R-687

OFFICE MEMORANDUM

MICHIGAN
DEPARTMENT OF STATE HIGHWAYS

October 28, 1968

To: L. T. Oehler, Director
Research Laboratory Section

From: A. J. Permoda

Subject: Protection of Substructure Concrete from Staining by A 588 Type Steel During Construction. Research Project 67 G-158. Research Report R-687.

Subject project was authorized on request of N. C. Jones in a memorandum to R. L. Greenman dated October 25, 1967, which suggested evaluating liquid protective coatings for this use.

In reviewing this matter, it was recalled that the Department's prior experience on, (a) its first structure carrying Eight Mile Rd over I 696 showed that some protection was needed, and (b) its second structure carrying I 75 over Fort St. showed that the polyethylene sheeting which was used was not totally satisfactory since staining leakage did occur due to difficulty in applying the sheeting properly and maintaining it intact during construction.

Regarding subject matter, an inquiry was directed to the two leading steel producers which elicited suggestions that, (a) the girder bearings be placed in drained recesses atop the piers, (b) steel stay-in-place forms be used, where practicable, and (c) linseed oil and other liquid sealers be tried. Regarding these suggestions, the former two can best be evaluated by Design and Construction Divisions, while the latter is the subject of this study.

The Laboratory screening tests of likely liquid coatings were conducted by A. R. Gabel, who secured them from our stock and from producers. Results of tests conducted on 15 coatings are given in appendix A.

A review of his results shows that coatings like linseed oil and dilute silicones and concrete curing compounds are not satisfactory since they penetrate deeply and thereby fail to form a surface-film barrier to absorption of the iron stain by the substructure concrete. However, four promising coatings were found. These develop the surface barrier, thereby preventing absorptive staining, and allow removal of the lesser non-preventable surface staining by application of a dilute oxalic acid wash.

The three most promising sealer coatings are:

1. Polyvinyl chloride resin (VYHH grade) sealer, as a 25 percent solution in an equal mixture of toluene and methyl ethyl ketone (Test block 119).

2. Guard Kote 250 epoxy sealer, furnished as a two-component mixture (Test block 303). As shown in Figures 1 and 2, this sealer darkens

the concrete more than the above sealer. However, this darkening could be masked by proper pigmentation.

3. Plasticized chlorinated rubber sealer, Hercules'X 15994-40-2 in a solvent blend of toluene and naphtha.

These three sealers were evaluated as single coats on concrete, applied by conventional methods. A fourth coating, Scotchal plastic sheeting of the pressure-sensitive type earned a reserved secondary rating since the sheeting would have unreliable adherence to substructure concrete, would be difficult to apply thereto, and is expensive.

Conclusions

It is anticipated that liquid sealers applied to bridge substructure concrete will not completely eliminate staining resulting from unpainted structural steel. If properly formulated, the sealers can eliminate the deep absorptive staining and also facilitate the removal of the lesser and expected surface staining. The latter can be removed by washing with dilute oxalic acid.

Three promising liquid sealers have been developed during this study. They could serve an additional function as sealers against deicing damage to the applied substructure concrete.

Recommendations

We recommend that the three promising sealers for substructure concrete be further evaluated by field test on bridges utilizing unpainted structural steel of the ASTM A 588 type.

TESTING AND RESEARCH DIVISION

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Appendix A
Research Project 67 G-158

Laboratory Evaluation of test coatings and wrappings for reducing staining of substructure concrete by unpainted structural steel was carried out.

The evaluations were conducted on cast 3- by 4- by 9-in. concrete blocks on which the coatings were applied and allowed to dry for 24 hours. Staining was induced by mounting a 3-1/2 by 3 by 1/8 in. piece of sandblasted steel on the upper face of the block and placing the assembly in a humidity cabinet for 68 hours. These produced staining on all specimens.

Test coatings applied on the blocks, in a single coat except as noted, were as follows:

Block 119 - 25% PVC sealer (VYHH) in 1:1 toluene-MEK

Block 152 - Uncoated Control

Block 262 - Uncoated Control

Block 303 - Guard Kote 250 epoxy (2 component)

Block 401 - 3M's 639 clear Scotchcal polyester film (Pressure sensitive adhesive)

Block 522 - As block 119

Block 701 - Raw linseed oil

Block 772 - Dow Corning's 772 Silicone as 3% water solution

Block 872 - Proprietary penetrating epoxy

Block 881 - Dow Corning's 773 Silicone as 5% toluene solution

Block 883 - Stand. Paint Co's GCL 10 Chlorinated rubber solution

Block 963 - Midland Finishes' Sicon M/A Gray silicone acrylic

Block - Boiled linseed oil

Block - Colma Dur LV epoxy (2 component)

Block - Resi-Weld BC 5045 epoxy (2 component)

Block - Tri-Kote 18% Chlorinated rubber (2 coats)

Block - Euclid's Reg-Seal Chlorinated rubber (2 coats)

Block - Euclid's T&T penetrating acrylic emulsion (2 coats)

Block - Hercules'X 15894-40-1 Parlon Acryloid Sealer

Block - Hercules'X 15894-40-2 Parlon Acryloid Sealer

Discussion of Test Results

1. All coatings and the plastic wrapping became stained under test conditions (Fig. 1). The stain could not be removed by scrubbing with soapy water and a stiff brush.

2. Application of 10 percent Oxalic Acid was effective in removing the stain to varying degrees, depending on the coating (Fig. 2). The Oxalic Acid was more effective than a suggested proprietary stain remover, Cindy 10.

3. Comparison of the photos shows effective removal by the acid wash on test blocks 119, 303, and 401: the coatings are vinyl, Guard Kote Epoxy, and plastic wrapping, respectively. Poorer stain removal was effected on test blocks 701, 772, and 872 representing raw linseed oil, aqueous silicone, and penetrating epoxy, respectively.

4. Comments on sealers not shown in photographs are as follows:

a) Ineffective treatments - silicones and other penetrating sealers including the proprietary epoxy and acrylic emulsion, and the dilute chlorinated rubber curing compounds.

b) Intermediate treatments - boiled linseed oil, and epoxies Colma-Dur and Resi-Weld.

c) Effective treatments - Hercules' Parlon sealers.

5. Examination of Figures 1 and 2 shows that some treatments, including the Guardkote epoxy, darken the concrete more than others. Adding pigments to those coatings would cover-up the darkening.

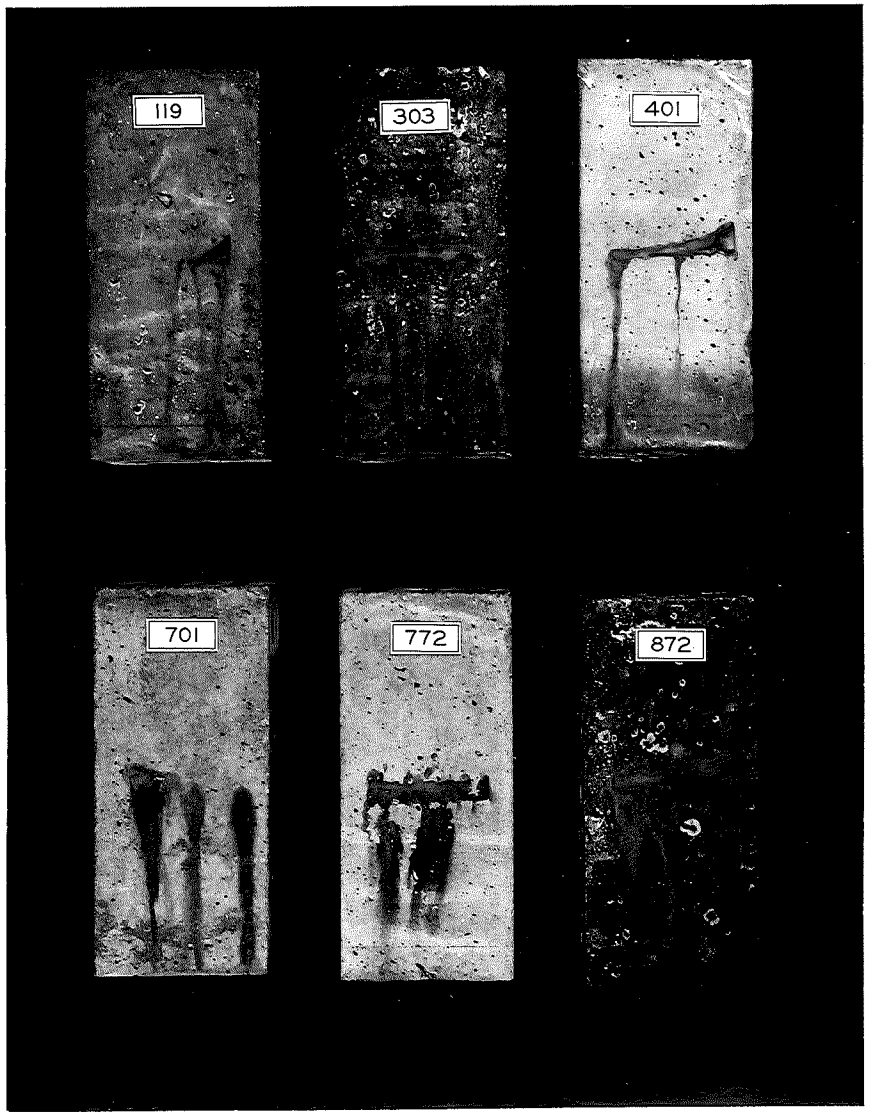

Figure 1. Iron staining produced intentionally on coated blocks under test.

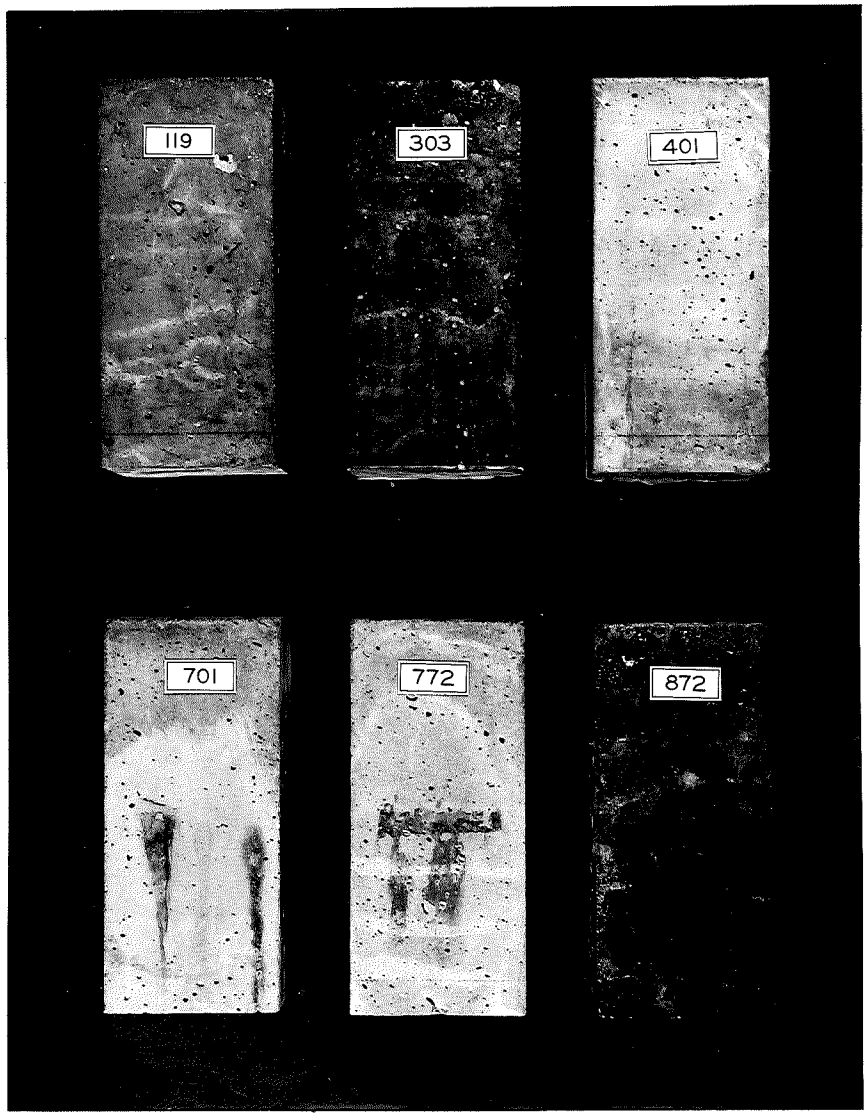

Figure 2. Same coated blocks after washing with 10 percent oxalic acid as stain removal measure, show varying success.