New Jersey Department of Transportation (NJDOT)

New Protocol for Accepting Over-coating Paint on Steel

2019 AASHTO Sweet Sixteen High-Value Research Project Award

U.S. Department of Transportation
Federal Highway Administration

Abstract

A new protocol for evaluating the durability of coatings for steel structures was developed. Basic concepts of accelerated testing specified in AASHTO and ASTM are incorporated in the proposed method. Growth of corrosion from a damaged-coat location, thinning of coating, color changes and influence of weld and bolt holes were the test variables. The major differences between the proposed method and the current practice are: a circular instead of X shape geometry of simulated damage-coat, adhesion strength of the coating to obtain corrosion-creep growth and addition of deep-freezing cycle as part of accelerated corrosion to enhance creep growth. These changes provide significant and clearly measurable degradation within 100 days of accelerated exposure. The protocol was evaluated by testing 6 coating systems and comparing the results with a 20 year field study. The experimental results simulates the field performance very well.

Current Status and Proposed Improvements

Current accelerated tests are expensive to perform, requires extensive exposure time, measuring accurate corrosion growth is difficult and there is lack of simulation between the accelerated test results and field performance. For example, typical tests last require 10,000 hours of exposure. The primary response variable is the measurement of corrosion creep growth that is fuzzy and in the order of mm, from a X scribe.

Therefore an investigation was initiated to develop an accelerated test method that can provide results within 6 months, distinctive measurable response variables and simulates field performance.

The developed test protocol incorporating key AASHTO and ASTM specifications and the current practices of automobile and offshore industries has excellent potential for adoption. The key enhancements are summarized in the following Table.

Description	Current practice	Proposed
Exposure Duration	5000 hrs salt fog + 5000 hrs weathering	2400 hrs
Response variable	Corrosion growth: 2 to 4 mm	Adhesion strength converted to equivalent corrosion growth
Scribe	X	O
Exposure	Wetting/drying Salt water UV and heating	Wetting/drying Salt water UV and heating and Deep freezing
Test sample	Rectangular plate	Rolled steel section

Details of the Test Protocol

The key parameters of the proposed test protocol were: (i) Selection of test specimens and specimen preparation (ii)Exposures conditions and duration of various cycles (iii)Response variables and their measurement and (iv) Criteria for acceptance of the coating.

- The test samples were made of rolled steel angle sections with weld lines and bolt holes as shown in Fig. 1.
- Exposure per day consisted of 8- one hour wetting/one hour drying cycles using 5% salt solution and 8 hour deep-freezing. During the drying cycle the samples were also subjected to UV radiation and heating. Test chamber is shown in Fig 2.
- Corrosion effects was measured at every 14 master cycles (days). Adhesion strength of the patch inside the circular shape scribe (damage) was measured, Fig. 3 and converted to equivalent corrosion creep-growth. Change in thickness and color were also measured at various stages of exposure, Figs. 4 and 5. In addition, visual inspection was conducted to assess the damages at weld and bolt-hole locations.

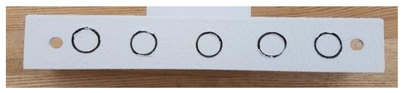

Fig.1 Test Sample

Fig.2 Test chamber

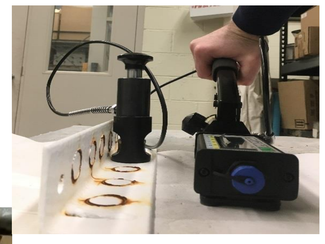

Fig.3 Adhesion strength tests

Fig.4 Color change test

Fig.5 Thickness change test

Results

The test method was evaluated using 6 coating systems, chosen based on a 20 year field study in which two of the coatings were weak while two others performed very well. Adhesion strength of the 6 coatings at various stages of corrosion, converted to equivalent corrosion growth are shown in Figs 6.

- The chosen accelerated test protocol provides a rapid corrosion growth rate resulting in considerable decrease in adhesion strength.
- A clear difference in strength-decreases between stronger and weaker coatings can be seen even at 14 cycles(days) of exposure.
- The adhesion strengths are consistent with the images of corrosion growth shown in Figs 7 and 8. Best coatings show more clear metal.
- The systems that performed best in the field, namely, systems with zinc primers also performed best in the accelerated test study. The creep growth for coatings with zinc primers were less than 4 mm after 100 master cycles whereas the worst performing epoxy mastic systems had a creep growth in excess of 7mm.

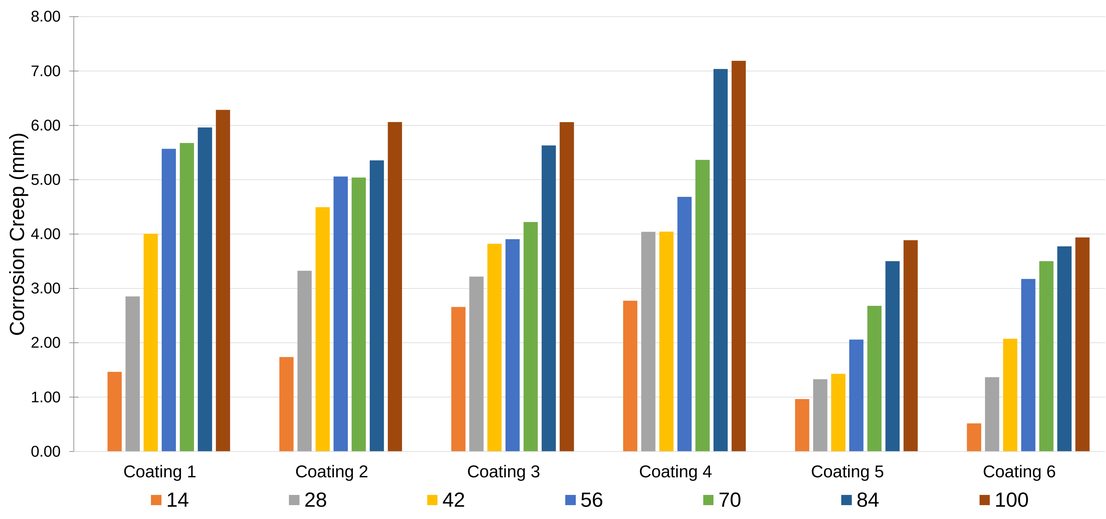

Fig.6 Equivalent corrosion growth for 6 coatings: 14 to 100 cycles of exposure

Fig.7 Images of corrosion growth: worst (left) and best (right) performing coatings

Fig.8 Enlarged view: Corrosion progresses from perimeter towards center

Conclusions & Future Direction

Conclusions

The circular scribe works well not only resulting in much faster corrosion but also provides means to estimate corrosion creep growth with more clarity.

Using the proposed protocol, a coating systems can be evaluated for acceptance within a time frame of 6 months.

Future Direction

It is proposed to conduct a Pool Fund study to develop a road map for approving new coatings. The primary tasks envisioned are: (i) validate and refine the test method by conducting a round robin study, (ii) formulate an acceptance criteria and (iii) develop a road map for accepting new coatings.

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