EVALUATION OF CONCRETE SURFACE SEALERS

RHODE ISLAND DEPARTMENT OF TRANSPORTATION
RESEARCH AND TECHNOLOGY DEVELOPMENT
TEST PROCEDURE

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Evaluation of Concrete Surface Sealers

I. Test Specimens

Ten test specimens, 3"x3"x14" in size, shall be fabricated for each concrete surface sealer under evaluation, using concrete typical of the highway structure to be protected. An additional set of 10 specimens shall be used as an uncoated control set.

All mix components shall comply with the Standard Specifications of the Rhode Island Department of Transportation and shall be obtained from sources approved by the Department of Transportation. The specimens shall be fabricated in accordance with AASHTO Test Method T 126[1] "Making and Curing Concrete Test Specimens in the Laboratory."

Upon fabrication of the required number of specimens, the individual specimens shall, when all specimens are fabricated from the same batch of concrete, be assigned at random to each set. When the required number of specimens are fabricated from more than one batch of concrete, the individual specimens shall be assigned to each set in accordance with a randomized block design.

II. Chloride Intrusion Screening Test

Salt Brine Immersion

The specimen sets shall be partially immersed to a depth of five inches in a saturated solution of highway deicing salt. The individual specimens shall be assigned positions in the immersion tank(s) at random. Each tank should include an uncoated control set.

The deicing salt shall be rock salt and contain approximately 0.1% of an anti-caking conditioner. Solution water lost through evaporation during the course of the experiment shall be replenished on a weekly basis with additional saturated salt solution.

One randomly selected specimen from each set shall be removed from the immersion tank(s) at 10-day intervals and be tested for chloride ion concentration.

Chloride Intrusion Sample Collection

The following procedure shall be used to obtain chloride intrusion samples from the test specimens:

1) After removing a specimen from the immersion tank, the crystallized salt shall be washed from its surface and the specimen should be allowed to dry in air for a minimum of three days.

2) A sample site shall be marked at a point 3 inches up from the bottom and at lateral face center on each of three sides. The three sides shall not include a trowelled surface.

3) A drill, fitted with a 3/4-in carbide-tipped masonry drill bit, shall be used to remove the sealer and concrete at each of the marked sample sites to a depth sufficient to remove approximately 1/8-in of concrete at the outer edge of the hole.

Removal of the first 1/8-in of concrete is intended to eliminate non-uniform surface conditions, which may exist between different specimen sets. These conditions include the accumulation of chloride at the sealer-concrete interface for film-formers and the reduction of concrete chloride content, down to the 1/8-in level, for penetrants, brought about by washing the crystallized salt from the specimen surface.

4) Immediately prior to collecting a chloride intrusion sample, the sample site and surrounding area shall be vacuumed clean and all equipment expected to come into contact with the specimen surface or the sample should be cleaned with isopropyl alcohol.

5) The drill, with a 3/4-in drill bit, should be used to obtain an additional 3/4-in depth, pulverized concrete chloride intrusion sample at each sample site.

The samples from each of the three sample sites are to be placed into one plastic container and

constitute the specimen chloride intrusion sample.

Determination of Chloride Content

The total chloride ion content of the specimen chloride intrusion samples shall be determined in accordance with the procedures of AASHTO Test Method T-260[1], Sampling and Testing for Total Chloride Ion in Concrete and Concrete Raw Materials, or in accordance with the procedure developed in FHWA-RI-90-1, "Laboratory Evaluation Of Concrete Sealers For Vertical Highway Structures"[2].

Data Analysis

Analysis of chloride intrusion data for the evaluation of sealer performance shall proceed as follows:

1) A plot of chloride Concentration versus Time shall be made for each specimen set and the best fit curve calculated for each.

2) The average concrete chloride content over the 24-week immersion period shall be calculated for each specimen set.

3) Using the results of (2), the effectiveness of each candidate sealer shall be expressed as the percent by which chloride absorption is reduced as compared to uncoated concrete.

Those sealers, which reduce chloride absorption by 55% or more, as compared to uncoated concrete, shall be considered eligible for the advanced tests of Sections III and IV below.

III. Water Absorption And Water Vapor Transmission Tests

Water Absorption

Each of the eligible candidate sealers shall be applied to a minimum of 3 concrete block specimens, the specimens to be fabricated as described is Section I above. An equal number of uncoated

specimens shall be used as an uncoated control set. The size of the specimens shall correspond to the requirements of the freeze-thaw cabinet used in Section IV below. It is recommended that the

number of specimens per set be as great (up to a maximum of 7) as can be accommodated by the freeze-thaw test cabinet.

The specimen sets of the eligible candidate sealers, plus an uncoated control set, shall be placed on end (long dimension vertical) in a holding tank and covered with three inches of tap water. The test blocks shall be removed from the tank, surface dried with a soft cotton cloth, weighed and reimmersed once daily for a period of two weeks. Sealer performance shall be rated according to average weight gain during immersion expressed as a percentage of original average dry specimen weight. The results shall also be presented as a plot of % versus time.

Water Vapor Transmission

Following the last weight gain measurement, the specimens shall be allowed two weeks to dry in air, during which time weight loss measurements are to be made on a daily basis. Candidate sealer performance is rated according to average weight loss during drying expressed as a percentage of average total weight gained during immersion and according to average net weight gain after drying expressed as a percentage of average original dry specimen weight. The results shall also be presented as plots of % versus time.

IV. Freeze-Thaw Resistance Test

Immediately following the conclusion of Section III, the specimens shall be tested for freeze-thaw resistance in a freeze-thaw test cabinet, meeting the specifications of ASTM Test Method C 666[3], "Resistance of Concrete to Rapid Freezing and Thawing", Procedure A.

The specimens shall be removed from the test cabinet periodically and inspected for weight loss, visible evidence of distress and fundamental transverse frequency. Each specimen, prior to inspection, shall be washed with a slow stream of tap water to remove loose particles.

Weight Loss

All surfaces of a specimen shall be patted dry with a soft cotton cloth before weighing. Weight loss shall be expressed as percentage of original weight and the specimen set average calculated

for each set at each inspection. The results shall also be presented as a plot of % versus Number of Freeze-Thaw Cycles.

Visible Evidence of Distress

Visible evidence of distress shall be monitored by two methods. The first method utilizes the Concrete Deterioration Rating Scale presented in Table 1, and is applicable to uncoated concrete and to concrete treated with a penetrating sealer. Each 3-in x 14-in side of a specimen shall be rated on a scale of 0 to 5. The specimen set average shall be calculated for each set at each inspection and the results plotted versus Number of Freeze-Thaw Cycles. Candidate sealer performance shall be rated according to the number of freeze-thaw cycles required to produce a given deterioration rating.

The second method determines the extent of surface deterioration and is applicable to uncoated concrete and all sealer-treated concrete. For film-formers, the deterioration recorded is that of the sealer itself. A grid (ruled on a sheet of transparent plastic film) may be superimposed over each 3-in x 14-in side of a specimen in turn, the deteriorated area units summed and the result expressed as a percentage of total area. The specimen set average shall be calculated for each set at each inspection and the results plotted versus Number of Freeze-Thaw Cycles.

The candidate sealers shall be rated according to the number of freeze-thaw cycles required to produce a given area extent of sealer/concrete deterioration.

Fundamental Transverse Frequency

A more objective method of determining the protection afforded concrete by the candidate sealers shall be provided by the resonant frequency test of ASTM Test Method C 215[3], "Fundamental Transverse, Longitudinal and Torsional Frequencies of Concrete Specimens," Section 6. Apparatus meeting the specifications of ASTM C 215 shall be used to determine the fundamental transverse frequency of each specimen before freeze-thaw cycling commences and at each inspection thereafter.

The average relative dynamic modulus of elasticity, calculated after each inspection, indicates the change in concrete integrity as the cycling progresses. The candidate sealers shall be rated according to the number of freeze-thaw cycles required to produce concrete failure, i.e. a decrease in relative dynamic modulus of elasticity (P_c) to 60%. The results shall also be presented as a plot of P_c versus Number of Freeze-Thaw Cycles.

Table 1: Concrete Deterioration Rating Scale

0 - No evidence of deterioration.

1 - Light scaling. Loss of cement paste around larger of fine aggregate particles, no coarse aggregate particles exposed. Includes loss of cement paste around edges of surface voids and loss of laitance at trowelled surface.

2 - Moderate scaling. Loss of mortar with coarse aggregate particles exposed. Includes loss of mortar around edges of surface voids.

3 - Heavy scaling. Loss of mortar around coarse aggregate particles which protrude above mortar remaining.

4 - Severe scaling. Loss of concrete (loss of coarse aggregate particles) and cracking of concrete. Includes cracking and disintegration of coarse and fine aggregate particles.

5 - Fracture or disintegration of specimen into two or more pieces.

Each of the four specimen sides to be rated separately and an average calculated. Specimen ends (3" x 3" surfaces) are not rated.

Add 0.5 to the above rating values if the deterioration occurs over more than 50% of the specimen side.

V. REFERENCES

1. American Association of State Highway and Transportation Officials, Standard Specifications for Transportation Materials and Methods Of Sampling And Testing, Part II, Washington, D.C., latest edition.

2. Fera, Joseph D., "Laboratory Evaluation Of Concrete Sealers For Vertical Highway Structures," Research Report No. FHWA-RI-90-1, Rhode Island Department Of Transportation, Materials Section, January, 1991.

3. American Society For Testing And Materials, "Annual Book of ASTM Standards", Volume 04.02, latest edition.