails at the joints and connections within six months to a year. The result is rust leaking from within the connections onto the exterior surfaces of the bridge. It is important to recognize that there is a solution to this problem.

All-access protection

Corrosion in inaccessible places that can reduce the load capacity and structural stability of structures that contain built-up members, splices and connections can be stopped.

The widespread existence and the potential severity of crevice corrosion and pack rust on steel bridges and structures can be chemically stopped with a Reacted Alkaline Viscolastic Calcium Sulfonate (RAVCS) coating system.

This system has been used on major highway and railroad bridges throughout the U.S. and Canada—on structures that had major pack rust problems. Where the coatings are between five and 11 years old there is no corrosion, including the crevice corroded joints and connections. Development of pack rust has been stopped.

The Termarust Technologies' Reacted Alkaline Viscolastic Calcium Sulfonate-based coating system (which has a pH of 10.5) includes:

1. A RAVCS penetrant/sealer which pulls itself into the connections (by polar attraction) and then neutralizes the acid in the crevice corroded joint; and
2. A RAVCS topcoat material that stops corrosion on the surface of the steel. In addition this is an excellent one-coat (three-step) "overcoat" coating system that is applied wet-on-wet and requires only minimal surface preparation to remove only loose paint and debris.

Maintaining the structural stability of bridges is important to the safety of all and it is important to recognize that there is an affordable solution to the problem of crevice corrosion and pack rust. RB

Ballinger is a structural engineer. Senick is a steel reclamation specialist. Both work for Termarust Technologies, Anjou, Quebec. This story was presented at the 20th Annual International Bridge Conference.

Quebec Bridge

CASE HISTORY

Type of Project: Rehabilitation and strengthening of the deteriorating structure; which included overcoating the existing paint system.

Project Description: Lead abatement project utilizing Ultra-High Pressure Water Jetting (35,000 - 40,000 psi) and High Pressure Water Washing (5,000 - 6,000 psi) with particular attention being paid to crevice corroded joints and connections.

Reason Project was Undertaken: To retrofit, strengthen, protect and extend the service life of the structure for 50 years.

Name and Location of Facility: Quebec Bridge: Mile 2.70 Bridge Sub-division Quebec City, Quebec Canada.

Project Start and Completion Dates: Start: 1997 - Completion: 2007

Service Environment: Temperature: -40C to + 40C (-40F to +104F) Bridge roadways are heavily salted in winter - over the St. Lawrence River.

Surface Preparation Methods, Degree of Cleaning: Splash zone - SSPC-SP12-WJ3L-SC2 except in areas where tightly adhered coating exists and the interiors of boxes.

Remaining structure: SSPC-SP12-WJ4-SC2

Coating System, Number of Coats, Dry Film Thickness per Coat, etc.: Termarust Series 2200 RAVCS® Penetrant/Sealer is applied to all joints and connections.
1) Non Splash Zone. Spot Prime: 2 - 3 mils DFT. Topcoat: 5 - 7 mils DFT
2) Splash Zone. Spot Prime: 5 - 7 mils DFT. Topcoat: 5 - 7 mils DFT
Note: All materials are applied as a single coat wet-on-wet system

Coating application methods, equipment: The Termarust RAVCS® Penetrant/Sealer and Topcoat are being applied using airless spray, brush and rollers.

Safety and Environmental Protection Measures: Lead paint and water were collected, filtered and recycled using a centrafuge and filter system. Flow-through tarps, which could be lowered during high wind periods, were utilized to contain the paint chips and water.

Unusual Job conditions: The large size and complex nature of the structural design required special procedures for collecting and handling hazardous paint material. Paint materials were delivered to locations on the structure through a lengthy system of pipes and hoses, which would have been impossible if traditional paint systems had been used.

Evidence of good performance: At this time (4 years into the project) the Termarust coating system is performing as specified and expected, with no warranty claims.

Why Termarust was used: Only the Termarust coating system met the contract requirements of:
1) A 5-year warranty which included leakage from crevice corroded joints and connections.
2) A 25-year service life without totally removing tightly adhered rust and aged existing paint.
3) Cost savings of $140,000,000.00 using Termarust Technologies system versus sand blasting and three-coat zinc system.