conference preview

HIGH-PERFORMANCE STEEL BRIDGE COATING OPTIONS

BY ROBERT KOGLER AND LAURA ERICKSON

There's more than one way to coat a bridge.

INDUSTRIAL PAINT SYSTEMS have been and continue to be the workhorse corrosion protection system for steel highway bridges.

For about the first 100 years of steel bridge construction, paint systems consisted of primarily simple, single-package, easy-to-apply, inexpensive, lead-containing paints. The lead pigment served as a corrosion inhibitor, and these coatings were easy to use in both new construction and maintenance painting applications. They were typically applied directly over intact mill scale and were used as a "one-size-fits-all" corrosion protection system.

Several key factors came together during the 1970s and 1980s to force the evolution of bridge painting systems toward the much more durable systems in use today. The advent of high-production centrifugal blasting equipment coupled with increased demands by bridge owners for durability allowed for truly clean, profiled surfaces for paint application—thus opening the door for use of high-performance coating systems. Additionally, concerns over environmental and worker health and safety issues associated with lead-containing paints helped force change.

Specifically, zinc-rich coating systems eventually became the standard due to their greatly improved performance in salt-rich environments. With the continuous pressure on owners to maintain open roads and "dry pavement" at all times in all seasons, the use of deicing chemicals increased the demands on corrosion protection systems nationwide. These factors conspired against the older steel bridges painted with no surface preparation and mediocre paint. When the use of deicers increased dramatically, these older systems were ill-suited to perform for long periods of time, and the condition of the steel bridge inventory suffered. However, for those structures built or repainted more recently with modern paint systems, performance has dramatically improved. So it is important to note that when considering design options for new or replacement bridges, the historical corrosion protection performance of a "painted steel bridge" in a specific environment will likely not be representative of the improved performance expected from a more modern "high-performance coating system" in the same bridge today.


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Zinc-Rich Systems

The shift to zinc-rich coatings as the primary steel bridge corrosion protection system has greatly increased the performance of painted steel in salt-rich environments. This includes bridges located on the coast or exposed to chemical-containing runoff, drainage and traffic splash in areas that receive significant deicing treatment in the winter. While real-time data regarding performance of modern paint systems is difficult to find, there is a significant body of published information (from the American Galvanizers Association, the Society for Protective Coatings, the Federal Highway Administration, the American Society for Testing and Materials and others) indicating that better zinc-rich paint systems last 20 years or longer in harsh marine environments (and likewise in the areas and details of non-marine bridges that are directly impacted by deicing chemicals). In fact, FHWA recently revisited the "Corrosion Protection of Steel Bridges" section of the *Steel Bridge Design Handbook*, Volume 19 specifically to enhance the discussion on performance of modern bridge coatings. This revision is presently in final review and should be published in late 2015.

Also important to modern coating performance is the fact that "failure" of these types of sacrificial paint systems is typically localized on the structure. Except for in the harshest marine exposures, there are usually specific areas of the structure that show coating breakdown and corrosion first, before the vast majority of the steel. These "micro-environments" concentrate the factors that drive coating breakdown and corrosion. The areas directly beneath failed or open deck joints, members directly in the way of traffic splash or details that tend to trap and hold debris, moisture and salts are usually the leading areas for failure. By identifying these areas in maintenance practices, the life-cycle maintenance burden of the structure can be focused on and greatly reduced when compared to the traditional approach of a regular blast and repaint cycle for the entire bridge, which is taken with so many older structures.

One Size does not Fit All

For continued progress in corrosion protection, bridge owners must get over the mindset that there is only one approach for corrosion protection. Many states have maintained a list of several different acceptable paint systems over the years. Typically, the various systems are targeted toward different required levels of durability, and for states that have many bridges in areas that are far from natural salt water and do not deice, this approach seems like a rational way to decrease the cost associated with coatings on the lower performance end. However, with ever-increasing performance demands in more corrosive applications, owners are increasingly looking toward use of hot-dip galvanizing and metalizing to enhance steel corrosion protection in a more targeted manner. The data available for both galvanizing and metalizing show excellent long-term performance, even indicating up to 40 years of protection for metalized exposed steel in marine environments. For many structures, this level of performance represents the potential for a "life of structure" corrosion protection system applied on new construction. That value proposition is gaining recognition within the owner and fabricator community, particularly for bridges in severe marine environments.

The next logical step in this evolution of coatings is to move toward the application of corrosion protection systems to specific bridge elements on an as-needed basis. That is, the areas of the bridge expected to be impacted by high levels of salt and moisture can be constructed with an appropriately durable coating system, while other areas expected to have a far less severe service environment can be fabricated with a less costly (and more efficiently constructed) system. Some possibilities include:

- priming interior girders with zinc-rich coatings and applying topcoats to fascia beams only
- preferential galvanizing or metalizing of bridge elements or areas known to have more corrosion incidents than the bulk of the bridge (e.g., beam ends under joints or horizontal members)
- the use of topcoats over galvanizing and metalizing in very aggressive environments

Corrosive Environments and Design Detailing

Bridge corrosion protection design must consider not only the macro-environment (e.g., marine, heavy deicing, urban, rural, etc.) but also, and perhaps more importantly, the micro-environments created by the detailing of the structure—e.g., the specifics of designed drainage, unintentional (but likely) life-cycle drainage paths caused by failed deck joints and splash created by traffic (both vertically and laterally) by considering these areas up front in the design process, these potential problem areas can be minimized or addressed specific high-durability coating treatments if not fully eliminated.

This general approach has already become increasingly popular for primarily aesthetic reasons. The beam ends of weathering steel bridge members are frequently painted as a risk mitigation measure for anticipating deck joint failure or to prevent staining of concrete in the vicinity. Also, fascia beams are frequently painted for aesthetics while the remainder of the members (out of obvious public view) are left as bare weathering steel. This general approach of selective application could provide a benefit for the many bridges constructed in non-marine areas that have only specific areas and details expected to require periodic maintenance repainting.

Details to Consider (and Avoid)

There are many steel bridge details on existing structures that have played a role in the initial failure of coating systems and have driven the need for maintenance actions. Built-up riveted members and boxes with lacing bars used in older designs tend to trap moisture and debris, causing coating breakdown and pack rust, and are notoriously difficult to clean and re-coat. The good news is that the majority of these details are no longer frequently employed on modern steel bridge designs, and there are a few items to consider that can provide a significant long-term benefit.

For example, splice and cover plates should be designed to consider as-constructed drainage paths for salt carrying water on flanges. The leading edges of these plates can either act as a dam and collection area for debris or, depending on fabrication angle, as an effective "drip bar" helping to move water off of the steel. Snipes in stiffeners have the same issue. A snipe small enough to easily become clogged with debris over time will create a small, focused area of coating failure and eventual corrosion. Welds should not leave small gaps between members that may serve as moisture traps to initiate corrosion. Smaller cross frames should also be placed in such a manner that allows proper access for blasting, painting and inspection (at least several inches apart).

Long-term durability in modern steel bridge design requires consideration of the global or macro-environment for the bridge location, but also important is the use of proper selection of modern, high-durability coatings and considerate design detailing to mitigate areas and details that present known risks for corrosion initiation. The high level of performance of modern zinc-rich coatings is significant when compared to the older "paint-over-the-mill-scale" approach, which has created the recent maintenance burden in the existing bridge inventory. ■

This article is a preview of Session B6 "High-Performance Steel Bridge Coating Options" at NASCC: The Steel Conference, taking place March 25-27 in Nashville. Learn more about the conference at www.aisc.org/nascc.