DEPARTMENT OF TRANSPORTATION

Transportation Research Synthesis

Minnesota Department of Transportation
Office of Research & Innovation
651-366-3780
www.mndot.gov/research

TRS 2302

February 2023

USE OF HOT WATER PRESSURE WASH SURFACE PREPARATION AND HRCSA COATINGS IN BRIDGE MAINTENANCE

Prepared by Xiaoning Qi
Department of Coatings and Polymeric Materials
North Dakota State University, Fargo, ND

In this Transportation Research Synthesis (TRS), state-of-the-art practice of highway bridge maintenance painting using high-ratio calcium sulfonate alkyd (HRCSA) and hot water pressure wash (HWPW) is reviewed and different state DOTs are surveyed.

Technical Report Documentation Page

1. Report No.	2.	3. Recipients Accession No.
TRS2302		

4. Title and Subtitle	5. Report Date
Use of Hot Water Pressure Wash Surface Preparation and HRCSA Coatings in Bridge Maintenance	February 2023
	6.
7. Author(s) Xiaoning Qi	8. Performing Organization Report No.
9. Performing Organization Name and Address Department of Coatings and Polymeric Materials North Dakota State University 1735 NDSU Research Park Drive / Fargo, ND 58102 / USA	10. Project/Task/Work Unit No.
	11. Contract (C) or Grant (G) No. (c) 1036338 (wo) 3
12. Sponsoring Organization Name and Address Minnesota Department of Transportation Office of Research & Innovation 395 John Ireland Boulevard, MS 330 St. Paul, Minnesota 55155-1899	13. Type of Report and Period Covered Transportation Research Synthesis
	14. Sponsoring Agency Code

15. Supplementary Notes

http://mdl.mndot.gov/

16. Abstract (Limit: 250 words)

In this Transportation Research Synthesis (TRS), state-of-the-art practice of highway bridge maintenance painting using high-ratio calcium sulfonate alkyd (HRCSA) and hot water pressure wash (HWPW) is reviewed and different state DOTs are surveyed. In summary, low-toxic HRCSA causes less pollution, eliminates waiting time between layers of coatings, and performs well for corrosion prevention. However, like any other protective coating system, optimum HRCSA performance requires following the manufacturer’s specifications. Contrary to what the term “one-coat system” may suggest, HRCSA application is a multi-step process that requires HWPW surface preparation. Based on the literature review and survey findings, without further testing and trials, HRCSA is recommended only for maintenance tasks that can strictly fulfill the manufacturer’s specifications, i.e., an initial HWPW followed by the multi-step process and sufficient drying time before an extreme weather event.

17. Document Analysis/Descriptors	18. Availability Statement
Bridges, Coatings, Surface preparation, Alkyd resins, Sealing compounds, Rusting, Corrosion	No restrictions. Document available from: National Technical Information Services, Alexandria, Virginia 22312

19. Security Class (this report)	20. Security Class (this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	72	

Technical Advisory Panel

Xiaoning Qi, Principal Investigator
North Dakota State University

Sarah Sondag, Technical Liaison
MnDOT Bridge Office

Andrew Fritz, Panel Member
MnDOT Bridge Office

Yuying(Betty) Hu, Panel Member
MnDOT Bridge Office

Elizabeth Klemann, Panel Member
MnDOT Bridge Office

Joseph Podobinski, Panel Member
MnDOT Bridge Office

Barbara Fraley, Project Coordinator
MnDOT Research and Innovation

1 Table of Contents

Use of Hot Water Pressure Wash Surface Preparation and HRCSA Coatings in Bridge Maintenance

1 Executive Summary

This Transportation Research Synthesis (TRS) reviews state-of-the-art practice of highway bridge maintenance painting using high-ratio calcium sulfonate alkyd (HRCSA) and hot water pressure wash (HWPW) and surveys different state DOTs.

As a bridge maintenance coating, HRCSA has a relatively small DOT user base. HRCSA differentiates itself from generic CSAs (calcium sulfonate alkyd) by a claimed higher total base number (TBN) and sulfonate content. As a more environment-friendly bridge maintenance painting solution, the one-coat process of HRCSA uses less solvent and toxic chemicals and eliminates the drying time needed between layers of a three-coat system. But it is still a multi-step process that could require most, if not all, of the following steps: surface preparation, applying a penetrating sealer, stripe coating/caulking, and applying a wet-on-wet topcoat. In addition, to optimize HRCSA performance, the surface needs to be cleaned with a HWPW using specialized equipment to remove rust and salt contamination.

One major drawback of HRCSA is its slow ambience-dependent drying time that could result in multiple performance issues, including soft final coating, substantial dirt pickup and retention, and premature mechanical damage. HRCSA is also prone to coating defects related to extreme temperatures. Survey results show these drying related issues as reasons for some DOTs not choosing HRCSA. On the other hand, the long curing time and soft nature of the HRCSA system may be advantageous to crevice corrosion and pack rust mitigation. HRCSA may increase crevice pH by slowly releasing calcium carbonate as a corrosion inhibitor.

In summary, low-toxic HRCSA causes less pollution, eliminates waiting time between layers of coatings, and performs well for corrosion prevention. However, like any other protective coating system, optimum HRCSA performance requires following the manufacturer's specifications. Contrary to what the term "one-coat system" may suggest, HRCSA application is a multi-step process that requires HWPW surface preparation. Deviation from this process may affect performance. In addition, its long ambience-dependent drying time after application makes HRCSA vulnerable to several common coating defects and the film could remain soft for an unacceptable amount of time. Therefore, besides following the multi-step process including using HWPW, careful planning is necessary to account for uncontrollable climate factors.

Based on the literature review and survey findings, without further testing and trials, HRCSA is recommended only for maintenance tasks that can strictly fulfill the manufacturer's specifications, i.e., an initial HWPW followed by the multi-step process and sufficient drying time before an extreme weather event. However, further laboratory and field tests are recommended to determine HRCSA's practical suitability for various bridge maintenance conditions and scenarios MnDOT commonly encounters.

2 Literature Review

2.1 Introduction

Steel highway bridge members are constantly exposed to aggressive environments: moisture, extreme temperatures, de-icing salt, etc. If left untreated, they are often susceptible to corrosion damage, leading to economic loss and even catastrophic failure. To mitigate corrosion and environmental damage of the steel members, a protective coating system is the most versatile and effective. Historically, red lead alkyd paints have successfully protected the steel for decades [1]. As the lead paint phased out due to its toxicity, newer coating systems use multiple layers of coatings on a properly prepared surface to provide the same level of protection. More recent bridges are typically coated with a three-coat system consisting of a zinc-rich primer, an epoxy tie coat, and an aliphatic polyurethane topcoat, with the substrate prepared to near white as specified by SSPC-SP10. According to a FHWA study [2], the three-coat system still out-performs other bridge coating systems. However, these three-coat systems require stricter surface preparation when it comes to maintaining existing bridges, such as removing the old paint and mill scale that would add additional cost for equipment, personnel, waste containment, traffic management, etc. The fact that many of these aged bridges have lead paint also makes the containment more costly and challenging.

Overcoating existing bridge coatings has been practiced to reduce both the cost and the potential environmental impact. The common practice of overcoating is to clean the general area of the existing coating surface and only locally remove coatings that are not sufficiently adhered to the steel surface. In overcoating situations, a one-coat calcium sulfonate alkyd (CSA) has many advantages, especially its tolerance to non-ideal surfaces.

One-coat systems, though not having the same performance as three-coat systems, provide benefits such as low cost and short waiting time between application steps, which leads to less traffic control needed. Assisted by a low-viscosity penetrating sealer and a stripe coat, one-coat systems such as CSAs often are the best candidate for mitigating pack rust, especially for inaccessible locations, such as crevices between joints. High-ratio calcium sulfonate alkyd (HRCSA) is a proprietary commercial CSA product described to have two unique properties: higher active sulfonate content and total base number, which differentiate itself from generic CSAs. Additionally, to reach its optimum performance, a one-coat CSA/HRCSA system requires the surface to be pressure washed preferably with hot water (e.g., 140 ˚F) to remove loose rust/paint and salt contamination. A significant shortcoming of a CSA/HRCSA coating is its environment-dependent long curing time, resulting in its remaining soft for a long time, and being prone to dirt-pickup and premature mechanical damage. The long curing time and soft nature of a CSA/HRCSA system need to be carefully considered to avoid a decision being made solely on its corrosion mitigation performance.

This literature review is intended to provide a summary of current state-of-the-art application of HRCSA in combination with HWPW for maintaining steel bridge structures. The summary will assist MnDOT's further decision on whether to adopt HRCSA and HWPW as part of its bridge maintenance practice. The review comprises steel bridge surface preparation, crevice corrosion and pack rust, generic CSA coatings, and cases of HRCSA coatings. HRCSA is exclusively used for infrastructures such as bridges and penstocks. Generic CSAs have been used in the automotive industry for their ability to wet crevices.

2.2 Surface Preparation for Steel Bridges

Surface preparation is one of the most critical steps for any coating system to perform up to its potential. Oftentimes inadequate surface preparation is to blame for a failed coating job. As an effort between the Society for Protective Coatings (SSPC) and the National Association of Corrosion Engineers International (NACE), currently the Association for Materials Protection and Performance (AMPP), there is a series of surface preparation standards. Most common surface preparation practices range from basic solvent cleaning (SSPC-SP1) to hand and power tool cleaning (SSPC-SP2 and SSPC-SP3), to the substantial near-white blast cleaning (SSPC-SP10), which would remove at least 95% of strongly adherent oxide, coatings, and mill scale. Abrasive blasting, specifically SSPC-SP10, is most suitable for newly fabricated steel surfaces, or for spot surface preparation (such as removal and recoating applications) in conjunction with other methods, such as power tool cleaning. The near-white blast cleaning gives an optimum surface for most coating applications. However, it is not always economically feasible due to the requirement of blasting equipment and containment of the debris and blasting medium, especially when maintaining aged steel bridges with lead-containing paints that require very strict waste handling (e.g., negative air containment) and lead level monitoring. For example, the owner of Quebec Bridge used high pressure water cleaning and selective ultra-high pressure water jetting as a cost-saving alternative to abrasive blasting, which would have cost hundreds of millions of dollars [3]. During the Quebec Bridge reclamation process, it was pointed out that abrasive blasting is not capable of removing pack rust which accumulated within the crevices of local structures: rivets, joints, expansion joints, bearings, etc. [4].

In an effort to identify the best practice for bridge preservation, cleaning in different forms are deemed as a critical part of the main activities [5]. Steel bearing maintenance usually comprises cleaning/flushing with low-pressure clean non-potable water, followed by lubrication. For pack rust removal, two methods are recommended: ultra-high pressure waterjetting and soaking pack rust followed by heat treatment [6]. Low-viscosity penetrating sealers, such as HRCSA, are claimed to be able to solidify surface rust and facilitate its removal [7]. When preparing the surface with existing coatings, mill scale removal needs to be considered if optimum performance is desired [8].

Water cleaning, through proper temperature and pressure settings, can also clean large intact existing coated structures without damaging the coating, creating a better overcoating surface. When it comes to preventing pack rust, flushing out the chloride salt and soluble corrosion product will reduce hydrolysis and maintain a favorable alkaline environment for sealer application. SSPC defines a range of waterjet cleaning intensities: from water cleaning (WC) with very little pressure to low-pressure water cleaning (LPWC) at below 5000 psi.

Pressure washing could also potentially be used for removing graffiti. Hot water is often used at around 3000 psi with a flow rate of 3 gallons per minute to remove graffiti, after it is treated with commercial removal/cleaning products. A survey on this application has been done for different DOTs [9]. Environmental impact of surface preparation also needs to be considered, especially when lead paint is involved. Cleaning water often needs to be collected and filtered. Sand filtration was found to be effective with proper sampling and testing lead level [10].

Hot water pressure wash (HWPW) as a surface preparation method, has its advantages on removing salt and oil/greasy surface contamination, compared to ambient water jetting methods. But it adds another safety concern especially if the temperature is reaching boiling temperature. There is not any systematic study on whether an efficient temperature exists for cleaning widely various bridge surfaces: intact/loose coatings, flat rusted areas, crevices with pack rust, etc. At boiling temperature, HWPW also potentially imposes unnecessary stress on existing coatings that are not intended to be removed.

2.3 Crevice Corrosion and Pack Rust

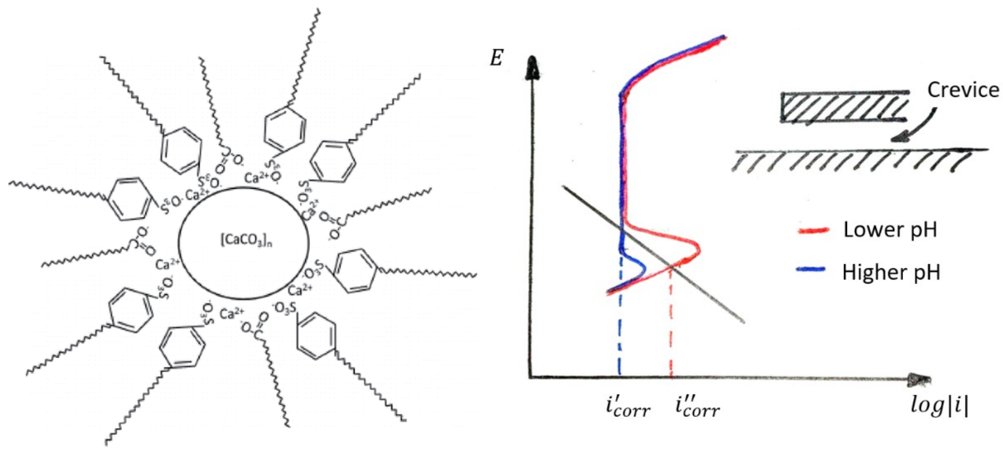


Figure 1. **Left:** the main active component of CSA/HRCSA: crystalline calcium carbonate stabilized by alkyl sulfonate (from reference [11]); **right:** corrosion current shifting with the crevice pH; higher crevice pH corresponding to lower corrosion current, thus slower corrosion.

Pack rust, a consequence of crevice corrosion, could happen at any joint of two materials (one being the corroding metal) that forms an occulated narrow space [12]. When crevice corrosion products accumulate (pack) to the extreme, it could bend joints or impede the movement of a bearing mechanism, causing catastrophic incidents [13]. Crevice corrosion initiates with a differential concentration cell, the anode being inside of the crevice, with lower oxygen concentration due to hindered mass transport. As the crevice corrosion propagates, the lower pH and chloride ions inside the crevice create a very corrosive internal electrolyte (Figure 1 right). The hygroscopic nature of the pack rust makes the mitigation even more difficult.

To mitigate pack rust, the ideal solution is its complete removal, but the more practical and effective approach is to wash the crevice, balance the pH, then seal the crevice. High pressure water cleaning is often recommended because it can reach occluded narrow space better than abrasive blasting. Using hot water, soap, and flash rust inhibitors can also enhance the cleaning efficiency but may cause environmental concerns. Combined with an initial pressure water wash, the application of a low viscosity penetrating sealer is often an effective solution, especially CSA sealers that can increase crevice pH by slowly releasing calcium carbonate as a corrosion inhibitor. HRCSA is expected to perform even better according to the company's description because it has higher total base number and active sulfonate than generic CSAs [14]. On the other hand, sealing/caulking a crevice without changing the internal corrosive electrolyte (flushing out the pack rust and salt contamination) is likely to worsen the corrosion [15]. The requirement of applying a penetrating sealer and caulking with stripe coat also makes the application of the one-coat CSA/HRSA system a multi-step process. Even though the waiting time is minimum between these steps, attributed to the system's wet-on-wet capability, it should not be overlooked.

When it comes to preparing surfaces with existing pack rust, removing the rust is the most critical first step of the surface preparation. Stripe coat sealing the opening of a crevice could slow the corrosion process prior to rust formation, whereas for existing pack rust, the moisture and chloride accumulation inside the crevice makes stripe coat sealing ineffective and could even worsen the corrosion. Removing pack rust is not always practical with power tools or abrasive blasting because of the inaccessible nature of steel bridge elements. Abrasive blasting can only clean where the abrasive medium can reach, leaving most of the trapped salt and pack rust behind. On the other hand, water cleaning could effectively remove loose rust particles and soluble contaminants, especially deicing salt. Higher water pressure often provides higher efficiency on removing loose particles but could pose safety and environmental concerns [16] and remove well-adhered coatings. Compared to cold water high-pressure water cleaning, which is often used to remove solid contaminants and paint, hot water often requires lower pressure due to lower surface tension, better penetration, and higher efficiency on removing oil/grease. Using hot water increases the efficiency but could pose burning hazards and remove coatings intended to be kept. Soap and other additives might be added to the water to make the salt removal more efficient [17], but may cause environmental concerns. An optimum pressure threshold is another critical parameter for pressured water wash (e.g. below 5000 psi for washing and around 5000 to 7000 psi for rust removal) [18, 19]. This optimum pressure threshold needs to be reached for pressure washing to be effective on removing salt contamination. In addition, if the existing paint is lead paint, stricter containment is required. Tarp containment and pump filtering with sand has been practiced [10]. However, the filtration efficiency heavily depends on the containment setup, sand particle size, sand packing density, etc. The filtration process also needs to be constantly monitored and the filtered waste tested to ensure no heavy metals pass through the process. The testing and monitoring of lead level will add to the cost of the process. As indicated on the HRCSA production information website [18], hot water (60 ˚C) pressurized around 7000 psi, with a flow rate of around 6 gallons per minute, sprayed by a rotating tip, could be the optimal setting. Salt removing additives such as vinegar and soap were recommended as well.

As reported in an earlier study [15], several pack rust mitigation and repair strategies were used by the surveyed DOTs: stripe coat, caulking, penetrating sealer, and backer rod. Except penetrating sealers, the other three methods all rely on sealing the outmost opening of a crevice to prevent the penetration of corrosive salt solution into the crevice. A penetrating sealer, on the other hand, penetrates further into the crevice. Not only can it seal the crevice opening, but also change the crevice chemical environment, e.g., increase the pH and replace the salt solution. This also explains why penetrating sealers can potentially be used on structures with an existing pack rust problem. Stripe coating is the most used strategy to mitigate crevice corrosion with 24 states recommending this method in their painting specifications. Caulking is recommended by 13 states and penetrating sealers by 8 states [15, 20]. Among the state DOTs surveyed in studies [15, 20], Oregon removes pack rust by mechanical cleaning, heating water-saturated pack rust to 250 ˚F to 400 ˚F, or using a 35, 000 psi water jet. Missouri uses a calcium sulfonate rust penetrating sealer. Michigan DOT demonstrated an alternative method by heating pack rust to 800 ˚F, loosening it by a rivet hammer, followed by blasting the loose material out [20].

2.4 <u>Comparative Studies on Steel Bridge Coatings that include CSA/HRCSA</u>

Historically, lead paints, usually lead oxide pigmented alkyds, were the most common coatings on existing steel bridges. Despite being very effective protective coatings, lead paints have been banned starting in the 1970s due to their toxicity and environmental impact. There are still ongoing efforts searching for lead paint alternatives. As for now, the three-coat system, with an epoxy zinc-rich primer, a tie coat, and an aliphatic polyurethane topcoat, is still the best performer [2]. However, for the three-coat systems to work the best, the steel surface must be abrasive blasted to SSPC-SP10. This is often done after fabrication and is more suitable for new construction. When it comes to maintaining an existing bridge structure, the surface preparation and the traffic control needed for curing the three layers of coatings make the process very long and costly. From a review conducted in 2019 [20], 35 states require a three-coat system for painting new structural steel. Seven states allow for a two-coat system. Nine states are using NEPCOAT qualified products. For overcoating, several state DOTs (VDOT, MDDOT, PennDOT and NYDOT) choose a proprietary one-coat HRCSA system manufactured by Termarust. A survey conducted for MnDOT in 2014 [21] had a response of 11.9% (5 agencies) stating their use of CSA for corrosion protection based on spot repair and overcoating.

Depending on surface conditions and the preparation needed, the three-coat systems often cost 4-24% of the cost of fabricating the steel [2]. The same FHWA study evaluated 3 three-coat systems, 4 two-coat systems, and a one-coat system. The goal of the study was to find a coating system that can provide 100-year maintenance-free service life, which none of the 8 coating systems could provide. The one-coat system, HRCSA, showed the lowest adhesion (259 psi), which however increased during accelerated laboratory testing (ALT) and natural weathering with daily salt spray (NWS) to 312 psi (ALT) and 506 psi (NWS). These results are not surprising considering the oxidation-based slow curing nature of HRCSA. The HRCSA system showed least rust creepage under ALT, but heavy rust staining under natural weathering (NW) and NWS, implying that the slow curing process has more effect on the corrosion performance than a higher adhesion force. The study concluded that the two best performing systems are the two three-coat systems: inorganic zinc-rich primer/epoxy tie coat/polyurethane topcoat (IOZ/E/PU) and zinc-rich epoxy primer/epoxy tie coat/polyurethane topcoat (ZE/E/PU), with the one-coat HRCSA as the second best.

Another FHWA sponsored study [22] investigated 8 one-coat systems along with a three-coat and a two-coat system. HRCSA showed no rust creepage after 4000 hours of ALT or 24 months of seaside exposure. However, it took the HRCSA system 24 hours to dry to touch and more than 240 hours to dry through. Though the slow drying property might be one of the reasons of HRCSA's good performance, its application needs to be carefully planned to avoid any premature mechanical coating failure. Highlights of HRCSA performance in the study are listed below:

- significant gloss reduction and color change
- pencil hardness stays below 6B
- during ALT, significant dust pickup rendering unclean appearance
- lowest adhesion force but a positive change during weathering
- performed similar to a 3-coat system but showed more blistering
- least rust creepage under ALT, minimum under ME, NW, NWS, but 3-coat and several other coatings performed better under NW and NWS.
- ranked no. 2 in a weighted ranking

A study intended to select paint systems for overcoating bridges concluded that a CSA containing zinc phosphate appears to perform well in accelerated weathering, and was more tolerant to non-ideal surfaces, although it had lower adhesion to steel (400-500 psi) and observed cohesive failure [23].

A study conducted by New Hampshire DOT intended to find alternative lead-free paint systems for maintenance overcoating [24]. The research studied 15 different coatings within 5 types of generic coating systems. Calcium sulfonate systems, SACI based drying and non-drying, performed well over rust, even acid-contaminated rust. However, the CSA systems did not seal well, stayed tacky and soft over two years and had excessive dirt pickup even in the maintenance yard with minimum traffic.

Missouri DOT conducted a study intended for selecting structural steel coatings to mitigate corrosion. A visual guide was developed to assist with objective decisions on whether to recoat or to overcoat a bridge structure.

Coatings are also tested over pre-rusted surfaces. Though CSA performed well it was not added to the qualified product list (QPL) of the program because it could remain soft for extended time after application [10].

2.4.1 Generic Calcium Sulfonate Alkyd Coatings

Calcium sulfonate alkyd (CSA) coatings contain a key component: organic sulfonate overbased with calcium carbonate, which was originally used as a corrosion-inhibiting detergent and a lubricant additive [25]. Overbased calcium sulfonates are still widely used as a corrosion inhibitor in lubricant oils. Being overbased, or having stoichiometrically excess calcium carbonate to organic sulfonate is the crucial property for CSA to provide corrosion inhibition effects on steel [26]. By controlling the extent of overbasing, calcium carbonate based mineral particles (calcite or vaterite) can form at different scales, further enhancing the barrier property. Typically, CSA formulas comprise drying oils, such as tung oil, and petroleum-based hydrocarbon oil, and the inorganic-organic complex of calcium sulfonate and calcium carbonate [27]. An example formula includes calcium monoalkyl benzene sulfonate, calcium carbonate, synthetic long oil alkyd, and phenolic modified alkyd, with other functional additives [28].

Calcium sulfonate coatings have been used in the automotive industry for decades [29]. These coatings show penetrating ability to wet crevices due to the surfactant-like sulfonate. Overbased calcium sulfonates are often combined with other polymers to improve its hardness and mechanical properties. The basicity of a calcium sulfonate compound is characterized by its total base number (TBN): milliequivalent KOH per gram of the compound, which can be acquired by an acid titration method. Distinctive peak at 886 cm^{-1} on a FTIR spectrum also indicates the formation of calcite crystals as result of the CSA being overbased [29]. A sketch showing an idealized structure of calcium sulfonate with a calcite core is shown in Figure 1 left [11].

Easy application of a one-coat system is the most desired benefit of CSA coatings because of the saved cost and short waiting time between application steps. CSA coatings are also often accredited with “self-healing” properties due to their ability to “flow” slowly to provide better surface coverage. However, this “self-healing flow” also means that the coatings take much longer to achieve cured/hardened state, making them susceptible to mechanical damage and dust entrapment. The Caruthersville Bridge across the Mississippi River between Caruthersville, Missouri and Dyersburg, Tennessee was coated with a red CSA primer and a beige CSA topcoat. Prior to coating, the entire bridge surface was pressure washed at 3000 psi, areas with rust or loose paint were cleaned with power tools to SSPC-SP 3, a penetrating sealer was applied to back-to-back angles, and the bolts and crevices were stripe-coated [30]. The study showed that CSA coatings can remain soft for up to months, which can result in premature damage and color bleeding issues [30]. The soft coating nature and slow curing process, probably the major contributors of its corrosion performance, also leave the coating curing process largely to the ambient conditions, which is not as controllable as a three-coat or two-coat system. In a FHWA technical note, CSA is also mentioned as the best performer among one-coat systems [8]. However, the characteristics of CSA coatings make them more suitable for painting underdeck steel members, joints, and connections.

2.4.2 HRCSA Coatings

High-Ratio Co-Polymerized Calcium Sulfonate Alkyd (HRCSA) is a commercial product of Termarust. As described on the company website [14] and its technical product sheets, HRCSA is different from generic CSA by the amount of their active sulfonate and total base number:

“HRCSA Self Priming Topcoat– High Ratio Co-Polymerized Calcium Sulfonate HRCSA (Minimum 9.5% active sulfonate, must maintain a 9-11 to 1 ± 2% ratio Total Base Number to Active Sulfonate i.e. total base number of 85 to 104 to 9.5% Active Sulfonate as determined by Titration Testing”[14]

“HRCSA Penetrant (Sealer) – High Ratio Co-Polymerized Calcium Sulfonate HRCSA (Minimum 15% active sulfonate, must maintain a 9-11 to 1 ± 2% ratio Total Base Number to Active Sulfonate ie. total base number of 135 to 165 to 15% Active Sulfonate as determined by Titration Testing”[14]

Performance results and case studies of HRCSA mainly come from two sources: the product specific website [7] and a JPCL e-book publication [31].

As published in the case studies, HRCSA was used in several different ways:

- Direct application of HRCSA self-priming topcoat to clean substrates, with additional stripe coat to fasteners and edges.
- Pressure-apply HRCSA penetrant/sealer into corroded crevices before applying the self-priming topcoat.
- HRCSA could be atomized and pressure-applied in the form of fog or mist.
- For areas with steel interfaces: fasteners, joints, connectors, bearings, etc., thorough cleaning is required for HRCSA application.
- HRCSA sealer could be used to detach black oxide, followed by high-pressure hot water cleaning and the final HRCSA topcoat.

There were cases with isolated photos showing that a HRCSA coated weathering steel hydro tower appeared in good condition after 10 years. And a section of the bridge with joints appeared in good condition after 7 years of HRCSA [32, 33]. The detachment of black oxide after HRCSA application needs to be removed and followed by further application of the HRCSA topcoat. Several other cases were presented on the website showing HRCSA application procedures and appearance after its application.

Newlay bridge, a cast iron bridge in Leeds, UK, was approved to be coated with HRCSA in 2018. The overall cost was estimated £15,3000 with paint purchase of £15000 [34]. The bridge surface was prepared with high-pressure waterjetting. The HRCSA system included a penetrant and a topcoat, both manufactured by Termarust. Six other cases of HRCSA application on bridges were also mentioned in the report, with 5 of the cases showing images between 8 years to 22 years after the HRCSA application [34]. Another report indicated that HRCSA was selected to maintain the Auckland Harbour Bridge in New Zealand [35]. The choice was made based on US studies, specifically the FHWA report in 2011 [22].

On the High Level Bridge in Edmonton, Alberta, HRCSA coating was used in accordance with the coating manufacturer’s quality application plan and was opened to all modes of traffic in 1995 [36]. The owner of the High Level Bridge conducted a warranty inspection in 2002 and the bridge had passed the inspection [36].

An FHWA study evaluated the performance of four coating systems on chloride-contaminated surfaces. At lower to no salt contamination, the HRCSA system performed close to three-coat systems but with more rust creepage. However, at higher salt contamination (60 $\mu g/cm^2$), the HRCSA system showed significantly more rust creepage than the three-coat systems after extended exposure (about 5000 hours under ALT and 54 months of outdoor exposure) [37].

FHWA's 100-year bridge coating study [2] concluded that the three-coat systems (IOZ/E/PU and ZE/E/PU) and the one-coat HRCSA shows good performance but none of the 8 coating systems were ready to deliver the 100-year maintenance free service. In the study, HRCSA showed the lowest adhesion which in contrary to other systems, increased during the weathering. It also showed the greatest color change, greatest gloss reduction, and least rust creepage during the ALT. However, HRCSA shows scattered rust stains under NW and NWS.

In a 2013 review summarizing innovative bridge coating systems, the authors conclude that a successful penetrating sealer needs to have a viscosity lower than 30 seconds, measured by a #4 Ford cup. It was found in their earlier 1998 study that the best penetrating epoxy sealer has ultra-low viscosity of 13 second [38]. The HRCSA sealer has a viscosity of 22 seconds and lowest surface tension among the sealers studied, which explains the penetrating and wetting properties of HRCSA to the rust-contaminated surfaces, further enhanced by a specialized penetrating HRCSA sealer. The authors suggest a new coating property priority as: “Wetting and Penetration > Inhibition and Passivation > Moisture Tolerance > Flexibility > Benign Influence > Barrier Properties > Adhesion [38].” As for surface preparation for overcoating, the authors recommended SSPC-SP WJ4 water cleaning, with additional salt remover to minimize surface salt contamination to less than 10µg/cm^2.

A detailed application process was reported in a case where HRCSA was used to overcoat Canadian hydroelectric penstocks with existing lead paint [19]. The authors reported the low toxicity of HRCSA with LC50-96h (the lethal dose to kill 50% fish in 96 hours) being about 42,000 ppm, zinc-rich 10 ppm, and epoxy 300-600 ppm (the lower the number, the more toxic). The surface was pressure washed at 5000 psi according to SSPC-SP WJ4. A waste containment and filtration system were also demonstrated. The case used a three-step, wet-on-wet, one-coat process: 1) Apply a penetrating sealer on the connections; 2) caulk joints with a flexible polysulfide caulk and spot prime the bare metal; 3) wet-on-wet overcoat with the HRCSA topcoat. Besides the common issues with HRCSA: being soft, prone to mechanical damage, and dirt pick up and retention, the author mentioned when the ambient temperature was high (90-100 °F), poor coating flow (uneven sheen) was observed due to faster solvent evaporation.

2.5 Summary and Key Findings

2.5.1 Summary

Literature sources were reviewed in this project on the state-of-the-art practice of highway bridge maintenance painting using high-ratio calcium sulfonate alkyd (HRCSA) coatings and hot water pressure wash (HWPW, 60 up to 100 °C and below 5000-7000 psi) surface preparation. Steel highway bridges, if left untreated, are often susceptible to corrosion damage, which could lead to economic loss and even catastrophic failure. To provide optimum protection to the steel surface on a bridge, multiple layers of coatings are usually applied to a properly prepared surface. An example is a three-coat system comprised of a zinc-rich primer, an epoxy tie coat, and a polyurethane topcoat with the steel surface prepared to near white as specified by SSPC-SP10. While this systematic approach does provide exceptional results, it is not always economically or environmentally feasible for maintaining existing bridge structures. As a one-coat system, HRCSA and generic calcium sulfonate alkyd (CSA) has been tested with impressive results, due to its high tolerance to non-ideal surface preparation. Commercial HRCSA products also include a penetrating sealer, potentially being able to mitigate pack rust and enhance adhesion of HRCSA to components susceptible to corrosion. It is also indicated in literature [18, 19] that combining HRCSA with HWPW provides optimal protection, as the pressure wash can remove loose rust, salt build-up, and poorly adhered existing coatings. The major findings from this literature study are:

1. Multiple studies showed that HRCSA performed well for corrosion protection, especially on non-ideal steel surfaces. Three-coat systems (a zinc rich primer, a tie coat, and an aliphatic polyurethane topcoat)

still have the best reported performance. But HRCSA is often ranked right behind the three-coat systems and superior to other alternatives.

2. HRCSA is claimed to be different from generic CSA based on total base number (TBN) and active sulfonate content. However, there is no comparative study between generic CSAs and HRCSA. There are generic CSAs reported to have satisfactory performance.
3. HRCSA/CSA coatings cure very slowly and could remain soft for months depending on weather conditions, leading to their tendency to pick up excessive dirt and be susceptible to premature mechanical damage. Several DOTs did not choose HRCSA/CSA coatings for this reason. On the other hand, the long curing time and soft nature of HRCSA system may be advantageous to crevice corrosion and pack rust mitigation. HRCSA may increase crevice pH by slowly releasing calcium carbonate as a corrosion inhibitor.
4. Proper surface preparation is needed for HRCSA applications. Removing rust and chloride salts with HWPW is critical to HRCSA's performance, which requires surface salt contamination being limited to less than 10μg/cm^2 (2.28E-6 oz/sq. inch).
5. To mitigate pack rust, HRCSA application involves several steps: removing loose pack rust, applying a penetrating sealer, applying stripe coat or caulk, and applying the HRCSA topcoat.
6. HRCSA penetrating sealer by itself could also mitigate pack rust and frozen bearings by temporarily impeding further rusting. But it cannot remove the rust or unfreeze the bearings. To achieve long-term mitigation, the above-mentioned multi-step process is required.

In summary, HRCSA is a very good candidate for steel bridge maintenance attributed to its corrosion performance and economical one-coat process with less environment footprint. However, factors such as slow curing and potential premature damage need to be considered. In addition, with the added steps of HWPW and penetrating sealer, the cost of the process will increase with the additional equipment and training of the personnel. HWPW equipment does provide other potential applications, such as graffiti removal. The ability to reach otherwise inaccessible space, such as crevices, also makes HWPW the most efficient way to remove loose pack rust.

2.5.2 Key Findings

As reported in the literature reviewed, HRCSA performs well for corrosion protection of bridge steel surfaces. Though not matching the performance of a traditional three-coat system, HRCSA application is a desirable multi-step one-coat process. HRCSA is claimed to work on non-ideal surfaces. Due to the lack of direct comparative study between generic CSAs and HRCSA, it is reasonable to consider both generic CSAs and HRCSA when a one-coat system is desired.

Even though the HRCSA application process is shorter than that of a three-coat system, it is still a multi-step one-coat process that could require most if not all the following steps: surface preparation, applying a penetrating sealer, stripe coating/caulking, and applying a wet-on-wet topcoat. Attention is needed so it will not be assumed as a one-step process.

To optimize HRCSA performance, the surface still needs to be cleaned with a hot water pressure wash using specialized equipment to remove rust and salt contamination. The equipment, in conjunction with the waste containment and filtration, adds additional cost to the HRCSA application process. The hot water pressure wash could have other applications, such as cleaning graffiti, which, to a certain degree, could justify the initial investment in the equipment.

HRCSA is more environment-friendly than a traditional three-coat system. But its long drying time could cause substantial dirt pickup and retention. Premature mechanical damage is also more likely during the drying process. The drying rate depends largely on ambient temperature, which makes it less controllable than a three-coat system and prone to coating defects related to extreme temperatures. On the other hand, the long curing time and soft nature of the HRCSA system may be advantageous to crevice corrosion and pack rust mitigation. HRCSA may increase crevice pH by slowly releasing calcium carbonate as a corrosion inhibitor.

In summary, HRCSA is a very good candidate as a bridge maintenance coating. However, contrary to what the term "one-coat system" may suggest, HRCSA application requires multiple steps to achieve its optimum performance.

2.6 Bibliography

1. Kline, E. S. (2008). *Steel Bridges: Corrosion Protection for 100 Years. Journal of Protective Coatings and Linings, 25*(5), 20-31.
2. Federal Highway Administration. (2012-November). *Federal Highway Administration 100-Year Coating Study (FHWA-HRT-12-044).* Washington, DC: Federal Highway Administration.
3. Ballinger, C., & Senick, W. (2003). *Blasting is No Way Out. Roads & Bridges, 41*(9), 48–49, 62.
4. Oladimeji Fasheyi, A. (2012). *Bridge Bearings: Merits, Demerits, Practical Issues, Maintenance and Extensive Surveys on Bridge Bearing*. Master of Science Thesis, Department of Civil and Architectural Engineering of KTH Royal Institute of Technology.
5. Bowman, M., & Moran, L. (2015). Bridge Preservation Treatments and Best Practices. *JTRP Technical Reports*, FHWA/IN/JTRP-2015/22, West Lafayette, IN: Purdue University.
6. Vinik, P., et al. (2016). *Successful Preservation Practices for Steel Bridge Coatings.* Arora and Associates, P.C., Lawrenceville, NJ.
7. HRCSAsteel. (2021). *Case Studies*. Retrieved from https://hrcsasteel.com/category/case-studies/
8. Bridge Coatings Technology Outreach Team (1997). *FHWA Bridge Coatings Technical Note: Overcoating (Maintenance Painting).* https://www.fhwa.dot.gov/publications/research/infrastructure/structures/bridge/overct.cfm
9. Eck, R. W., & Martinelli, D. R. (1998). Assessment and Mitigation Measures for Graffiti on Highway Structures. *Transportation Research Record, 1642*, (1), 35-42.
10. Myers, J. J., Washer, G., & Zheng, W. (2010). *Structural Steel Coatings for Corrosion Mitigation.* Missouri DOT, Jefferson City, MO.
11. Bosman, R., & Lugt, P. M. (2018). The Microstructure of Calcium Sulfonate Complex Lubricating Grease and Its Change in the Presence of Water. *Tribology Transactions, 64(6), 1127-1137.*
12. Kulicki, J.M., et al., (1990). *Guidelines for Evaluating Corrosioon Effects in Existing Steel Bridges.* Washington, DC*:* NCHRP.
13. FHWA. (2012). *FHWA Bridge Inspection Manual Section 9—Bridge Bearings - a PDH Online Course for Engineers, Architects and Surveyors.* Washington, DC: FHWA.
14. HRCSAsteel. (2021). *HRCSA – Material Specification*. Retrieved from https://hrcsasteel.com/2021/11/15/hrcsa-material-specification/
15. Patel, C., & Bowman, M. (2018). *Pack Rust Identification and Mitigation Strategies for Steel Bridges* (FHWA/IN/JTRP-2018/16). West Lafayette, IN: Joint Transportation Research Program.
16. Smith, L., & Wright, P. (2014). Safe Use of Ultra-High-Pressure Waterjetting. *Journal of Protective Coatings & Linings, 31(9),* 25-31.
17. Hotsy. (2021). When to Choose a Hot or Cold Water Pressure Washer. Retrieved from https://www.hotsy.com/en/resources/media-library/articles/when-to-choose-a-hot-or-cold-water-pressure-washer.html

18. HRCSAsteel. (2021). *High Pressure Water Cleaning*. Retrieved from https://hrcsasteel.com/2021/11/28/high-pressure-water-cleaning/
19. O'Donoghue, M., et al. (2009). Overcoating Lead-Based Alkyd Paint on Steel Penstocks: Practical Experience. *Journal of Protective Coatings & Linings, 26*, 18-31.
20. Stephens, M.T., et al. (2019). *Steel Bridge Corrosion Prevention and Mitigation Strategies: A Literature Review (IRISE-19-P19-01-01)*. Pittsburgh, PA: IRISE Consortium.
21. Burgess, R. (2014). *Transportation Agency Practices Currently Employed for Bridge Maintenance Painting Operations: Findings from a National Survey*. MnDOT TRS 1404. KTA-Tator, Inc.
22. Yao, Y., et al. (2011). *Performance Evaluation of One-Coat Systems on New Steel Bridges* (FHWA-HRT-11-046). Washington, DC: FHWA.
23. Chong, S-L., et al. (2007). *Selecting Overcoats for Bridges (FHWA-HRT-07-006). Public Roads, 71*(2), https://highways.dot.gov/public-roads/septoct-2007/selecting-overcoats-bridges
24. Tinklenberg, G.L. (2000). Corrosion Control, *Alternate Paint Systems for Overcoating*. New Hampshire DOT, SPR-PL-PR-1(31) Project 12323 D
25. Chen, Z., et al. (2011). Calcium Carbonate Phase Transformations During the Carbonation Reaction of Calcium Heavy Alkylbenzene Sulfonate Overbased Nanodetergents Preparation. *Journal of Colloid and Interface Science, 359*(1), 56-67.
26. Wurstner, R. G. (1969). *Corrosion Inhibiting Compositio*n. US Patent 3453124.
27. Lechner, T. G., & Besse, M. E. (1975). *Corrosion Inhibition or Prevention with Inorganic-Organic Complexes*. US Patent US3925087A.
28. Christhilf, H. H., & Clark, S. D. (1992). *Corrosion-Inhibiting Coating Compositions for Metals*. European Patent EP0309472A4.
29. Kmetz, J. J. (1991). Calcium Sulfonate-Based Coatings as Used in the Automotive Industry Today. SAE Technical Paper 912295, 1991, doi:10.4271/912295
30. Toussaint, E., et al. (2010). *The Caruthersville Bridge: Challenges of a Calcium Sulfonate Alkyd System.* Phoenix, AZ: SSPC.
31. Journal of Protective Coatings and Linings (2009). Overcoating Bridges and Other Structures. In *A JPCL eBook*. https://www.paintsquare.com/store/assets/201609_Overcoating.pdf: Technology Publishing Company.
32. HRCSAsteel. (2021). *HRCSA is a Maintenance Coating*. Retrieved from https://hrcsasteel.com/2021/12/16/hrcsa-is-a-maintenance-coating/
33. HRCSAsteel. (2021). *Weathering (A588, COR-TEN) steel*. Retrieved from https://hrcsasteel.com/2021/12/07/weathering-a588-cor-ten-steel/
34. Jackson, M. (2018). *Use of Termarust for the Newlay Bridge Repainting Scheme Report*. Leeds, UK: Leeds City Concil.
35. El Sarraf, R., Mandeno, W., & Ingram, A. (2014). Auckland Harbor Bridge Painting: Development of a Future Maintenance Strategy. Paper presented at the Austroads Bridge Conference, 9th, Sydney, New South Wales, Australia.
36. O'Donoghue, M., Datta, V., & Hollins, G. (2017). Bedevilled Bridges: An Answer to a National Scandal. *In SSPC Video Proceedings*. Tampa, FL: SSPC.
37. Liu, R., & Runion, A. (2020). *Coating Performance on Existing Steel Bridge Superstructures*. Washington, DC: FHWA.
38. O'Donoghue, M., et al. (2013). *Innovative Coating Systems for Steel Bridges: A Review of Developments. Journal of Protective Coatings and Linings, 30*(1), 34-36,38,40,42,44,46,48,50,52.

3 Agency Survey

3.1 Introduction

The objective of this project is to review and survey state of the art and practice of highway bridge maintenance painting using high-ratio calcium sulfonate alkyd (HRCSA) and hot water pressure wash (HWPW). Steel highway bridges, if left untreated, are often susceptible to corrosion damage, which could lead to economic loss and even catastrophic failure. To provide optimum protection to the steel surface on a bridge, multiple layers of coatings are usually applied to a proper prepared surface. An example is zinc-rich primer, epoxy tie coat, and polyurethane topcoat with the substrate prepared to near white as specified by SSPC-SP10. While this systematic approach did provide exceptional results, it is not economically or environmentally feasible for maintaining existing bridge structures between full coating removal and replacement cycles. As a one-coat system, HRCSA has been tested with impressive results, due to its high tolerance to non-ideal surface preparation. HRCSA products also include a penetrating sealer, potentially being able to mitigate active corrosion, unfreeze bearings, and enhance adhesion of HRCSA to components susceptible to corrosion. It is also indicated in literature that combining HRCSA with HWPW provides optimal protection, as the water cleaning can remove rust and salt build-up and degraded existing coatings that lost adhesion to the substrate. However, the HRCSA coating and HWPW are not currently approved or used by MnDOT. The proposed project is intended to facilitate the process of evaluating and potentially adopting the HWPW/HRCSA combination based on a literature review and survey of practice.

3.2 Analysis

A total of 17 responses were collected during the survey period. Of the responses, 14 (82%) do not use HRCSA/CSA and 3 (18%) use HRCSA/CSA. Note that for some questions, a respondent can select all the choices that apply, meaning the total response count may not necessarily equal the total count of individual respondents.

Among the 14 responses that do not use HRCSA/CSA, 8 (57%) had not tried this coating before. The rest of the responses indicate that their agencies do not choose HRCSA/CSA because of either performance or aesthetic issues. These results show that 6 respondents (43%) had unsatisfactory experiences with HRCSA/CSA coatings. Particularly, 2 (14%) of the respondents (NYSDOT and KYTC) indicated HRCSA/CSA coatings did not meet performance requirements in the past based on their firsthand field study, 3 (21%) of the respondents (NYSDOT, NDOT, and TDOT) indicated "coating is too soft, accumulates dirt, and is prone to premature damage", 2 (14%) respondents (TDOT and KYTC) indicated "poor UV resistance". Four respondents (29%) provided other reasons, including: aesthetic rust bleed-through, poor performance, not UV stable, not required to use the type of system, and used in the past but not recently. One respondent provided a paint inspection report that is attached in Appendix C. When asked what other coating systems they use, 13 (93%) use a three-coat system, 3 (21%) use two coat moisture-cured urethane (MCU), 6 (43%) use metalizing coating, and 5 (36%) use other coating systems (see question 2.4 in the complete report in section 6)[1].

For the 3 respondents (MDOT, TxDOT, and MoDOT) that use HRCSA/CSA, all 3 use HRCSA, but not generic CSA. However, one of the respondents (MoDOT) commented that they are in the process of eliminating HRCSA from

[1] Note a respondent can select all the choices that apply, meaning the total response count may not necessarily equal the total count of individual respondents.

their use. The most common use of HRCSA/CSA is to coat bearings or connections. One respondent (33%, TxDOT) uses HRCSA to unfreeze bearings. Two respondents (67%, TxDOT and MDOT) use a penetrating sealer. The respondents use other coating systems as well: all 3 use a three-coat system, one uses metalizing coating, and one uses "Epoxy mastic one coat or epoxy with a urethane topcoat" [1]. All the HRCSA users selected the "tolerant to non-ideal surfaces" as the determining factor for using HRCSA. Two of the three users also selected "cost savings" and "easy application". One user mentioned corrosion mitigation as another reason.

Among the 17 respondents, 4 (24%) use hot water pressure wash (HWPW) and 13 (76%) do not use it. The most selected other purpose for HWPW is pack rust mitigation (2 responses, 12%). The results are very diversified on the limitations of using HWPW. No respondents have limitations related to operator other than requiring operational and safety training for new employees. When asked "do you have any limitation on using HWPW on the following surfaces," among the three respondents, one (Caltrans) selected "Steel" and two (Caltrans and NYSDOT) selected "existing coatings". Two respondents (Caltrans and NYSDOT) provided their HWPW pressure range (1800 psi to 2000 psi and 1160 psi to 5000psi) and temperature range (185°F to 200°F and 212°F). The most used surface preparation methods are power tools and abrasive blasting. Eight of the respondents (47%) use cold water pressure wash, but one respondent commented that containment of the wastewater makes this method cost prohibitive. When asked what bridge maintenance tasks are performed, 10 (59%) of the respondents perform pack rust mitigation, 6 (35%) of the respondents perform salt contamination mitigation, and 4 (24%) of the respondents perform frozen bearing mitigation.

Based on the survey results and literature review, it can be inferred that the HRCSA coating could be tolerant to non-ideal substrates but is susceptible to the extremities of the climate. Examples are:

- Cold weather would slow the coating drying process substantially.
- Extreme hot weather could cause premature solvent loss, resulting in undesired defects.
- Intense and extended sunlight could degrade the coating faster than expected.

In addition, based on the survey responses, the HRCSA coating is not "universally tolerant" to non-ideal substrates. The mixed results or concerns of performance indicate there are conditions that need to be satisfied for the optimum performance of HRCSA. Literature also indicates that application of HRCSA is a multi-step one-coat process (removing loose pack rust, applying a penetrating sealer, applying stripe coat or caulk for connections, and applying HRCSA topcoat), and recommends hot water pressure wash (HWPW), to get the best results. According to the survey, there are agencies not using penetrating sealers or HWPW, possibly indicating that HRCSA is not applied under optimum conditions. The requirement of the multi-step application process and HWPW surface preparation could make the decision on using HRCSA difficult. Other factors to consider include the condition of the existing coating system and steel substrate, equipment availability, cost, personnel training, environmental regulations, site conditions, and coating performance. Switching maintenance tasks exclusively to using HRCSA is not practical. But keeping it as a maintenance coating option when the conditions can be satisfied, could be beneficial to cost and/or time savings, environment, and corrosion performance.

3.3 Additional Information

A Paint Inspection Report from the New York State Department of Transportation is attached in Appendix C.

Additional responses regarding limitations on using hot water pressure wash were provided by Michigan Department of Transportation after a follow-up.

5.2 Do you have any limitations on using hot water pressure wash? Select all that apply.

- **Operator** **Yes** **No** **Do not know**
    - **Michigan DOT Response**: No, other than operational/safety training for new employees.

- **Wastewater Containment** **Yes** **No** **Do not know**
    - **Michigan DOT Response**: Yes, we build containments if lead is involved, and then dispose of paint chips and treated (triple-filtered) water. Paint chips and sludge are sent in a tote for disposal, and water is sent into an approved treatment facility once it has been cleared for lead. So far, we've only water blasted where lead primer was present. Right now, we're thinking that if we knew there was NOT lead, we would still catch paint chips for disposal, although there would be no lead disposal considerations, just into a dumpster. As far as the water, I'd still want to be sure there weren't any heavy metals like zinc that may be present, so the same routine would be used as for lead. Contain and capture into a tote, flocculate with lime to settle out solids, filter, and pump to second tote, test, and dispose.

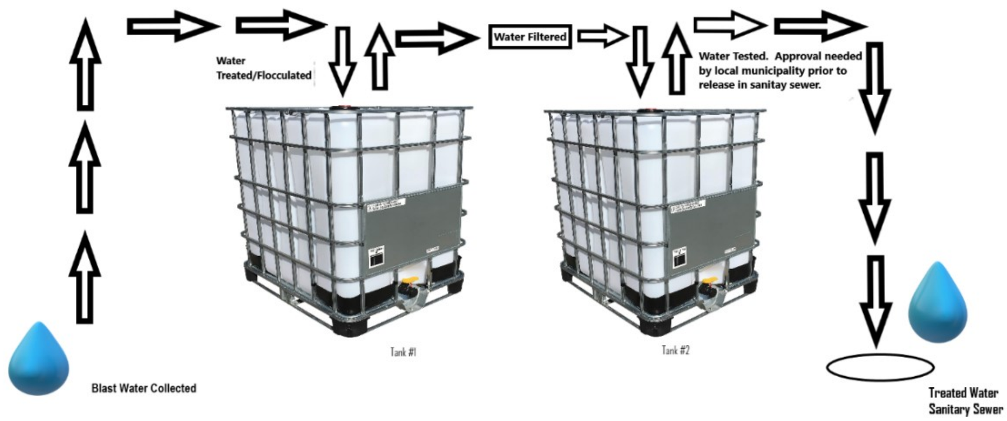


Figure 1 Water Treatment Process Flow Chart (provided by Michigan DOT)

- **Surface can be cleaned** **Yes** **No** **Do not know**
    - **Michigan DOT Response**: Stay away from HMA surfaces as 7,200 psi pressures will cut the pavement. Other than that, we've used it on steel and concrete.

- **Water Pressure** **Yes** **No** **Do not know**
    - **Michigan DOT Response:** We keep the pressure at 7,000 – 7,200 psi.
- **Water Temperature** **Yes** **No** **Do not know**
    - **Michigan DOT Response:** We try to keep the temp at 90+ Celsius. The hotter the water is the more will vaporize, meaning less collection. We did run tests on vapors coming off a steel surface with lead paint on it, and no lead was present in the vapors we collected for testing.

3.4 Key Findings

The key findings of the survey are listed below:

- Only three (18%) of the respondents use HRCSA; none of them use generic CSA.
- For the 14 DOTs that are not using HRCSA/CSA, they either had no experience with it (57%) or had unsatisfactory experience (43%). The reasons for not choosing HRCSA/CSA include:
  - not meeting the performance based on firsthand field study (NYSDOT and KYTC, 14%)
  - coating is too soft, accumulating dirt, and is prone to premature damage (NYSDOT, NDOT, and TDOT, 21%)
  - poor UV resistance (TDOT and KYTC, 14%)
- Only a small portion (24%) of the total respondents use HWPW. Two of those respondents indicated a limitation on using HWPW over existing coatings and one respondent indicated a limitation on using HWPW on steel.

Performance concerns are the main reason that surveyed DOTs do not use HRCSA/CSA despite having experience with it. As listed above, specific concerns include slow drying time, poor UV resistance, and potential premature damage. Another possible reason HRCSA is not meeting performance expectations may be related to surface preparation. Most of the surveyed DOTs do not use HWPW. Only one DOT uses HWPW among the 6 DOTs that had experience with HRCSA. Among the three current HRCSA users, two use HWPW; and the one not using HWPW is in the process of eliminating HRCSA from its maintenance coatings.

4 Conclusions and Recommendations

As a bridge maintenance coating, high-ratio calcium sulfonate alkyd (HRCSA) has a relatively small DOT user base (only three of the surveyed state DOTs, namely MDOT, TxDOT, and MoDOT) compared to the mainstream three-coat systems. HRCSA is different from generic calcium sulfonate alkyds (CSAs) because of its higher total base number (TBN) and sulfonate content. However, due to the lack of a direct comparative study between HRCSA and generic CSAs, it is reasonable to consider both when a one-coat system is desired for bridge maintenance tasks.

As a more environment-friendly bridge maintenance painting solution, HRCSA uses less solvent and toxic chemicals and eliminates the drying time between layers of a three-coat system. But it is still a multi-step process that could require most, if not all, of the following steps: surface preparation, applying a penetrating sealer, stripe coating/caulking, and applying a wet-on-wet topcoat. Attention is needed to not assume it is a one-step process.

In addition, to optimize HRCSA performance, the surface needs to be cleaned with a hot water pressure wash (HWPW) using specialized equipment to remove rust and salt contamination. The equipment, in conjunction with the waste containment and filtration, adds additional cost to the HRCSA application process. The HWPW could have other applications, such as cleaning graffiti, which, to a certain degree, could justify the initial investment in the equipment.

One major drawback of HRCSA is its slow ambience-dependent drying time. Consequently, the less-controlled drying process could result in multiple performance issues, including soft final coating, substantial dirt pickup and retention, and premature mechanical damage. HRCSA is also prone to coating defects related to extreme temperatures. Survey results show these drying related issues are the reason for some DOTs not choosing HRCSA.

On the other hand, the long curing time and soft nature of the HRCSA system may be advantageous to crevice corrosion and pack rust mitigation. HRCSA may increase crevice pH by slowly releasing calcium carbonate as a corrosion inhibitor.

In summary, low-toxic HRCSA causes less pollution, eliminates waiting time between application steps, and performs well for corrosion prevention. However, like any other protective coating system, optimum HRCSA performance requires following the manufacturer's specifications. Contrary to what the term "one-coat system" may suggest, HRCSA application is a multi-step process that requires additional HWPW equipment. Its long ambience-dependent drying time after application makes HRCSA vulnerable to several common coating defects and the film could remain soft for an unacceptable amount of time. Therefore, besides following the multi-step process including using HWPW, careful planning is necessary to account for uncontrollable climate factors.

Based on the literature review and survey findings, without further testing and trials, HRCSA is recommended only for maintenance tasks that can strictly fulfill the manufacturer's specifications, i.e., an initial HWPW followed by the multi-step process and sufficient drying time before an extreme weather event. However, further laboratory and field tests are recommended to determine HRCSA's practical suitability for various bridge maintenance conditions and scenarios MnDOT commonly encounters. Below is a list of recommended laboratory work and field testing:

- A systematic laboratory characterization of
  - drying process: time, temperature, humidity, acceptable tackiness, and final coating hardness
  - corrosion performance at different drying stages
  - effects of deicing agent accumulation on corrosion performance
  - HRCSA interaction with different existing coatings
- Field-testing HRCSA
  - during the typical time of year for bridge maintenance
  - optimum conditions for placement
  - on different locations of a bridge
  - on bridges with representative existing coatings
  - on bridges with accumulated deicing agents and cleaned under different conditions: cold water, hot water, and various pressure ranges

5 Next Steps

The Technical Advisory Panel recommends the following next steps in response to the findings in this Transportation Research Synthesis.

- Develop a work plan to conduct field reviews and evaluate the performance of an HRCSA coating applied to the steel beam ends, tie rods, and bearings on bridge 62882.
- Consider a research implementation project or off-cycle research project to monitor, test, and evaluate the application process and performance of HRSCA for:

    - mitigation of pack rust on bridge 9090 (summer 2023);
    - and mitigation of frozen bearings.
- Consider field and lab testing of HRCSA application to evaluate various factors such as temperature, humidity, UV exposure, coating hardness, equipment, containment.
- Compare schedule, cost, and performance of HRCSA with traditional coating methods.

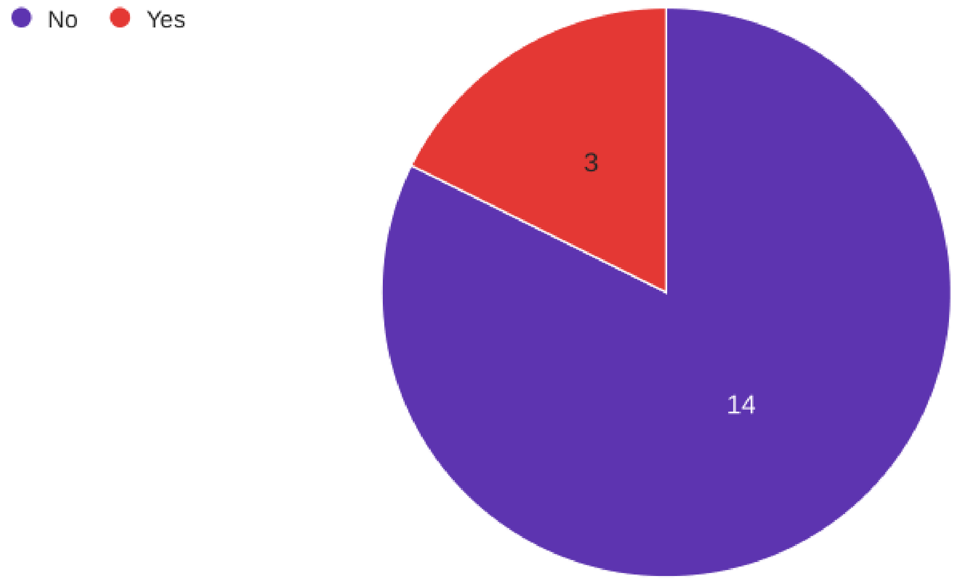
6 Appendix A – Complete Qualtrics Survey report

Q1.1_3 - Agency

17 Responses

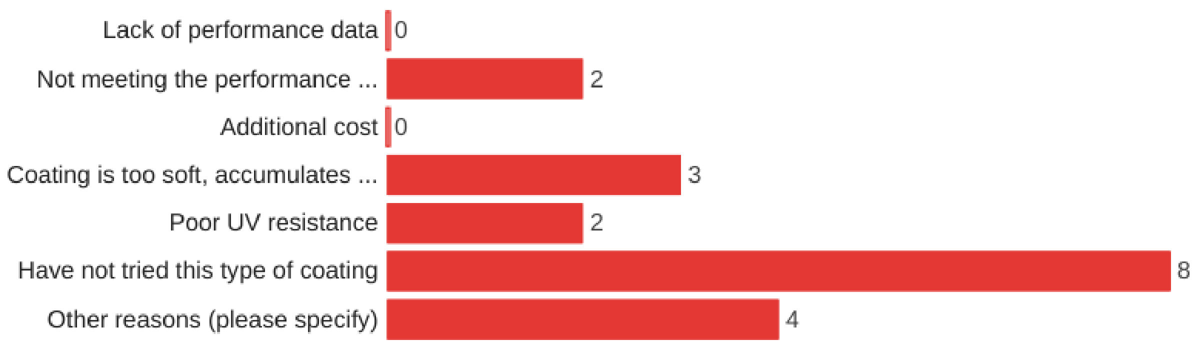
Agency
FDOT
Illinois Department of Transportation
NYSDOT Materials Bureau
Michigan Department of Transportation
Nebraska DOT
Kentucky Transportation Cabinet
Caltrans (CA DOT)
Mississippi DOT
Texas Department of Transportation - Bridge Division
Missouri Department of Transportation
State of Alaska DOT&PF
Ohio DOT
Tennessee DOT
Iowa DOT
DelDOT
Indiana DOT
ODOT

Q1.2 - Do you use HRCSA or CSA for Bridge Maintenance? HRCSA -- high ratio calcium sulfonate alkyd; CSA -- calcium sulfonate alkyd



Field	Percentage
Yes	17.65%
No	82.35%

Q2.1 - The reasons not choosing HRCSA/CSA are (select all that apply):



Field	Percentage of Responses
Lack of performance data	0.00%
Not meeting the performance requirement	14.29%
Additional cost	0.00%
Coating is too soft, accumulates dirt, and is prone to premature damage	21.43%
Poor UV resistance	14.29%
Have not tried this type of coating	57.14%
Other reasons (please specify)	28.57%
Total	

Other reasons (please specify) - Text
rust bleed through, aesthetics
Product was used on two projects and performance has been poor at best. Coating is not UV stable and breaks down and peels.
Not required for the type of paint system that we use
We used HRCSA in the past but not recently

Q2.2 - You indicate that HRCSA/CSA is not meeting the performance requirement. Please specify your source of performance data and provide optional links/details if available (select all that apply):

Field	Responses
You indicate that HRCSA/CSA is not meeting the performance requirement. Please specify your source of performance data and provide optional links/details if available (select all that apply): - Selected Choice	3

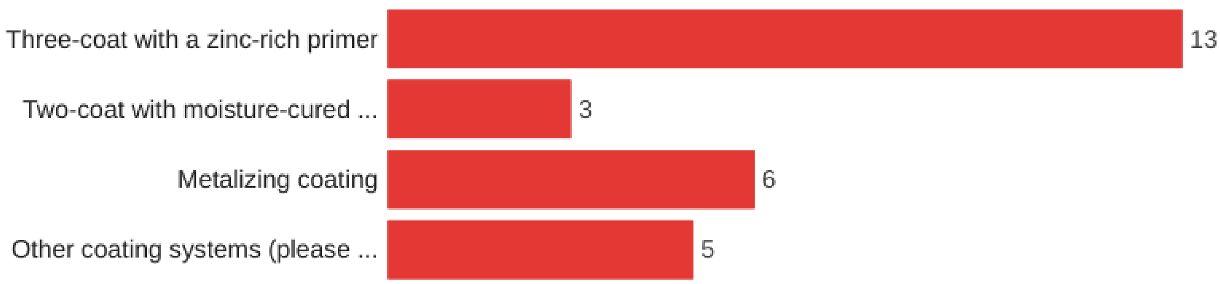
Field	Choice Count
Past DOT reports	0
Professional experience/recommendations	0
First hand field study	2
Other sources (please specify)	1
Total	3

Other sources (please specify) - Text
Visited NYS Thruway bridge over railroad- 10 year exposure (in Albany area)

Q2.3 - Please upload any relevant report/document that you would like to share. You can only upload one file; one zip file is allowed.

Please upload any relevant report/document that you would like to share. You can only upload one file; one zip file is allowed. - Name	Please upload any relevant report/document that you would like to share. You can only upload one file; one zip file is allowed. - Type
N/A	N/A
N/A	N/A
THWY Job BIN 5513679 Evaluation 9_27_12 Calcium Sulfonate.pdf	application/pdf
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A

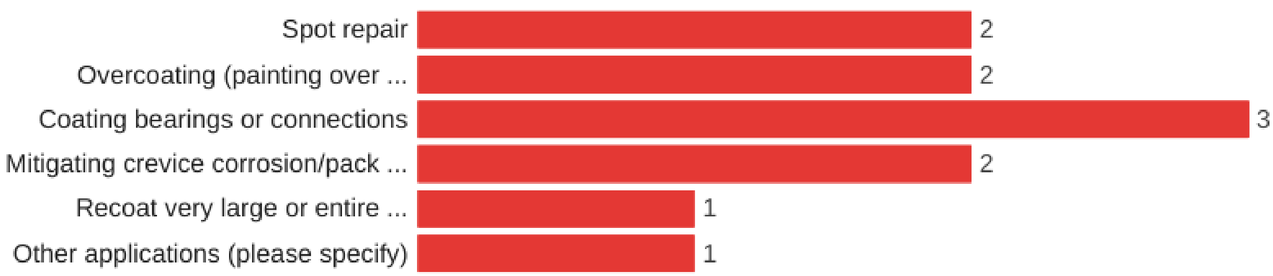
Q2.4 - What are the other coating systems you use? Select all that apply.



Field	Choice Count
Three-coat with a zinc-rich primer	13
Two-coat with moisture-cured urethane (MCU)	3
Metalizing coating	6
Other coating systems (please specify)	5
Total	27

Other coating systems (please specify) - Text
ILDOT uses three-coat paint systems, weathering steel, metallized steel, and galvanized steel. ILDOT keeps MCU paint as an option for cold-weather painting.
hot dip galvanized primary members
Caltrans in-house developed and formulated water-borne acrylic latex.
Rust Grip by SPI Coatings
Two-coat with zinc rich silicate/waterborne acrylic
Some use of Rhomar Black-Max on corroded bearings/beam ends to get by until re-painting projects are scheduled.

Q3.1 - Please select your HRCSA/CSA application for bridge maintenance. Select all that apply.



Field	Choice Count
Spot repair	2
Overcoating (painting over existing coating surfaces)	2
Coating bearings or connections	3
Mitigating crevice corrosion/pack rust	2
Recoat very large or entire bridge surface	1
Other applications (please specify)	1
Total	11

Other applications (please specify) - Text
We are in the process of eliminating this product from our use.

Q3.2 - Do you use HRCSA to unfreeze bearings?

Field	Choice Count
Yes	1
No	2
Do not know	0
Total	3

Q3.3 - Do you use a penetrating sealer?

Field	Choice Count
Yes (please specify the penetrating sealer you use)	2
No	1
Do not know	0
Total	3

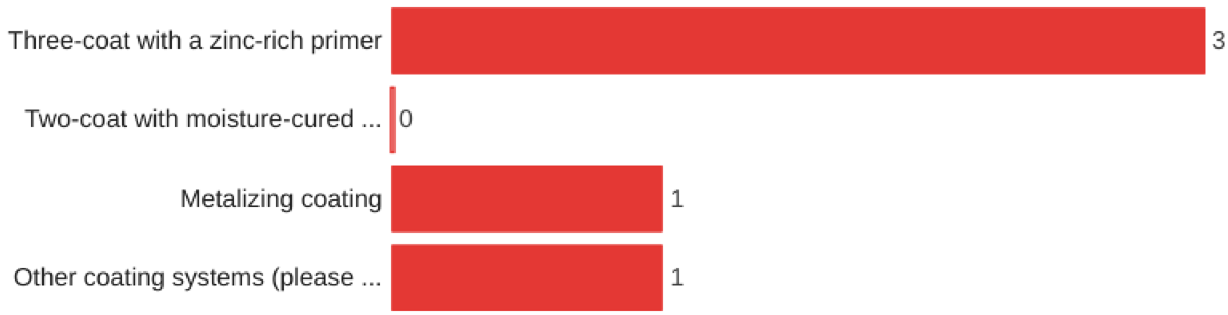
Q3.4 - Do you use HRCSA or generic CSA?

Field	Choice Count
HRCSA	3
Generic CSA	0
Both HRCSA and generic CSA	0
Total	3

Q3.5 - Do you use other coating systems as well?

Field	Choice Count
Yes	3
No	0
Total	3

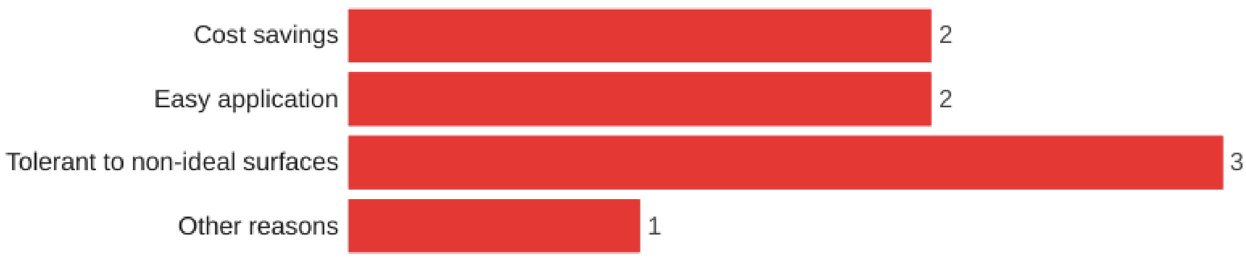
Q3.6 What are the other coating systems you use? Select all that apply. - Selected Choice



Field	Choice Count
Three-coat with a zinc-rich primer	3
Two-coat with moisture-cured urethane (MCU)	0
Metalizing coating	1
Other coating systems (please specify)	1

Other coating systems (please specify) - Text
Epoxy mastic one coat or epoxy with a urethane topcoat.

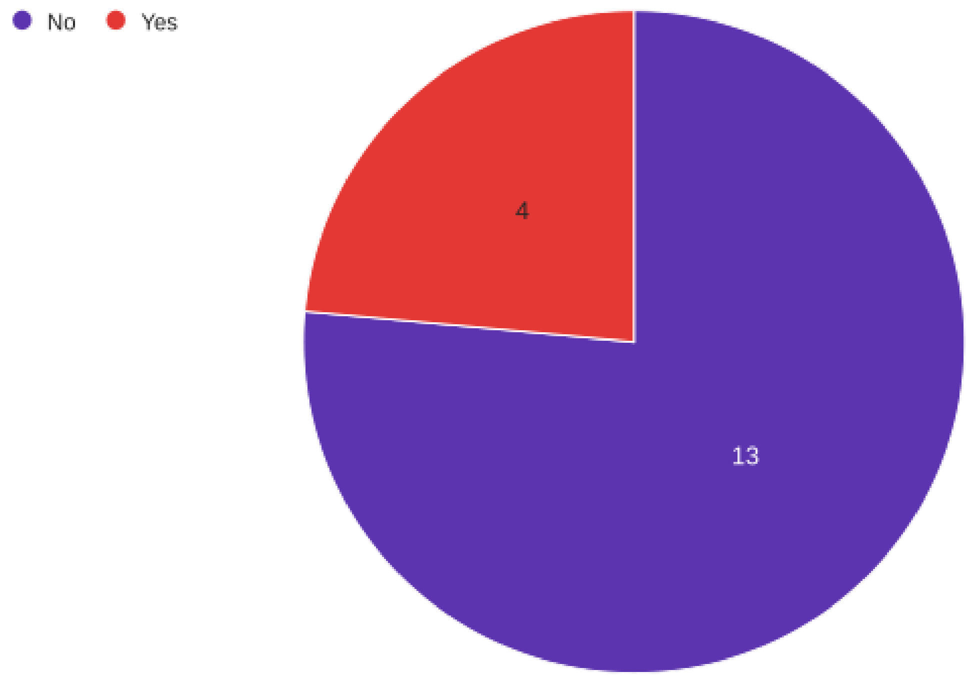
Q3.7 - How do you determine when to use HRCSA/CSA? Select all that apply.



Field	Choice Count
Cost savings	2
Easy application	2
Tolerant to non-ideal surfaces	3
Other reasons	1
Total	8

Other reasons - Text
Areas where corrosion mitigation is desired, pack rust suspectible, plate bearings, etc.

Q4.1 - Do you use hot water pressure wash to prepare bridge surfaces for HRCSA/CSA or other coating application?



Field	Percentage
Yes	23.53%
No	76.47%

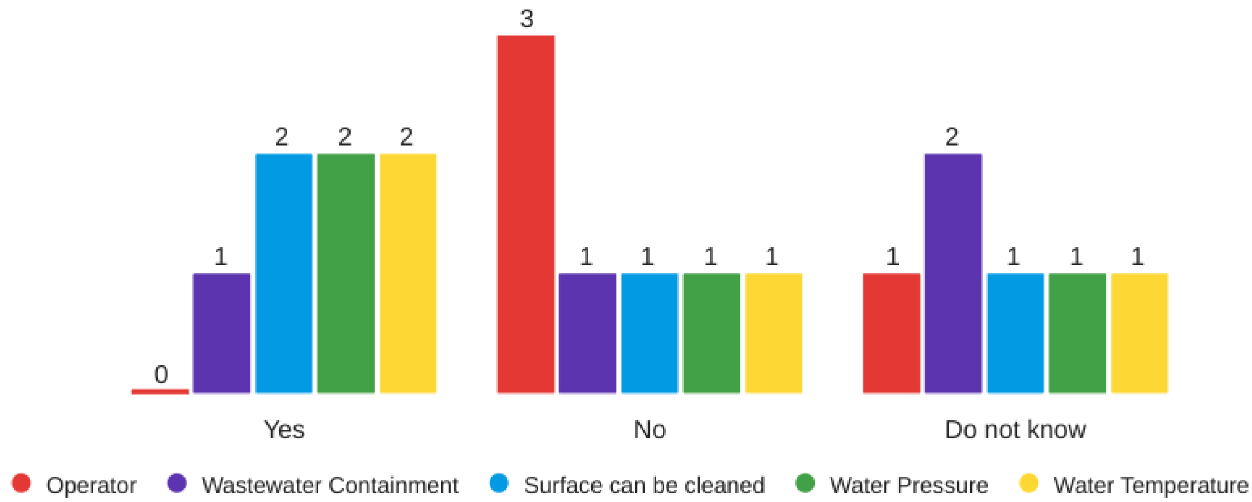
Field	Choice Count
Yes	4
No	13
Total	17

Q5.1 - Do you use the hot water pressure wash equipment for any other purpose listed below? Select all that apply.

Field	Choice Count
Unfreeze bearings	1
Graffiti removal	1
Removing joint sealant	1
Flushing drainage structures	0
Pack rust mitigation	2
General bridge cleaning	1
Other uses (please specify)	2
Total	8

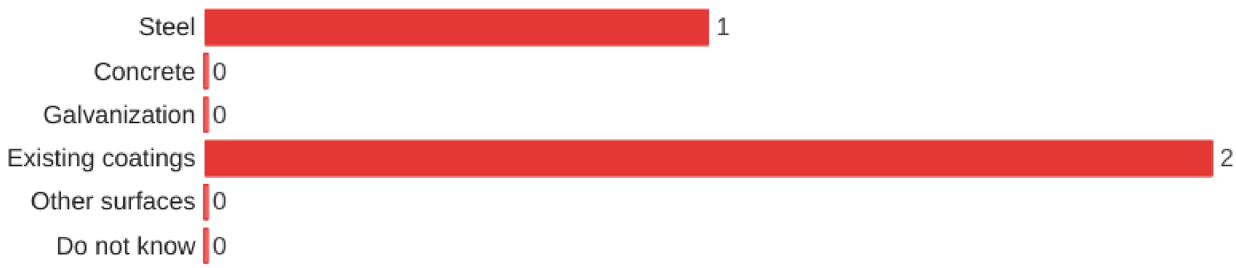
Other uses (please specify) - Text
Was used to remove rotting cellulose outer layer from a large timber bridge.
Steam cleaning to remove grease and foreign materials from existing coatings.

Q5.2 - Do you have any limitations on using hot water pressure wash? Select all that apply.



Field	Yes	No	Do not know	Total
Operator	0	3	1	4
Wastewater Containment	1	1	2	4
Surface can be cleaned	2	1	1	4
Water Pressure	2	1	1	4
Water Temperature	2	1	1	4

Q5.3 - Do you have any limitation on using hot water pressure wash on the following surfaces? Select all that apply.



Field	Choice Count
Steel	1
Concrete	0
Galvanization	0
Existing coatings	2
Other surfaces	0
Do not know	0
Total	3

Q5.4 - Please provide your hot water pressure wash water pressure range.

Upper Pressure Limit (psi)	Lower Pressure Limit (psi)
N/A	N/A
N/A	N/A
1800	2000
N/A	N/A
N/A	N/A
N/A	N/A
5,000	1,160
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A

Q5.5 - Please select your hot water pressure wash water temperature range.

2 Responses

Lower Temperature Limit (°F)	Upper Temperature Limit (°F)
N/A	N/A
N/A	N/A
200.00	185.00
N/A	N/A
N/A	N/A
N/A	N/A
212.00	212.00
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A
N/A	N/A

Q6.1 - Do you use any of the following surface preparation methods? Select all that apply.

Field	Choice Count
Hand tools	14
Power tools	17
Abrasive blasting	17
Cold water pressure wash	8
Other methods	1
Total	57

Other methods - Text
In the past cold water washing was used with overcoats but that is no longer used. Age of coatings and required containment of water makes it cost prohibitive

Q6.2 - Do you perform any of the following bridge maintenance tasks? Please provide details in the text boxes. Select all that apply.

Field	Choice Count
Pack rust mitigation	10
Frozen bearing mitigation	4
Salt contamination mitigation (e.g., rust inhibitors, vinegar, soap, or other methods)	6
Total	20

Pack rust mitigation - Text
Power tool chisel, needle gun.
Generally only as part of painting projects
no
No. Indiana does not do anything additional to pack rust areas above the typical cleaning that is done to the rest of the bridge.

Frozen bearing mitigation - Text
no
No

Salt contamination mitigation (e.g., rust inhibitors, vinegar, soap, or other methods) - Text
Flushing and use of Chlorid
Rust inhibitors.
Rust inhibitors are sometimes used.
no
Indiana requires water misting and a second blast cleaning after 24 hours has elapsed to help mitigate areas of known or suspected soluble salt contamination.

Q6.3 - Do you have any more information you would like to add?

Do you have any more information you would like to add?
No
Please contact the NYS Thruway Authority and the NYS Bridge Authorities because both may use CSAs.
I did not understand question 5.2.
We have only been specifying the use of HRCSA for a few years; performance is still to be determined.
We have had very mixed results with the HRCSA and moving away from using the product. We have had a lot of coating failures with this product.

7 Appendix B – Survey Questionnaire and Flow Chart

Minnesota Department of Transportation (MnDOT)
Transportation Research Synthesis (TRS)
High-Pressure Hot Water Blasting Surface Preparation and HRCSA Coatings for Bridge Maintenance

You are invited to participate in a survey as part of a Transportation Research Synthesis (TRS). Thank you in advance for your consideration and time.

Objective of the Survey

This survey, together with a literature review, is part of a TRS conducted by North Dakota State University and contracted by the Minnesota Department of Transportation (MnDOT). This survey is intended to gather information on state of the art and best practice of highway bridge maintenance painting using high ratio calcium sulfonate alkyd (HRCSA) and pressurized hot water cleaning (PHWC).

Dissemination of Questionnaire/Survey Data

The information gathered through this survey is anticipated to be beneficial to MnDOT and other agencies with ever increasing challenges maintaining steel bridges with coatings. A summary of this survey, its data analysis, and the literature review will be available as a final synthesis report.

Survey Process

This survey will be released through Qualtrics. There are a total of 22 questions in this survey, predominantly multiple choice or multiple select. However, you will not see all 22 questions. Some questions are only triggered based on the response selected in a previous question. A pdf of the survey is provided in case you want to preview the questions ahead of time. Please note that you need to complete the survey in one sitting.

To facilitate a timely summary of the TRS, we ask that you complete the survey June 10, 2022. At the beginning of the survey, please enter your contact information for us to contact you if any follow-up on your response is necessary.

Your participation in this survey is very important for the success of the TRS, which will benefit the advancement of bridge maintenance strategy and practice. We sincerely appreciate your assistance. If you have any questions, please contact:

Sarah Sondag, Engineer Principal, Minnesota Department of Transportation (sarah.sondag@state.mn.us)
Xiaoning Qi, Assistant Research Professor, North Dakota State University (xiaoning.qi@ndsu.edu)

1. Opening Questions
   1.1. Please provide your contact information below so that we can follow up with you if necessary.
      1.1.1. First Name ____
      1.1.2. Last Name ____
      1.1.3. Agency ____
      1.1.4. Email ____
   1.2. Do you use HRCSA or CSA for Bridge Maintenance?
      (HRCSA -- high ratio calcium sulfonate alkyd; CSA -- calcium sulfonate alkyd)
      1.2.1. Yes
      1.2.2. No
      1.1.1. [If you choose "Yes" you will answer Questions in Sections 3 and 4. If you choose "No", you will answer questions in Sections 2 and 4]

2. IF YOU CHOOSE "NO" FOR QUESTION 1.2
   2.1. The reasons not choosing HRCSA/CSA are (select all that apply):
      2.1.1. Lack of performance data
      2.1.2. Not meeting the performance requirement
      2.1.3. Additional cost
      2.1.4. Coating is too soft, accumulates dirt, and is prone to premature damage
      2.1.5. Poor UV resistance
      2.1.6. Have not tried this type of coating
      2.1.7. Other reasons (please specify) __________________
   2.2. **[if you choose "*2. Not meeting the performance requirement*" for Question 2.1]** You indicate that HRCSA/CSA is not meeting the performance requirement. Please specify your source of performance data and provide links/details if available (select all that apply):
      2.2.1. Past DOT reports ____
      2.2.2. Professional experience/recommendations ____________________________
      2.2.3. First hand field study ____
      2.2.4. Other sources (please specify) ______________________________________
   2.3. Please upload any relevant report/document that you would like to share. You can only upload one file; one zip file is allowed. [Drop file or click here to upload]
   2.4. What are the coating systems you use? Select all that apply.
      2.4.1. Three-coat with a zinc-rich primer
      2.4.2. Two-coat with moisture-cured urethane (MCU)
      2.4.3. Metalizing coating
      2.4.4. Other coating systems (please specify) ______________________________________

3. IF YOU CHOOSE "YES" FOR QUESTION 1.2
   3.1. Please select your HRCSA/CSA application for bridge maintenance. Select all that apply.
      3.1.1. Spot repair
      3.1.2. Overcoating (painting over existing coating surfaces)
      3.1.3. Coating bearings or connections
      3.1.4. Mitigating crevice corrosion/pack rust
      3.1.5. Recoat very large or entire bridge surface
      3.1.6. Other applications (please specify) ____
   3.2. **[if you choose "*3. Coating bearings or connections*" for Question 3.1]** Do you use HRCSA to unfreeze bearings?
      3.2.1. Yes
      3.2.2. No

3.2.3. Do not know

3.3. **[if you choose "*3. Coating bearings or connections*" or *"4. Mitigating crevice corrosion/pack rust"* for Question 3.1]** Do you use a penetrating sealer?

3.3.1. Yes (please specify the penetrating sealer you use) __________

3.3.2. No

3.3.3. Do not know

3.4. Do you use HRCSA or generic CSA?

3.4.1. HRCSA

3.4.2. Generic CSA

3.4.3. Both HRCSA and generic CSA

3.5. Do you use other coating systems as well?

3.5.1. Yes

3.5.2. No

3.6. **[if you choose "*1. Yes*" for Question 3.5]** What are the other coating systems you use? Select all that apply.

3.6.1. Three-coat with a zinc-rich primer

3.6.2. Two-coat with moisture-cured urethane (MCU)

3.6.3. Metalizing coating

3.6.4. Other coating systems (please specify) ____

3.7. **[if you choose "*1. Yes*" for Question 3.5]** How do you determine when to use HRCSA/CSA? Select all that apply.

3.7.1. Cost savings

3.7.2. Easy application

3.7.3. Tolerant to non-ideal surfaces

3.7.4. Other reasons ____

4. QUESTIONS ON IF YOU USE HOT WATER PRESSURE WASH

4.1. Do you use hot water pressure wash to prepare bridge surfaces for HRCSA/CSA or other coating application?

4.1.1. Yes

4.1.2. No

5. IF YOU CHOOSE "YES" FOR QUESTION 4.1

5.1. Do you use the hot water pressure wash equipment for any other purpose listed below? Select all that apply.

5.1.1. Unfreeze bearings

5.1.2. Graffiti removal

5.1.3. Removing joint sealant

5.1.4. Flushing drainage structures

5.1.5. Pack rust mitigation

5.1.6. General bridge cleaning

5.1.7. Other uses (please specify) ____

5.2. Do you have any limitations on using hot water pressure wash? Select all that apply.

5.2.1. Operator	Yes	No	Do not know
5.2.2. Wastewater Containment	Yes	No	Do not know
5.2.3. Surface can be cleaned	Yes	No	Do not know
5.2.4. Water Pressure	Yes	No	Do not know
5.2.5. Water Temperature	Yes	No	Do not know

5.3. **[if you choose "Yes" for 3. "Surface can be cleaned" in question 5.2]** Do you have any limitation on using hot water pressure wash on the following surfaces? Select all that apply.

5.3.1. Steel
5.3.2. Concrete
5.3.3. Galvanization
5.3.4. Existing coatings
5.3.5. Other surfaces ___________
5.3.6. Do not know

5.4. **[if you choose "Yes" for 4. *"Water Pressure"* in question 5.2]** Please provide your hot water pressure wash water pressure range.
5.4.1. Lower Pressure Limit: ________________
5.4.2. Upper Pressure Limit: ________________

5.5. **[if you choose "Yes" for 5. *"Water Temperature"* in question 5.2]** Please select your hot water pressure wash water temperature range. [Slider to choose temperature range.]

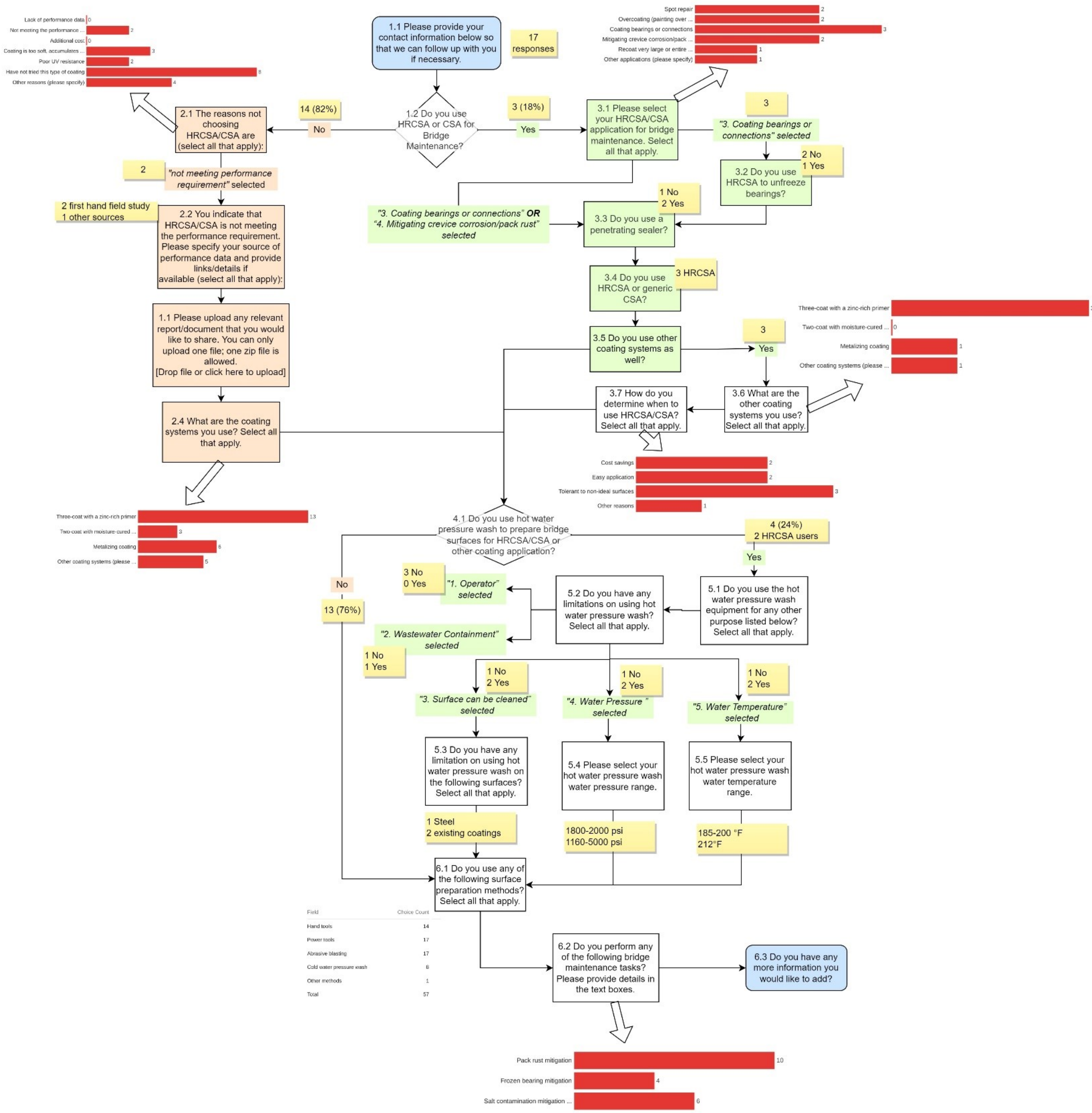
6. CONCLUDING QUESTION

6.1. Do you use any of the following surface preparation methods? Select all that apply.
6.1.1. Hand tools
6.1.2. Power tools
6.1.3. Abrasive blasting
6.1.4. Cold water pressure wash
6.1.5. Other methods ____

6.2. Do you perform any of the following bridge maintenance tasks? Please provide details in the text boxes. Select all that apply.
6.2.1. Pack rust mitigation
6.2.2. Frozen bearing mitigation
6.2.3. Salt contamination mitigation (e.g., rust inhibitors, vinegar, soap, or other methods)

6.3. Do you have any more information you would like to add?
____

<u>A flow chart of all the questions is shown on the next page</u>.


Lack of performance data 0
Not meeting the performance ... 2
Additional cost 0
Coating is too soft, accumulates ... 3
Poor UV resistance 2
Have not tried this type of coating 8
Other reasons (please specify) 4
1.1 Please provide your contact information below so that we can follow up with you if necessary.
17 responses
Spot repair 2
Overcoating (painting over ... 2
Coating bearings or connections 3
Mitigating crevice corrosion/pack ... 2
Recoat very large or entire ... 1
Other applications (please specify) 1
14 (82%)
No
2.1 The reasons not choosing HRCSA/CSA are (select all that apply):
1.2 Do you use HRCSA or CSA for Bridge Maintenance?
3 (18%)
Yes
3.1 Please select your HRCSA/CSA application for bridge maintenance. Select all that apply.
3
"3. Coating bearings or connections" selected
2 No
1 Yes
3.2 Do you use HRCSA to unfreeze bearings?
2
"not meeting performance requirement" selected
2 first hand field study
1 other sources
2.2 You indicate that HRCSA/CSA is not meeting the performance requirement. Please specify your source of performance data and provide links/details if available (select all that apply):
"3. Coating bearings or connections" OR "4. Mitigating crevice corrosion/pack rust" selected
1 No
2 Yes
3.3 Do you use a penetrating sealer?
3.4 Do you use HRCSA or generic CSA?
3 HRCSA
1.1 Please upload any relevant report/document that you would like to share. You can only upload one file; one zip file is allowed.
[Drop file or click here to upload]
3.5 Do you use other coating systems as well?
3
Yes
Three-coat with a zinc-rich primer 3
Two-coat with moisture-cured ... 0
Metalizing coating 1
Other coating systems (please ... 1
2.4 What are the coating systems you use? Select all that apply.
3.7 How do you determine when to use HRCSA/CSA? Select all that apply.
3.6 What are the other coating systems you use? Select all that apply.
Cost savings 2
Easy application 2
Tolerant to non-ideal surfaces 3
Other reasons 1
Three-coat with a zinc-rich primer 13
Two-coat with moisture-cured ... 3
Metalizing coating 6
Other coating systems (please ... 5
4.1 Do you use hot water pressure wash to prepare bridge surfaces for HRCSA/CSA or other coating application?
4 (24%)
2 HRCSA users
Yes
No
13 (76%)
3 No
0 Yes
"1. Operator" selected
5.2 Do you have any limitations on using hot water pressure wash? Select all that apply.
5.1 Do you use the hot water pressure wash equipment for any other purpose listed below? Select all that apply.
"2. Wastewater Containment" selected
1 No
1 Yes
1 No
2 Yes
"3. Surface can be cleaned" selected
1 No
2 Yes
"4. Water Pressure" selected
1 No
2 Yes
"5. Water Temperature" selected
5.3 Do you have any limitation on using hot water pressure wash on the following surfaces? Select all that apply.
5.4 Please select your hot water pressure wash water pressure range.
5.5 Please select your hot water pressure wash water temperature range.
1 Steel
2 existing coatings
1800-2000 psi
1160-5000 psi
185-200 °F
212°F
6.1 Do you use any of the following surface preparation methods? Select all that apply.
Field Choice Count
Hand tools 14
Power tools 17
Abrasive blasting 17
Cold water pressure wash 8
Other methods 1
Total 57
6.2 Do you perform any of the following bridge maintenance tasks? Please provide details in the text boxes.
6.3 Do you have any more information you would like to add?
Pack rust mitigation 10
Frozen bearing mitigation 4
Salt contamination mitigation ... 6

8 Appendix C – A Paint Inspection Report from the New York State Department of Transportation

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION

Paint Inspection Report

Contract "D" No. NYSTA Job	BIN Number 5513679	Location Region 1; I-90 Thwy over CSX RR, Town of Rotterdam	Date 9/27/12
Inspector W. Feliciano		Co-Inspector(s) R. White & M. Crannell	

General Paint Condition ☐ 10 ☐ 9 ☐ 8 ☐ 7 ☒ 6 ☐ 5 ☐ 4 ☐ 3 ☐ 2 ☐ 1

Rusting; especially on bottom flanges, at joints (despite scuppers & SP-5 prep), & at bearings. Paint still soft & waxy, dull & dirty, especially bottom flange. (see figures 1 – 38, pages 3 – 21) Details of late 2002 paint prep and application are presented on page 2.

Surface Rust ☐ 10 ☐ 9 ☐ 8 ☐ 7 ☒ 6 ☐ 5 ☐ 4 ☐ 3 ☐ 2 ☐ 1

Rusting; especially on bottom flanges, at joints & at bearings (see figures 1 – 29 & 33-38, pages 3 – 17 & 19 – 21)

Color Retention ☐ 10 ☐ 9 ☐ 8 ☐ 7 ☐ 6 ☐ 5 ☐ 4 ☐ 3 ☐ 2 ☐ 1

N/A – No photos of job after completed in late 2002.

Color Match ☐ 10 ☐ 9 ☐ 8 ☐ 7 ☐ 6 ☐ 5 ☐ 4 ☐ 3 ☐ 2 ☐ 1

N/A – Bridge completely overcoated not localized painted, so no areas of new paint adjacent to old. Can not rate how closely the paint color matches the intended color ten years after the job was completed.

Gloss Retention ☐ 10 ☐ 9 ☐ 8 ☐ 7 ☐ 6 ☐ 5 ☐ 4 ☐ 3 ☐ 2 ☐ 1

N/A - Can not rate how closely the paint gloss matches the intended gloss ten years after the job was completed. Gloss is flat, at least after ten years.

Adhesion ☐ 10 ☐ 9 ☐ 8 ☐ 7 ☐ 6 ☐ 5 ☐ 4 ☐ 3 ☐ 2 ☐ 1

N/A – Did not do ASTM D4541 adhesion testing because we would not be able to touch up areas of paint pull off. No touchup calcium sulfonate paint available, and calcium sulfonate overcoating reportedly problematic.

Dry Film Thickness ☐ 10 ☐ 9 ☐ 8 ☒ 7 ☐ 6 ☐ 5 ☐ 4 ☐ 3 ☐ 2 ☐ 1

Performed DFT measurements per SSPC PA-2 on a single spot on the inner web of the south fascia girder near the southeast corner with a Type 2 magnetic gage. The average of 5 measurements made within a one square meter spot was 25.4 mils, with a range of 24.1 to 26.4 mils. This area was presumably overcoated. Its > 25 mils DFT would preclude a second overcoating job per NYSDOT guidance in EI 05-040.

Surface Contamination ☐ 10 ☐ 9 ☐ 8 ☒ 7 ☐ 6 ☐ 5 ☐ 4 ☐ 3 ☐ 2 ☐ 1

Paint was soft & waxy, dull & dirty, especially on the bottom flanges & fascias.

General Remarks: (10 = excellent; 1 = poor)

Considering the relatively mild conditions presented by this bridge (high bridge over low traffic, slow freight trains with scuppers at joints), the performance after ten years was disappointing, especially in comparison to our 3-coat organic zinc-rich / epoxy / urethane system. Rusting was evident even at the support piers, which were SP-5 blasted, and protected from leaking bridge deck joints by drainage scuppers.

(prep & paint application details on pg 2; photos on pgs 3-21)

From: Bob Schabhetl [Bob.Schabhetl@thruway.ny.gov]
Sent: Tuesday, September 25, 2012 11:46 AM
To: White, Raymond (DOT)
Cc: Kirk Huang
Subject: RE: NYSTA Calcium Sulfonate (TERMARUST) Trial
Ray,

The entire bridge was painted. The areas 5' each side of the two joints over the piers were blast cleaned to white metal, SSPC-SP5, and the rest of the bridge was overcoated. The previous paint system was two coats of aluminum epoxy mastic over commercial blast cleaned (SP6) steel. Power tool cleaning was required at pack rusted areas only. The surfaces were pressure washed at 5000 psi to SP12 WJ-3 M. Bridgecote 8100 penetrating sealer was applied to crevice corrosion areas only (I think there were very few, if any, crevice corrosion areas). If there was any crevice corrosion, it received a spot prime coat of 10 dry mils of Bridgecote 8200 self priming top coat. I'm not sure when, but the product name changed from Bridgecote to Termarust at some point. The blast cleaned areas at the joints got a single coat of Bridgecote 8200 at 10 dry mils. For the overcoated part of the bridge, the rusted areas were spot primed with 5 dry mils of Bridgecote 8200, then all area were overcoated with 5 dry mils of the same material.

>>> "White, Raymond (DOT)" <Raymond.White@dot.ny.gov> 09/25/2012 10:38 AM >>>
Kirk/Bob,

We will share our findings, if we are able to access the bridge without infringing on CSX RR right of way.

We do have questions on the calcium sulfonate (CS) application:
-was the entire bridge painted with CS, if so was it overcoat or full removal
-if not, where on the bridge were the test patches applied, & was test patches overcoat or full removal
-if overcoated, what was the underlying paint system
- what was the preparation (just power wash, at what pressure; power tool; blasting ...)
- application details (was Termarust 2100 primer/sealer & 2200 topcoat applied, and approx. DFTs)

Thanks,
Ray
-----Original Message-----
From: Kirk Huang [mailto:Kirk.Huang@thruway.ny.gov]
Sent: Tuesday, September 25, 2012 10:14 AM
To: White, Raymond (DOT)
Cc: Bob Schabhetl
Subject: RE: NYSTA Calcium Sulfonate (TERMARUST) Trial

Ray, I checked with Bob Schabhetl, it was BIN 5513679. Let us know with further questions. Also, can you share your findings? Please say hi to Willie for me. Thanks. Kirk

>>> "White, Raymond (DOT)" <Raymond.White@dot.ny.gov> 9/24/2012 10:53 AM >>>
Actually, I have in our files that that application would have been September of 2002.

From: White, Raymond (DOT)
Sent: Monday, September 24, 2012 10:51 AM
To: 'kirk_huang@thruway.state.ny.us'
Cc: Feliciano, William (DOT)
Subject: NYSTA Calcium Sulfonate (TERMARUST) Trial

Kirk,

Willie asked me to contact you to see if you knew anything about a calcium sulfonate trial application that the Thruway did on one of your bridges over the CSX railroad in November of 2001 (I assume in this area). We are hoping to locate a bridge within driving distance to inspect that has a ~10 yr old application of calcium sulfonate to check performance. We'd appreciate hearing back from you with any info you can provide. Thanks.

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

Figure 8

Figure 9

Figure 10


Figure 11


Figure 12

Figure 13

Figure 14


Figure 15


Figure 16

Figure 17


Figure 18

Figure 19

Figure 20


Figure 21


Figure 22

Figure 23

Figure 24


Figure 25


Figure 26

Figure 27

Figure 28


Figure 29


Figure 30

Figure 31

Figure 32


Figure 33


Figure 34

Figure 35

Figure 36

Figure 37

Figure 38