C9 Bridge Aesthetics

C9.5.8 Special lighting on bridges

Table C9.5.8 contains examples of projects with special lighting.

Table C9.5.8. Special lighting projects

Location	Lighting Features
US 71 Okoboji Lakes Bridge and Causeway Dickinson Co. (original project no. unknown)	Ornamental light poles on pedestals along MSE retaining wall
I-80 over IA 965 in Coralville IM-080-6(168)241—13-52, Des. No. 102	Aluminum light sconces and fixtures at piers
Pedestrian bridges over I-235 in Des Moines IM-235-2(327)9—13-77, Des. No. 303	Arch rib and cable floodlights, abutment lights
IA 1 over the Des Moines River in Keosauqua BRF-001-1(24)—38-89, Des. No. 105	Ornamental light poles on custom deck cantilever pedestals along pedestrian railing
24th Street over I-29/I-80 in Council Bluffs BRFIM-080-1(308)2—05-78, Des. No. 508	Continuous fiber optic light on pedestrian fence, abutment artwork floodlighting
US 18/US 71 over the Little Sioux River in Spencer BRF-018-2(72)—38-21, Des. No. 106	Ornamental light poles on pedestrian railing pedestals
US 169 over E. Fork of Des Moines River in Algona BRF-169-8(41)—38-55, Des. No. 107	Lighting in decorative metalwork at railing ends
Wesley Parkway over I-29 in Sioux City IM-NHS-029-7(37)149—03-97, Des. No. 1711	LED spotlights and LED wall-wash fixtures
US 6 Broadway Viaduct in Council Bluffs BRF-006-1(113)—38-78, Des. No. 210	Decorative roadway light poles on custom deck cantilever pedestals, pier artwork floodlighting
I-29 Ramp at Nebraska Ave in Sioux City IM-NHS-029-6(206)147—03-97, Des. No. 1617	LED wall-mount up-down lights at piers
I-29 over Virginia St./Floyd Blvd at Sioux City IM-NHS-029-6(201)147—03-97, Des. No. 817 IM-NHS-029-6(203)147—03-97, Des. No. 1017	LED wall-mount up-down lights at piers
US 52 over Mill Creek in Bellevue BRF-052-1(70)—38-49, Des. No. 108	Ornamental light poles along trail, spotlights at abutment towers
US 65 over Iowa River in Iowa Falls BRFN-065-6(42)—39-42, Des. No. 110	Ornamental light poles on pedestrian railing pedestals
US 63 over CC&PRR in Waterloo NHSX-063-6(75)—3H-07	Light poles with banners on cantilevered barrier pedestals above MSE retaining wall
US 20/US 151 and Southwest Arterial interchanges in Dubuque; NHSX-032-1(42)—3H-31, Des No. 617; NHSX-032-1(40)—3H-31	Decorative lighted pier lanterns, decorative truss floodlighting (all LED fixtures)
I-35 over 1st Avenue (DDI) in Ankeny IM-NHS-035-4(196)92—03-77	Wall-mount lights at piers, barrier light fixtures for central pedestrian path through DDI
Edgewood Road over IA 100 in Cedar Rapids NHSX-100-1(66)—3H-57, Des. No. 514	Ornamental light poles on barrier pedestals
US 30 over Boyer River in Woodbine BRF-030-1(147)—38-43, Des. No. 116	Ornamental light poles with banners on barrier pedestals
I-74 over the Mississippi River in Bettendorf IM-NHS-074-1(198)5—03-82, Des. Nos. 617, 717	Color-changing LED lighting for arches, decorative light poles along trail, LED lighting at overlook
IA 3 over the Cedar River in Waverly BRF-003-6(69)—38-09, Des. No. 323	Ornamental light poles

I-80 over IA 146 near Grinnell IM-NHS-080-5(355)183—03-79, Des. No. 520 IM-NHS-080-5(362)183—03-79, Des. No. 122	Pier artwork spotlights, trail underdeck lighting
Pedestrian tunnels (most projects since ca. 2000)	Various barrel and headwall lighting solutions

C9.5.9 Decorative Concrete

C9.5.9.1 General

Table C9.5.9.1 contains examples of precedent projects with decorative concrete treatments.

Table C9.5.9.1 Precedent projects with decorative concrete treatments (incomplete listing)

Example Location	Decorative Concrete Treatments											
	Articulation	Rustication	Texture	Thin brick	Integral color	White concrete	Abrasive blast	Rubbed finish	Decorative insert	Broomed finish	Acid etching	Exposed aggreg.
Dickinson Co., US 71 Okoboji Lakes Bridge & Causeway, FHWA# 23671	X	X			X (MSE)	X						
Polk Co., I-35/I-80 over Merle Hay Rd, FHWA# 41441/41451	X	X			X							
Polk Co. Des. 2201, Douglas Ave over I-35/I-80, FHWA# 41331	X	X										
Polk Co. Des. 704, 42nd St over I-235, FHWA# 42171	X	X								X		
Johnson Co. 102, I-80 over IA 965 (widening), FHWA# 32030/32040	X	X								X		
Van Buren Co. Des. 105, IA 1 over Des Moines River, FHWA# 50181	X	X	X									
Kossuth Co. Des. 107, US 169 over E. Fork Des Moines R., FHWA# 32921	X	X	X									
Jackson Co. Des. 108, US 52 over Mill Creek & CPRR, FHWA# 609770	X	X	X		X (MSE)		X					
Greene Co. Des. 117, US 30 over UPRR and 222nd St, FHWA# 025641	X	X					X		X			
Woodbury Co. Des. 202, 1st Street over I-29, FHWA# 609080	X	X										
Woodbury Co. Des. 1617, I-29 Ramp B over Virginia St, FHWA# 700325	X	X	X	X	X (MSE)				X	X		
Linn Co. Des. 414/1214, IA 100 over Ushers Ferry, FHWA# 70445/70450	X	X	X	X	X (MSE)							
Polk Co. Des. 2002/1125, Living History Farms RCB tunnel extension	X	X	X									
Linn Co. Des. 614, bike trail RCB under Covington Rd		X	X	X								

Story Co. Des. 616, I-35 NB to US 30 WB, FHWA# 700825	X	X		X	X (MSE)			X			X (MSE)	
Wapello Co. Des. 519, West Park Blvd over IA 149, FHWA# 50661	X	X		X				X				
Johnson Co. Des. 1020, Herbert Hoover Hwy over I-80, FHWA# 32161	X	X	X						X			
Linn Co. Des. 321/421, Tower Terrace over I-380, FHWA# 701060/605041	X	X	X	X				X				
Polk Co. Des. 423, NE 126th Ave over I-35, FHWA# 040791	X	X		X				X				
Bremer Co. Des. 323, IA 3 over Cedar River, FHWA# 15571	X			X				X				
Poweshiek Co. Des. 520/122, I-80 over IA 146, FHWA# 46051/46061	X	X		X					X	X		
Allamakee Co. Des. 124, IA 9 over Mississippi River, FHWA# 13521	X	X (MSE)			X (MSE)		X (MSE)					X (MSE)

C9.5.10 Commentary – history of concrete coatings usage by Iowa DOT

The Department has used various concrete coating types for aesthetic purposes on many past projects, primarily on surfaces of bridges and pedestrian tunnels. Important lessons regarding appropriate material, usage, and surface preparation have been learned along the way.

Some bridges received aesthetic coating in the late 1990s. At that time, the DOT had a “Class 3 Surface Finish” in its Standard Specifications that had previously been used only very rarely. Materials meeting this specification were what is known in the painting industry as “texture paint”, which contains cementitious material along with a pigmented acrylic binder. Some bridges were coated with this material without reference to any specific surface preparation method (because the Standard Specifications lacked any), and the results varied widely. Some coatings were successful, probably due to the care in surface preparation that was undertaken by some contractors in accordance with product manufacturer’s recommendations. Other coated projects were much less successful, due at least in part to inadequate or nonexistent surface preparation. Discussions with one contractor indicated that their understanding was that since the Class 3 finish material contained cement, it would stick to concrete under any circumstances. This was clearly not the case, as many bridges coated with this material experienced sloughing of entire sections of the coating, which clearly had little to no bond strength with the substrate. One contractor at the new 50th Street bridge over I-235 (ca 2000) indicated that the only surface preparation that occurred on parts of that bridge’s painting project was a blow-down of the surfaces with compressed air. That was followed by coating application using a spray gun fed by an open hopper full of cementitious finish material on a hot, windy summer day. Most of that coating flaked and fell off those surfaces within the first year.

At that time, MnDOT had more experience with concrete coatings than Iowa DOT, so some Minnesota bridges were visited as references in the search for a remedy or a better specification. Similar coating failures were seen on some bridges in Minnesota when Iowa DOT was experiencing coating problems. A similar cementitious acrylic coating had been used by MnDOT on some bridges. Upon close inspection, a lack of bond strength between the coating and the concrete was also clearly the issue on those bridges.

Iowa DOT decided to perform field testing with the help of a Houston-based painting contractor that was doing remediation work on the 50th Street bridge over I-235 in late summer of 2000. That fall, a bridge painting investigatory project was set up at the existing S. Dayton Avenue PPCB bridge over US 30 due to its proximity to the DOT’s Central Office. The project was meant to inform future bridge painting work that was planned for the entire I-235 corridor involving more than 70 replacement bridges. The investigation included proper surface preparation and application of 3 different material types:

cementitious acrylic coating (texture paint) in accordance with the Class 3 Special Surface Finish; a high-silicone content acrylic sealer proposed by the Houston-based painter, and 100% acrylic emulsion masonry paint.

The concrete surfaces to be coated were pressure washed at 3000 psi and allowed to dry for a minimum of 24 hours. Prior to coating applications, Central Office Materials staff performed testing of the prepared concrete surfaces for pH levels using pencil tests and checked concrete moisture using thin plastic film taped to the surface and left overnight to check for condensation. Presence of sealers was also checked via a water mist test, and none were found. The bridge had been built 8 years earlier in 1992, so pH and internal moisture levels were within coating manufacturer's recommended limits, probably not least due to the age of the concrete and to the generally low humidity air conditions prevalent during the fall season.

Two coats of each of the 3 material types were applied on separate sections of the bridge, with the east elevation (barrier, fascia beams and abutments) receiving the cementitious coating, and the west elevation and the entire pier receiving the high-silicone acrylic sealer. 100% acrylic emulsion paint was used on both elevations for the red accent stripe on the deck edge to verify the material's superior color retention even in bright hues. The different materials were not allowed to overlap on any surface. Materials staff performed pull-off adhesion tests on all 3 materials applied to the bridge. All were found to have excellent adhesion to the concrete, with each test showing failure of the concrete just below the layer of the bond between the concrete and the coating.

One notable difference between the high-silicone sealer and the cementitious coating was how quickly the white-colored texture paint on the east elevation of the Dayton Avenue bridge started to change due to collection of airborne dirt and dust on its slightly textured surface. Color went from pure white to a grayed off-white in just a few months.

Despite the generally acceptable performance of the Class 3 Special Surface Finish cementitious acrylic coating at the Dayton Avenue test site, the high-silicone acrylic sealer was seen as promising the best combination of appearance and longevity for use on the I-235 corridor bridge work. One important factor in the decision was the test's painting contractor's extensive experience in applying this material in Texas, Utah, and New Mexico, where it had reportedly performed very well with no adhesion problems for the many years it had been used on infrastructure projects. The high silicone sealer was expected to have a service life of 15 to 20 years. The Class 3 Special Surface Finish was subsequently abandoned and recommended for removal from the Standard Specifications (which occurred much later but prior to the 2015 release).

As a side note, the Houston-based painting contractor's remediation work at 50th Street over I-235 involved the use of 100% acrylic emulsion paint due to the presence of an existing coating (the cementitious acrylic material). This is because the high-silicone acrylic sealer can only be applied to raw concrete or to an original coat of high-silicone acrylic sealer placed on raw concrete. The cementitious acrylic coating at 50th Street was pressure washed to clean it and remove any loose material and was allowed to thoroughly dry before the acrylic paint was applied as a topcoat over the cementitious coating and over some areas of exposed raw concrete. The resulting coating system overall can be classified as vapor-permeable, though to what degree is unknown.

Since the chosen coating material for the I-235 corridor rebuild project was a concrete sealer that would not allow vapor transmission, it was decided that bridges would not be coated as part of their original construction contracts but would be allowed to weather for at least 2 full years prior to receiving the sealer. This was to ensure that the concrete's internal moisture from initial curing would be fully dissipated, to allow pH levels to become compliant for coating, and to allow any weak surface concrete to spall on its own through seasonal freeze-thaw cycles. Recognition that the Iowa climate is not the same as that in Texas or the desert southwest, this seemed the prudent approach. It was also anticipated that this tactic would be relatively economical since painting-only contracts could bundle multiple adjacent bridges and would not involve any other construction activity besides traffic control. The new coating material became known through the bid item "Colored Sealer Coating for Structural Concrete".

Piers, abutments, deck edges and overhang soffits, and concrete barrier outside surfaces of I-235 overhead and mainline bridges were prepared and coated with the high-silicone content acrylic sealer via controls in the “Developmental Specifications for Colored Sealer Coating for Structural Concrete”. For the original application of this coating on these bridges, plain-water pressure washing at 3000 psi and a rate of 3 to 14 gal./minute was the specified surface preparation method as was used at Dayton Avenue. Tests for moisture, pH levels, and presence of sealers were required to meet specifications prior to coating application. All bridges had weathered in the field for at least 2 years prior to being coated under one of 4 different painting projects that occurred within the 14-mile corridor between 2005 and 2008. Mainline bridges included a stripe of blue paint on the outside face of concrete barriers that was executed in 100% acrylic emulsion paint for the best color retention. Each coating type was applied to raw unpainted concrete and overlapping of the 2 different materials was not allowed.

Despite the precautions of waiting at least 2 years to apply colored sealer coating to the I-235 bridges, coating failures became evident within a few years after application. A 2011 survey of more than 20 bridges coated with colored sealer, most of them on I-235, revealed substantial problems. Coating degradation at deck edges was particularly pronounced on many bridges and represented some of the worst conditions. This is when field staff made us aware of the practice of deck finishing workers throwing screeded, partially dried concrete from the screed toward the form boards at the deck edge, creating inherently weak material in that area. Some abutment mask walls also exhibited pronounced issues. Cracks that had leached efflorescent salts were an issue on some bridges. I-235 bridge piers, which had been constructed with high performance concrete, were assessed as generally good, with most of the aesthetic impact on them identified as road spray soiling.

Upon close inspection of the pieces of coating material that had spalled off I-235 bridge abutments and deck edges, it was clear that most failures did not occur at the bond between the sealer and the concrete, but somewhere below the surface. Most spalls with coating on the front side had remnant cement, sand, and even small aggregate adhered to the back. Very few pieces of inspected coating had clearly failed at the bond layer. Many pop-outs of small to medium sized aggregate from formed vertical surfaces was also highly suggestive. This evidence was deemed to be strong indication of entrapped moisture as the culprit rather than an adhesive failure. It wasn’t necessarily the surface preparation method that was at fault, but the conditions inside the concrete and inherent weaknesses near the surface.

The only exception was at Euclid Avenue over I-235, where it was reported that the north elevation of the bridge may have been damp with overnight condensation when it was coated. Euclid Avenue is the only overhead bridge on I-235 that runs east-west, rather than north-south, and its north elevation would have been especially susceptible to the condensation problem during the morning hours. The adhesive bond between coating and concrete on the outside face of the north barrier most likely failed because persistent moisture on the surface was not allowed to fully dry before painting occurred.

Repainting of I-235 bridges began in 2012 and continued on a near-annual basis until 2022, at which time all bridges that were deemed to exhibit unacceptable coating appearance issues had been repainted. Some 53 bridges had been repainted during this period. Due to the presence of well-adhered colored sealer coating material on many surfaces of the affected bridges, water-only pressure washing was the surface preparation method in accordance with product manufacturer’s recommendations. It would not have been practicable to fully remove the existing material, and deeply abrasive-blasting an adhered coating would not have yielded any better result than the cleaning and top-coating produced. Due to the thermoplastic nature of the sealer, there is no adhesive bond layer between the original and any number of subsequent coats, and if the original coat was well-bonded there was no reason to remove it.

Following the experiences on I-235 bridges and others that received the colored sealer coating, it was prudent for the Iowa DOT to explore other coating types for future projects. Switching to highly breathable coatings seemed to be the proper change in policy, based on our assessment of the entrapped moisture failures seen with the sealer. New coatings with vapor-transmissive characteristics were investigated, including revisiting 100% acrylic emulsion coatings. In 2014 however, it was discovered that a material that had been used on concrete in Europe for over 150 years was finally being marketed by multiple manufacturers and suppliers in the USA: mineral silicate paint. Known informally as “water glass”, this

typically potassium-based mineral paint had projected service life of over 100 years by some accounts. It had been used to paint many multi-color murals and other complicated installations that one would not want to repaint very often, if ever. It also has environmental and sustainability advantages due to its water base and low VOC content. The product is so vapor-permeable, it is possible to use it on new concrete without as much concern about internal moisture as with other coatings. Also a proven concrete penetrant, this material showed real promise as one to try on Iowa projects.

In 2014, the City of Urbandale had a new interchange project under design for 100th Street over I-35/I-80 including a new bridge which would ultimately be owned by the DOT. The bridge was being designed to replicate aesthetic features at the Douglas and Meredith Avenue bridges over the same interstate facility, but those bridges had been color-coated with the sealer product. The 100th Street project looked ideal for Iowa's first use of mineral silicate paint on a bridge. However, this material was reportedly much more expensive per gallon than anything the DOT had used before, so there were some questions related to budgeting if this material were to be specified. It was expected that the overall cost of painting would not substantially increase, because most of the cost of painting is in the associated labor, not the material. Upon the prompting of Iowa DOT Bridges and Structures, City staff agreed to try the mineral silicate paint.

A Special Provisions document was written for the mineral silicate paint usage at 100th Street. The material was required to have 92% vapor transmission in accordance with ASTM E 96. Specified minimum concrete age was just 14 days. Three preapproved manufacturers were listed. Since manufacturer's recommendations for surface preparation were met or exceeded by those in our previous coating DS, they were employed on the project. Water-only pressure washing at 3000 psi and 3 to 14 gal./minute was used, and the surfaces were tested for readiness in accordance with manufacturer's recommendations.

For the year prior to the December 2015 letting for 100th Street, colored sealer coating averaged $74/SY. The awarded price for mineral silicate paint work at 100th Street was just $24/SY, with 2 other bids of $75/SY and $71/SY for an average of $57 for this "new" material. Clearly its higher per-gallon price had no effect on the overall cost of painting a bridge. That fact continued to be borne out in subsequent project lettings that included mineral silicate paint. The applied results in the field at 100th Street were exemplary, as well, and the painting contractor had no complaints about using the material.

After I-235 it was also prudent for our standard coating surface preparation method to become more aggressive so that as-cast concrete surface weaknesses could be reduced or eliminated prior to coating application, even if highly breathable coatings were to be the new standard. A new DS for Concrete Surface Preparation and Testing Prior to Coating Application was created under the 2015 Standard Specifications. It included a critical change from water-only pressure washing of concrete surfaces to a combined sand- and water-blast surface preparation method in accordance with International Concrete Repair Institute (ICRI) recommendations. This was expected to ensure that weak surface concrete zones would be removed before any coating was applied. Greater depth of surface profile and removal of polished zones (especially on precast beam faces) for better paint adhesion was also seen as an improvement over pressure washing.

An entirely separate DS for Structural Concrete Coating was created to cover the application of the coating, but paint material type would be handled by plan notes on all future projects. Keeping the DSs free of listed products meant that they wouldn't need updating as new manufacturers and products became available. If necessary, preapproved products could be listed in the MAPLE associated with a DOT Materials I.M., as they ultimately would be for mineral silicate paints under I.M. 482.12.

With the success at the 100th Street project, the switch was made to mineral silicate paint as the preferred aesthetic coating for material applied with the original bridge construction contract. The next bridge to receive mineral silicate paint under a State project was Morningstar Drive over I-35/I-80 east of the 100th Street interchange, aka. Polk Co. Design No. 1317. Then the delayed painting work at the Council Bluffs Interchange System (CBIS) was developed, where multiple bridges were packaged into several standalone bridge painting projects that exclusively used mineral silicate paint. A similar delayed

painting project took place on 4 bridges in the IA 100 corridor near Cedar Rapids in 2019 using mineral silicate paint.

Other coatings were used during this same period. At US 461 over IA 22 in Davenport, Scott Co. Design No. 318, 100% acrylic emulsion paint was used so that the DOT would have other breathable coating types on the system that could provide more information regarding paint performance over time. The Dayton Avenue bridge was repainted in 2018 to color match the new I-35 interchange bridge work in progress at the time, and all 3 original coating types were again used to recoat the bridge for consistency. At the new tunnel under US 63 in Waterloo, Black Hawk Co. Design No. 1315, high-silicone acrylic sealer was used on tunnel interior walls because of high future graffiti potential due to extant problems in the immediate area, and the sealer could be more easily top-coated rather than pressure-washed or scrubbed as remediation. The development of new DOT pedestrian tunnel standards was also underway at this time, and it was decided that 100% acrylic emulsion paint would be used to lighten the barrel interiors, with anti-graffiti coating used as a standard topcoat.

More recent aesthetic bridge projects indicate a dedicated trend toward painting of accent surfaces rather than the entirety of exposed substructure, beam, and barrier surfaces. The painting work at the bridges in the CBIS exemplify this, as do such projects as the IA 100 corridor bridges, the US 30 bridge over UPRR at Grand Junction, the Tower Terrace Road DDI bridges over I-380 at Cedar Rapids, the I-80/I-380 interchange project, the US 30 Mount Vernon-Lisbon Bypass, the Herbert Hoover Highway bridge over I-80 near Iowa City, County Road S14 over US 30 near Nevada, and IA 3 over the Cedar River at Waverly. In many cases, only the fascia precast beams received concrete coating. Some projects combined painted fascia beams with integral thin veneer brick for color in the substructure and barrier faces. Other recent aesthetic bridge projects such as at the NB I-35 to WB US 30 Ramp H near Ames, 580th Street over US 30 near Ames, and the I-35 Ankeny to Ames Monarch Highway corridor bridges employ no concrete coatings at all but rely solely on integral thin brick for their color accents. And again, edges of bridge decks are never painted on DOT projects due to the suspected inherent weakness of those surfaces.

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Email to Mr. Scott Dockstader (former Iowa DOT District 1 Engineer) dated Jan. 30, 2024:
Thank you very much for your inquiry into bridge coatings and for expressing concern about what you thought might be a continuation of practices undertaken on I-235 many years ago. Your query allows us to convey that nearly everything related to our basic bridge painting practices has changed since I-235. We learned many important lessons from our experience there and have since taken steps to ensure that other projects don’t suffer the same fate nor endure the added maintenance costs that were incurred there.

The paint materials we use on bridges have substantially changed since I-235. Whereas I-235 bridges received an impermeable silicone sealer, newer bridges have been painted with a highly permeable mineral silicate paint. The sealer failures we saw on I-235 and elsewhere were associated with entrapped moisture within the concrete, which caused weak surface material to spall during freeze-thaw cycles experienced by the structure. The sealer adhered well; it just didn’t allow the concrete to breathe. The mineral silicate paints we are now predominantly using are up to 92% vapor permeable, so they allow moisture to move in and out of the concrete very much like unpainted concrete. Freeze-thaw cycles don’t have the same effect they had on the sealed concrete. The mineral silicate paint is also a proven concrete penetrant, whereas the silicone sealer was a surface coating. Mineral silicates have been successfully used in Europe for over 150 years and are considered to have service lifetimes of up to 100 years but have only recently been marketed by USA-based companies. This type of paint can be seen in place on I-35/I-80 overhead bridges at Morningstar Drive, 100th Street, and the IA 141 Urban Loop flyover.

The success of any coating system is also highly dependent on surface preparation. After the issues we experienced with the old sealer material, we changed our basic surface preparation to include a much more aggressive combined sand- and water-blast requirement in place of the old power-washing
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technique. Our improved specification better ensures that any weak surface concrete is removed and therefore cannot spall and expose raw concrete after being painted with a breathable coating. This aggressive blasting also serves to increase surface profile of the concrete for improved adhesion. Mineral silicates are better suited to new concrete than the sealers, so there are fewer concerns about achieving low internal moisture levels prior to painting.

To date, we haven't experienced any of the kinds of performance problems in the breathable coatings that we had with the sealers. We are confident that these materials will continue to perform well throughout the expected service life of the few structures that receive this treatment annually. Concrete painting is now typically limited to fascia beam and accent surfaces, rather than entire pier, abutment, and barrier faces as on I-235. Bridgework in the I-80/I-380 Interchange and in the Council Bluffs Interstate System interchanges exemplify this new design approach. Some enhancement projects, such as the new overhead bridges along I-35 from Ankeny to Ames, receive no coatings at all, but rely on other sustainable means of incorporating color such as integral thin veneer brick treatment.

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C9.5.11 Commentary – history of steel railing coatings usage by Iowa DOT

The Department has used various steel railing coating types on many past projects, primarily on surfaces of bridge pedestrian and traffic railings. Important lessons regarding appropriate material, usage, and surface preparation have been learned along the way.

During the mid-1990s, design was underway for replacement of the Okoboji Lakes bridge and causeway carrying US 71 between Arnolds Park and Okoboji. The roughly 1200-foot-long causeway was to be entirely rebuilt using an MSE wall-supported roadway with a new parallel sidewalk. The sidewalk would require fall protection railing and the separation traffic barrier was also planned to receive a top-mounted decorative steel bicycle railing as part of an overall aesthetics package.

Given the quantity of painted railing that was required and the proximity to high levels of traffic and associated road salt spray, it seemed prudent to the Iowa DOT to employ a duplex coating system of paint over galvanized steel. This was known to be the first such application on a State project in Iowa, and there were no specifications in existence to cover this work type. A national standard for preparation of galvanized surfaces for paint, ASTM D 6386, would not be released for several years, in 1999.

Iowa DOT bridge office staff set out to write a specification for surface preparation of galvanized steel surfaces for paint by contacting American Galvanizers Association (AGA) representatives for advice. With AGA assistance, a Special Provisions (SP) document was written for the Okoboji project. As well as stringent surface preparation requirements, the SP contained a list of acceptable topcoat paint products and their manufacturers. The specified paint was a 2-coat, polyamide epoxy primer with aliphatic polyurethane topcoat system. Dry film thicknesses of 2.6 to 4 mils for the prime coat and 2 to 4 mils for the topcoat were specified. Four different manufacturers were identified in the SP.

The AGA advised the DOT to include restrictions on the galvanizer's use of water quenching after galvanizing and application of chromate conversion coating in the DOT's specification. AGA published documents a few years later that specifically targeted these practices as having negative effects on paint adhesion.

Around this time, ASTM D 6386 was first issued (1999). This was the first national-level specification addressing preparation of galvanized steel surfaces for painting. While it might have been assumed that painting industry representatives would be aware of the new ASTM document, the DOT continued use of the SP since the preparation requirements were essentially identical to those in the ASTM for newly galvanized surfaces. ASTM D 6386 also included recommendations against water quenching and chromate conversion coating following galvanizing.
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The Okoboji specification performed satisfactorily as a control over the steel railing surface preparation and painting work, though there were some issues associated with the required maximum time that was allowed to elapse between the galvanizing and the preparation/painting. Separate facilities performed these two tasks on the assemblies, and there was physical distance between them that challenged the contractor's ability to meet the specification due to trucking time. The galvanizer was essentially forced to galvanize and ship small portions of the job at a time, rather than completing the job and shipping all assemblies at once, which would have been more economical for them. They may not have anticipated this while preparing their bid, so there were some complaints.

Duplex painting on the Okoboji railings yielded a satisfactory result on the completed project, at least initially. That initial success led to additional projects using the same specifications for painting galvanized steel products. Some of the first bridge replacements on I-235 included the SP for painted pedestrian railings and steel-on-concrete traffic railings.

After some years of service, it became apparent that the durability of the epoxy/polyurethane paint system specified in the duplex system SP was not meeting expectations. Fading and chalking were evident, but flaking of the entire coating from the substrate was the greatest concern. There were questions about whether the galvanizers were restricting their use of water quenching and chromate conversion coating, as these procedures had clearly been identified as impediments to proper topcoat adhesion. DOT Materials staff made inquiries with galvanizers, but records of those contacts and any discoveries made have not been found for inclusion in this summary.

Paint failures were noted at the Okoboji project and on the first I-235 overhead bridge at 50th Street in West Des Moines. In some instances, the entire 2-coat paint system had de-bonded from the galvanized surface in large flakes. The paint was characterized as being very brittle, and additional partially-bonded paint was easily delaminated by slipping the edge of a tool underneath the paint. The bond was poor, and the characteristics of the paint itself seemed to intensify the problem. Some failures could be characterized as handling damage, and the pressure placed on the paint by adjacent assemblies or blocking during shipping appeared to have been the initial cause of some paint surface fracturing. Problems with the same characteristics were seen on other DOT projects that used the epoxy/polyurethane system, including where it had been used to paint galvanized chain link fence post assemblies for structure-mounted fencing.

Another problem was particularly evident in the blue paint used on I-235 railings: severe UV fading. The same problem occurred with the blue paint used on the superstructure steel arch of the first I-235 pedestrian bridge replacement near the Des Moines Botanical Center. It was later discovered by DOT Materials staff in consultation with KTA Tator that the types of paint the DOT was using had an inappropriate pigment vehicle in the paint's chemical structure for the bright color used. The pedestrian bridge was ultimately repainted in situ with high-performance fluoropolymer paint to correct the problem and to improve UV fading resistance during remaining service, and the 2 subsequent steel arch pedestrian bridges were shop-painted with fluoropolymer systems to avoid the problem suffered by the first bridge.

The DOT's duplex system SP became Supplemental Specification SS-01025, first issued in 2003. It continued to list the epoxy/polyurethane paint systems originally specified. Applications of this paint type continued until the serious adhesion and fading problems were identified on I-235 bridge railings that had seen several years of service. In 2008, a bridge maintenance project was undertaken to field repair and repaint the steel railings on 19 I-235 bridges using high-performance fluoropolymer paint. Special notes were developed to cover the surface preparation and repainting procedures. Since only portions of the in-place pedestrian railings were painted as part of their design, with surrounding surfaces galvanized-only, extensive masking was required to avoid adjacent surface contamination.

The painted steel traffic railing (the upper portion of the MnDOT Type 3 Combination rail used primarily on I-235 overhead bridges) at the I-235 mainline bridges over the Des Moines River has suffered the most extensive damage during its service life than other such installations within the corridor. These railings were repainted with 3-coat fluoropolymer paint as part of the 2008 maintenance project, but

repeated high-speed vehicle strikes and routine snowplow scraping have taken their toll on all layers of the duplex coating system. Some deep scrapes and gouges through the galvanizing have caused the steel to corrode, and this is likely to be accelerated by chemical action from road salt spray. Painting is strongly discouraged for future steel traffic railings intended for service in similar conditions. By contrast, the identical rail type was installed on two curving ramp bridges at the I-35 and Iowa 5 interchange but with unpainted galvanized finish. Those installations, while having required some touch-up of the galvanizing throughout service, have fared much better and do not have the negative appearance effects of deep paint scratches and scrapes.

A problem related to both unpainted and painted galvanized surfaces was also found on some I-235 railings. Areas of mill scale on some steel components was not being adequately removed by standard surface preparation practices prior to galvanizing. It was decided that the following note would be included in all future plans for plain or painted galvanized steel railings: Prepare the fabricated railing surfaces by abrasive blast cleaning to a minimum of SSPC SP-6 “Commercial Blast Cleaning” prior to hot-dip galvanizing.

Supplemental Specification SS-01025 became Iowa DOT Standard Specification Section 2509 with the publication of the 2009 edition. However, given the troubles experienced with the epoxy/polyurethane paints, many projects that included duplex coated railings were already using polyester powder coating as the preferred topcoat instead of paint.

The first powder-coated, duplex system-finished bridge railing that the DOT was made aware of was used at the Dayton Avenue over UPRR bridge in Ames, ca. 2003. Even though this was a Local Systems project, DOT staff had an opportunity to comment on the specifications used to control the duplex coating work, and then to observe the results. While the overall finish quality was very good, some minor coating condition issues were identified. Upon very close inspection, some areas of the powder coating exhibited pin-holing, which is typically attributed to off-gassing of the galvanized surface during the topcoat baking process that follows electrostatic powder application in the shop. Investigation into the topic revealed that it is ideal to include specification of “de-gassing grade” polyester powder to reduce the pin-holing potential when coating galvanized steel. The pin-holing seen on the Dayton Avenue example was not expected to have any long-term effect on coating performance and was very difficult to see from normal viewing distances.

The Iowa DOT’s first powder-coated duplex system-finished bridge railing occurred at the US 65 bridge over the Iowa River in Iowa Falls, ca. 2010. Instead of referencing Standard Specification Section 2509, which still called for the 2-coat epoxy/polyurethane paint associated with the early performance problems, surface preparation was specified in the plans to be in accordance with ASTM D 6386 and with Iowa DOT Materials I.M. 568. The powder coating material and application requirements were entirely controlled by I.M. 568 and plan notes. Other than minor installation touch-up and slight gloss changes over time, no coating performance issues have been experienced to date.

More recent projects that include powder-coated galvanized railings did not reference ASTM D 6386 but relied entirely on I.M. 568 to control both surface preparation and application. Approved powder coating shops are listed in the MAPLE.

Custom, powder-coated duplex system-finished pedestrian railings were used at the following locations (list not comprehensive):

- Linn Co. Design 915, E Ave over IA 100, Cedar Rapids, FHWA #700610
- Linn Co. Design 514, Edgewood Blvd over IA 100, Cedar Rapids, FHWA #700455
- Johnson Co. Design 2417, Forevergreen Rd over I-380, North Liberty, FHWA #600431
- Johnson Co. Design 220, S. Park Rd (Jasper Ave) over I-80, Tiffin, FHWA #31981
- Linn Co. Design 321, Tower Terrace Road over I-380, Cedar Rapids, FHWA #701060
- Franklin Co. Design 120, US 65 over Squaw Creek, Hampton, FHWA #25111
- Wapello Co. Design 519, West Park Blvd over IA 149, Ottumwa, FHWA #50661
- Johnson Co. Design 1020, Herbert Hoover Highway over I-80, Iowa City, FHWA #32161

- Scott Co. Design 222, US 461 NB over Duck Creek, Davenport, FHWA #46941
- Dubuque Co. Design 323, Grandview Ave over US 61, Dubuque, FHWA #23951
- Webster Co. Design 124, IA 926 over Des Moines River, Fort Dodge, FHWA #52081
- Webster Co. Design 224, IA 926 over CCPRR and 7th St SW, Fort Dodge, FHWA #52102
- Bremer Co. Design 323, IA 3 over the Cedar River, Waverly, FHWA #15571

Most projects involving structures with vinyl coated chain link fence since ca. 2012 have also employed powder coating over galvanizing for the fence post assemblies.

Custom, unpainted galvanized pedestrian railings were used at the following locations (list not comprehensive):

- Woodbury Co. Design 402, 1st St over I-29, Sergeant Bluff, FHWA #609080
- Polk Co. Design 115, NW Beaver Dr over I-35/I-80, Des Moines, FHWA #700420
- Jefferson Co. Design 1702, Cedar View Trail over US 34, Fairfield, FHWA #609805
- Clay Co. Design 106, US 18/US 71 over Little Sioux River, Spencer, FHWA #20331
- Polk Co., US 6 over the Des Moines River in Des Moines, FHWA #40400
- Van Buren Co. Design 106, IA 2 over the Des Moines River, Farmington, FHWA #50271
- Van Buren Co. Design 114, IA 98 over Des Moines River, Douds, FHWA #50381
- Kossuth Co. Design 107, US 169 over E. Fork of Des Moines River, Algona, FHWA #32921
- Woodbury Co. Design 1711, Wesley Pkwy over I-29, Sioux City, FHWA #700200
- Woodbury Co. Design 1811, Wesley Pkwy over Tri-View Avenue, Sioux City, FHWA #700205
- Polk Co. Design 125, IA 28 SB over the Raccoon River, West Des Moines, FHWA #3825

Unpainted galvanized steel traffic railings have been used at the following locations (list not comprehensive):

- Polk Co. Design 100, IA 5 WB to I-35 SB Ramp B, West Des Moines, FHWA #608230
- Polk Co. Design 200, I-35 SB to IA 5 EB Ramp C, West Des Moines, FHWA #608240
- Hardin Co. Design 199, US 20 over the Iowa River, Steamboat Rock, FHWA #608350
- Van Buren Co. Design 114, IA 98 over Des Moines River, Douds, FHWA #50381
- Linn Co. Design 114, IA 100 over the Cedar River, Cedar Rapids, FHWA #700375
- Story Co. Design 616, I-35 NB to US 30 WB Ramp H, Ames, FHWA #700825
- Des Moines Co. Design 117, SB US 61 over Flint Creek, Burlington, FHWA #700760
- Des Moines Co. Design 217, NB US 61 over Flint Creek, Burlington, FHWA #023491
- Scott Co. Design 1108, 53rd St over I-74, Davenport, FHWA #47371
- Scott Co. Design 617, I-74 WB over Mississippi River, Bettendorf, FHWA #47281
- Scott Co. Design 717, I-74 EB over Mississippi River, Bettendorf, FHWA #47291
- Polk Co. Design 125, IA 28 SB over the Raccoon River, West Des Moines, FHWA #3825
- Allamakee Co. Design 124, IA 9/WI 82 over the Mississippi River, Lansing, FHWA #13521

Weathering steel has also been explored on some projects as an option for adding color to pedestrian railings and eliminating coating requirements. Material availability must be checked for the steel shapes required by the design, and the possibility of higher material cost should be considered against traditional coated steel material options. Weathering steel was employed for pedestrian railings at the following locations:

- Jackson Co. Design 108, US 52 over IC&E RR and Mill Creek, Bellevue, FHWA #609770
- Des Moines Co. Design 117, SB US 61 over Flint Creek, Burlington, FHWA #700760

Other steel railing and steel accessory coatings have been used on some projects in Iowa. For example, a Local Systems project at Des Moines' Southeast Connector (now MLK Jr Pkwy) over the Des Moines River employed a high-performance paint system controlled through Special Provisions SP-011181, ca. 2007. The precise details of the system used on the project were not archived by Iowa DOT and were not available for this summary. It is believed to be a duplex system based on Iowa DOT SS-01025 but with a 3-coat high-performance paint classified as a thermoset solution fluoropolymer. A 15-year warranty period on the finish was required as part of the SP. As of 2024, the coating appears to be performing well,

although some corrosion can be seen on expanded metal lath material (part of the canopies over trails near the abutments) that was painted. Surface preparation of this material may have been difficult to properly perform due to its intricate surface characteristics.

In Sioux City at Wesley Blvd over I-29 and at I-29 over Pierce Street, bridge abutment accent towers included metal roof features. The Special Provisions for the metal roof panels (developed ca. 2011) indicated factory pre-finishing using a fluoropolymer of polyvinylidine fluoride (PVDF) with 2 preapproved coating systems listed (Kynar 500 PVDF and Hylar 5000 PVDF). Use of these systems is highly specialized to the prefabricated metal roofing industry and is not a practicable option for coating of other types of traditionally shop-fabricated steel assemblies.