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Sticky Solution

A maintenance inspection of cables coated with polymer paste showed promising results, eight years after it was first applied.

Sometimes, a new approach to an old problem can completely change the game, as New York State Bridge Authority chief engineer William Moreau concluded last autumn, while standing on top of the main cable of the Bear Mountain Bridge.

The structure straddles the Hudson River, just north of New York City, and Moreau was overseeing an inspection of the 84-year-old bridge's main cable, which had been rewrapped eight years earlier using a new corrosion protection barrier. The new material, a polymer-based, non-toxic paste developed by Grignard Company, had been applied in 2000 to replace the traditional red lead paste on the cable.

The inspection was carried out last autumn when Piasecki Steel Construction Corporation was contracted to unwrap the cable, a process overseen by Moreau and consultant Ammann & Whitney.

The contractor painstakingly removed the wrapping wire from the sections that were to be inspected, carefully inserting wedges into the cables to a depth of approximately 230mm. This provided an unobstructed view of the wires from the outer surface right down to the core.

As the operatives unwound the cable's wrapping wires, they found that the Grikote Z polymer paste had not dried and cracked like red lead, but had remained pliable. "The paste looked terrific. It looked like it had the day we put it in, still tacky and sticky," Moreau recalled. "In the past, the red lead paste exposed to the sun was always completely dried out within a few years. But the Grikote Z was not."

Even more critical was the condition of the inner cable strands. As Moreau, his fellow NYSBA engineers and the consulting engineers examined the interior of the cable, they liked what they saw. "We didn't see any new corrosion or advance of the corrosion we had observed during the last inspection," Moreau says. "Over the six years preceding the last inspection, we had seen significant advance of corrosion, but since applying the Grikote Z, we saw no further change. In my mind, there's not a whole lot more that needs to be evaluated regarding this as a red lead replacement."

The Bear Mountain Bridge is a piece of engineering history. When it opened in 1924, it was the largest suspension bridge in the world, spanning 497m (687m overall) with a tower height of 110m. It was also the first suspension bridge built with a concrete deck. Its design, innovative at the time, influenced many later suspension bridges.

The bridge's concrete superstructure is suspended from 457mm-diameter main cables which were spun by John A Roebling & Sons, of Brooklyn Bridge fame. The cables consist of 7,752 individual galvanised steel wires spun into 37 bundled strands.

Periodic inspections were conducted to gauge the degree of corrosion these wires had suffered; early inspections involved removing small sections of the cable's outer wrapping wire to inspect the strands to a depth of a few inches. But in the 1990s, NYSBA engineers decided to look further into the cable.

“We started opening up 5.5m or more, wedging the main cable open right to the core,” Moreau says, and recalls that they discovered an unwelcome surprise: significant corrosion close to the core in some areas. One contributing factor was the technique used to spin the cable in the 1920s, which involved the use of metal retention straps to hold the bundles together during manufacture. Although these were meant to be removed, many of them had been left in place.

“These straps hampered compaction, leaving spaces where moisture could accumulate,” Moreau explains. “Because the straps were not galvanised, they tended to create corrosion cells in the cable.”

Fortunately, the bridge was designed with extremely robust safety factors and NYSBA immediately initiated repairs to the affected cable sections. But one thing was clear: they needed a better way of preventing moisture from getting into the cables. The timing was right, since the bridge cables were due to be recoated and painted in 2000, so Moreau started looking for a red lead substitute.

“We considered some other materials, but there just didn’t seem to be any good alternatives,” he says. Then a possible solution emerged from an unlikely source. To help displace moisture in the bridge’s cables, Moreau had been using a product called Prelube 19, a polymer-based alternative to linseed oil, developed by Grignard. The company's chemists offered to try and develop an alternative to red lead paste.

Moreau needed a paste that was non-toxic and non-flammable, requiring no special safety measures for handling, removal or disposal. It had to be easy to apply, with good adhesion and without dripping, even at elevated temperatures. And it had to remain pliable in order to provide a flexible barrier that would resist drying out and cracking.

Working closely with Moreau and his team, a number of formulae were developed and put to the test under real life conditions. “We decided to test them in the cable anchorages of the Bear Mountain Bridge, which had been dehumidified,” Moreau says. “We thought this environment would provide us with accelerated knowledge about whether the materials would dry out.”

The cables were coated with each of the formulae to be tested, and with one cable coated in red lead paste as a control. They were left for approximately a year - not very long time in 'bridge years', but long enough for a difference to emerge.

At the conclusion of the test, the red lead was dry and beginning to crack. The cables coated with the Grignard formulae looked much better, with the one the chemists called Grikote Z Complex 2 clearly standing out.

“We felt we had found something that would not dry and crack and would stay pliable and provide an effective barrier,” Moreau says.

The winning formula combined a blend of zinc oxide and zinc dust in an environmentally friendly base with a blend of polymer-based corrosion inhibitors designed to bond with steel or galvanised surfaces. Other additives were incorporated to improve wear and pressure characteristics, and stand up to the challenges of extreme compaction and strain that common in main cables.

Although Moreau worked with Grignard to develop the new paste, he was not the first to use it. That distinction went to the Wheeling Suspension Bridge across the Ohio River in West Virginia, an historic bridge from 1849 that was undergoing a complete rewrapping of the main cable. Moreau and his team had the opportunity to witness application of the new paste first-hand.

“We were very impressed by the product’s consistency and how well it held up to the wrapping operation,” Moreau recalls. Soon after, he gave the go-ahead to rewrap the Bear Mountain Bridge with the same product, a task completed by the end of 2000According to Richard Piasecki, owner of contractor Piasecki Steel Construction that carried out the rewrapping, the Grikote Z was much different to work with than other products his team had used.

“It was easier to apply because it’s only a single component,” he said, noting that most corrosion barrier products are two-part compounds that require mixing. “Also, we found that the Grikote was not as temperature-sensitive, so there are no weather restrictions as to when you can apply. And because it is not hazardous material, there are no special handling or disposal requirements. For those reasons, we have been asking owners of other bridges to use Grikote Z.”

Moreau and his NYSBA colleagues firmly believe main cables should undergo thorough, regular inspections every five years, but the results from the Bear Mountain Bridge could spark a review of that rule. Although he is still awaiting an official recommendation from his consulting engineers, Moreau is hopeful he can extend the interval by expanding the use of Grikote Z.

“The goal of our inspection programme is to give us information we can use to plot a curve for deterioration over time,” Moreau says. “Based on this last inspection, we now have a dead-level spot on the curve, which is great. We got six years for no deterioration cost.”

Extending cable life is critically important from both safety and financial viewpoints. NYSBA studies have estimated that cable replacement could cost anywhere between US$100 million and US$150 million, so the longer it can be delayed, the better.

“At this point, we don’t have that replacement project in our 20-year plan," says Moreau, "and we didn’t see anything in our most recent inspection at Bear Mountain that would change that. If we can maintain this performance, we can extend the life of the bridge.”

The Bear Mountain Bridge is currently not listed by Federal Highway Administration as structurally deficient or functionally obsolete, and Moreau wants to keep it that way.

By contrast, the cables of New York State's Franklin Delano Roosevelt Mid-Hudson Bridge at Poughkeepsie were rewrapped using red lead paste between 1991 and 1994. When it was inspected in 2004, Moreau and his team were not pleased with what they found.

“The red lead paste was completely dried out and cracked, so we weren’t getting any protection from that sub-surface barrier," recalls Moreau. The wire and paint on top provided the only real surface barrier,” he says, noting that inspectors also detected moisture intrusion. Dehumidifiers were installed in the tower tops of the Mid-Hudson Bridge in the hope of preventing the development of condensation moisture there, which might then run down into the cables.

With a major inspection of the Mid-Hudson Bridge scheduled for next year, Moreau hopes to find that moisture intrusion has been stemmed. But one thing is certain, he says. “Anything that is unwrapped for inspection and gets rewrapped will be put back together using the Grikote Z. We won’t be using red lead paste anymore.”

Why red lead is becoming history

Like many suspension bridges, the Bear Mountain Bridge employed the traditional approach to inhibiting corrosion: a thick layer of red lead paste - the standard method of corrosion protection for bridge cables for more than a century.

As with most other 100-year-old technologies, red lead has significant shortcomings. Exposed to the elements, it dries out and loses its pliability fairly quickly. As the cables move with seasonal changes, wind and road loads, the red lead cracks, allowing moisture to pass into the cable, where it can accumulate and cause corrosion.

Another problem with red lead paste is its toxicity. Bridge owners are increasingly focused on the health concerns associated with red lead. During application, the paste gets all over tools, workers’ gloves, clothes and shoes, following them home. It is especially hazardous during cable inspection or repair. Because it dries out, it generates dust that can be ingested. In many jurisdictions, worker health and safety regulations require lead abatement procedures that are very costly and time-consuming.