Joint Transportation Research Program

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Pack Rust: Mitigation Strategy Effectiveness

Introduction

Corrosion is one of most challenging natural phenomena in bridge preservation. Different structural elements in bridges start to show signs of deterioration long before the bridges reach the end of their service life. This damage is caused by environmental conditions and the presence of chemicals, salts, and dirt from natural and human activities.

The cost of the damage caused by corrosion in highway bridges was estimated to be $13.6 billion per year in 2013. Moreover, the Federal Highway Administration claims that the cost has increased to $20.5 billion per year in recent years (Association for Materials Protection and Performance, n.d.). Even though serious consequences, such as bridge collapses, are not usually caused by corrosion issues, there have been some well-documented examples, such as the Mianus River bridge collapse (1983) and the sagging of one of the spans of the Leo Frigo Memorial Bridge (2013). For all bridges, however, approximately 15% are structurally deficient with corrosion being the leading cause of bridge deterioration (Koch et al., 2002).

Most steel bridges will eventually suffer from general surface corrosion and pitting corrosion, which causes section loss and reduction of the load capacity. Mitigation efforts against these types of corrosion have been accomplished through the use of various coatings systems. In 1997 approximately 5.56 billion liters of organic coating material worth $16.56 billion were used in the United States—for all types of structures—to address general surface corrosion (Roberge, 2008).

Most of the bridges in Indiana that were built between 1950 and 1960 are nearing the end of their service life, and many are in need of repair. Approximately one third of the steel bridges in Indiana were found to exhibit some degree of pack rust corrosion (Patel & Bowman, 2018). Surveys conducted during the SPR-4121 study demonstrated the importance of finding and implementing effective alternatives to mitigate pack rust corrosion for various structural components, especially splice connections. Consequently, the current study evaluates different methodologies and commercial products to mitigate the effects of crevice corrosion in splice connections.

Findings

Accelerated corrosion tests were conducted to evaluate the effectiveness of commercial products used to halt or slow the progression of pack rust. The specimens were subjected to a salt solution misting environment to develop corrosion in the gap region of a splice connection. The commercial products included one caulk sealer (GE Advanced Silicone Sealant) and two different penetrating sealers (Fluid Film and Termarust).

General Observations and Conclusions

- For the set of conditions developed in this experiment and the amount of pack rust corrosion produced, there is no evidence that the ultimate strength of the connections was affected for any of the different conditions studied. The connections were not affected because rust did not reach the area where the ruptures occurred and did not compromise the gap region to a degree more than the critical net section.
- The corrosion developed within the gap of the specimens was observed to affect the slip resistance of the splice connections due to its "gluing" effect of the middle plates. After removing the rust product during repair, it was observed that the slip resistance decreased.
- Based on visual inspection, the corrosion

formation rate was higher for the first 3 months of exposure, which was followed by a lower apparent corrosion rate thereafter.

- Bulging of the splice plates, caused by the formation of corrosion product, was slightly visible towards the beginning of the ninth month of exposure. The maximum bulging observed was 0.081 inch, which did not affect the structural performance of the connection.
- The 1/2-inch gap specimens delayed the sealing of the gap with corrosion material since more space was available. If there are no effects on the structural capacity, increasing the gap opening of field splice connections should be considered.

Conclusions from the Mitigating Products' Performance

- All mitigating products effectively delayed significant pack rust formation in the initial condition test.
- As a repair method, the mitigation strategies exhibited fair performance at best. All methods exhibited some corrosion product inside the gap joint at the end of the testing.
    - First, for Fluid Film the physical characteristics of the "sacrificed" wax changed somewhat in texture and color. This can be an indicator of a chemical reaction taking place due to some small amount of existing rust remaining after pressure washing.
    - Second, GE caulk was resistant with some discoloration. Despite the durability of the material, caulking should not be employed as a mitigating repair approach, since removal of all corrosion product from a connection in the field is very difficult and encapsulating corrosive material within the gap promotes the rapid formation of black rust caused by the lack of oxygen.
    - Finally, Termarust performed slightly better than the other two strategies. Some difficulty was encountered with the viscosity of the Termarust topcoat and its curing. Corrosion product was found inside all repaired specimens, but since Termarust demonstrated slightly better performance than the other methods, its application in the field is recommended as a mitigation strategy.
- Even though the application of these mitigating products was performed on the geometry of a flange splice connection, implementation of these products could be extended to other members with overlapping elements that are at risk for pack rust. It is important, however, to ensure that space or air is not being encapsulated and trapped within the member.

Implementation

- For new bridges, the use of a stripe coat is recommended to prolong the service life of splice plate details and improve their resistance to the formation of pack rust. An application procedure for stripe coating in new bridges is attached in the appendix section.
- For existing bridges, the application of a penetrating sealer (Termarust or Fluid Film) is recommended to mitigate pack rust. Procedures for pack rust removal and the application of the mitigating repair treatments are attached in the appendix section.

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