CHAPTER 8

Surface Coatings

A. Introduction

Concrete surface coatings serve to slow down or prevent the ingress of chloride into the concrete. Over the years, numerous sealer materials have been investigated including several types of oil and rubber, a wide variety of resins, petroleum products, silicones and other inorganic and organic materials. A 1989 Survey of Highway Agencies indicated that although interest in the use of penetrating sealers is high, their application is low. External concrete sealers may be classified as hydrophobic (water-repellant) and water-blocking. Water-repellant sealers, such as silanes, typically coat or chemically combine with the surface of the concrete to provide a water-repellant surface. Water-blocking sealers such as linseed oil and methacrylates, fill the voids in the concrete and block out water and salt. This section of the report will deal with the above two types of sealers.

Although surface sealers generally cannot be used on bridge decks since they will rapidly wear off, there are some products that provide deep penetration and, therefore, long service life of even abraded surfaces. Surface sealers are particularly useful on substructure units, such as under bridge joints, or on columns in salt water, if other protective systems are not used.

NCHRP Report 244 "Concrete Sealers for Protection of Bridge Structures" provides a comprehensive evaluation of numerous penetrating sealers and coatings. Report 244 notes that a silane, and a methacrylate gave very good to excellent performance in all four laboratory test series. Because of the number of proprietary products available with claims of preventing corrosion in concrete structures, it is suggested that a report on prequalification of products not previously tested, and using procedures similar to those reported in NCHRP Report 244, be required from the supplier.

B. Concrete Surface Penetration Sealer

1. Description

This work shall consist of furnishing and applying a water repellant concrete surface coating in accordance with this provision and conformity with the details and locations indicated on the plans. The color of the penetrant sealer shall be clear, unless specified otherwise.

Concrete surface penetrant sealer hereinafter will be referred to as penetrant sealer.

2. Material Specifications

The penetrant sealer used in the performance of this work shall be a product as listed.

3. Criteria

Penetrant sealer may be used on the concrete surfaces where water repellant protection is desirable. This would include all superstructure and substructure components subject to deicing chemicals or corrosive environments.

4. Construction Specifications

The penetrant sealer shall be applied in accordance with the Manufacturer's recommendations, except as otherwise specified herein. The penetrant sealer shall not be applied until all adjacent or superimposed concrete placements have been completed. All surfaces to receive the penetrant sealer shall be sandblasted to provide a clean uniform texture free of foreign substances such as oils, release agents or efflorescence. All sandblasting residue shall be completely removed prior to application of the penetrant sealer.

Each container of penetrant sealer material shall be thoroughly mixed in strict compliance with the manufacturer's recommendations. The penetrant sealer material shall be applied by experienced persons using spray, brush or roller and shall not be thinned or reduced, except as may be specifically required by the Manufacturer.

The rates of application are approximate only. Actual application rate shall be based upon a minimum of two test sections of approximately one foot square each for each structure to be treated. Such tests shall consist of applying initial coats and allowing each to thoroughly dry prior to placing the final coat. An acceptable application rate shall consist of that quantity required to effect a complete and uniform absorption of the final coat at an optimum time period of approximately 15 minutes. In the event the absorption time of the final coat varies significantly from the 15 minute period, then the rate of application shall be adjusted as necessary to meet this requirement within a period of approximately 15 minutes.

5. Maintenance Requirements

No special maintenance is required. Maintenance such as the annual washing and cleaning of chlorides (salts) and the removal of debris and/or vegetation from the structure needs to be performed to assure excessive deterioration does not occur.

6. References/ Other Information

"Concrete Surface Penetrant Sealer" Special Provision 404, Virginia Department of Transportation, April 1, 1987.

D. W. Pfeifer and M. J. Scali. NCHRP Report 244: "Concrete Sealers for Protection of Bridge Structures." TRB, National Research Council, Washington, D.C., December 1981, 138 pp.

D. Whiting. "Penetrating Sealers for Concrete: Survey of Highway Agencies." Transportation Research Record No. 1284. Transportation Research Board, Washington, D.C., 1990.

M. M. Sprinkel. Comparative Evaluation of Concrete Sealers and Multiple Layer Polymer Concrete Overlays. Report FHWA/VA-88/R2. Virginia Transportation Research Council, Charlottesville, Virginia, 1987.

C. Linseed Oil

1. Description

This work shall consist of furnishing and applying a linseed oil treatment (50/50 solution of linseed oil and mineral spirits) in accordance with this provision and conformity with the details and locations indicated on the plans.

2. Material Specification

The linseed oil treatment material shall consist of a mixture of equal volumes of boiled linseed oil and mineral spirits. Pre-blended mixtures shall be furnished unless otherwise authorized by the Engineer.

Pre-blended mixtures of linseed oil and mineral spirits shall conform to the following:

	Limits		ASTM
	Minimum	Maximum	Test Number
Acid Value	---	4	D1639
Iodine Value	90	---	D1959
Saponification Value	100	---	D1962
Drying Time on Glass, hours	---	16	D1953
Nonvolatile Content*	54%	60%	D1960
Specific Gravity 25/25c	0.850	0.875	D1963
Flash Point (Tag Closed Cup)	100°F	---	D56
Distillation Test Percentage			
Recovered at 177°C	25	---	D86
Recovered at 200°C	45	---	D86
Color (Gardner)	---	13	D1544

*Note:Air pollution regulations may require a lower limit.

In determining the Nonvolatile Content, ASTM D1960 shall be modified using a sample of 20 grams and increasing the length of time in the oven to one hour.

When furnished as separate ingredients, the boiled linseed oil and mineral spirits shall conform to the following:

a. Boiled linseed oil shall conform to ASTM D260, Type I modified as follows:

	Limits		ASTM
	Minimum	Maximum	Test Number
Viscosity (Gardner Holdt)	A	---	D1545
Color (Gardner)X	---	13	D1544
Acid Value	4	6	D555

b. Mineral spirits shall conform to ASTM D235.

3. Criteria

A linseed oil treatment may be used on all concrete surfaces where a water-blocking sealer is desirable. Generally it is used on bridge deck surfaces, top and inside surfaces of parapet walls, sidewalk and medians.

4. Construction Specifications

Following the termination of cure, concrete shall be allowed to air dry for as long as practicable before the first application of the linseed oil-mineral spirits mixture, however, in no event shall the cure and drying time be less than 30 days.

Surfaces to be treated shall be cleaned of all foreign material and shall be thoroughly dry. When necessary, the Engineer may require bridge surfaces to be scrubbed with water and a stiff bristle brush after which the concrete shall be allowed to dry before treatment. Curing compounds must be removed by sand blasting or the linseed oil will not be able to penetrate the concrete.

Surface temperature shall be 50°F or above at the time of application.

The treatment shall consist of two applications of a 50-50 mixture, by volume, of linseed oil and mineral spirits, the first application at a rate of one gallon of mixture per 40 square yards of surface area; the second application at a rate of one gallon of mixture per 67 square yards of surface area.

The second application shall be delayed until the first coat has been completely absorbed and the concrete has regained its dry appearance. Vehicular and pedestrian traffic shall not be permitted to use the treated surface until after the second application is dry to touch.

Application shall be by spray using portable backpack sprayers or a combination of truck distributor and portable sprayers. The operational condition and performance of the spraying equipment shall be subject to the approval of the Engineer. Care shall be taken during application to obtain full and uniform coverage of the specified surfaces.

5. Maintenance Requirements

No special maintenance is required. Ordinary maintenance such as the annual washing and cleaning of chloride (salts) and the removal of debris and/or vegetation from the structure shall be performed.

To provide long-term protection, reapplication will be required at about 2 year intervals for bridge decks. Other uses may require reapplication at different intervals. Care must be taken that excessive material is not applied to bridge decks during reapplications.

6. References/ Other Information

"Section 256 - Linseed Oil." VDOT Road and Bridge Specifications, January, 1987.

"Item 428 - Concrete Surface Treatment," Texas Standard Specifications for Construction of Highways, Streets and Bridges, 1982.*

* Note: This reference is included in Appendix F for the Reader's use.

D. Silanes

1. Description

Silane sealers do not block the porosity of concrete. Instead, they react chemically with the surface of the concrete to form a hydrophobic layer repellent to liquid water but permeable to water vapor. By chemical reaction, a water repellent hydrocarbon group is bonded to the substrate. The treated surface becomes water repellent through the elimination of water between the silanols in the organosilane and those in the concrete surface with a resultant bonding of the hydrocarbon group to the concrete.

2. Material Specification

The penetrating water repellent treatment solution shall be one of the following non-epoxy resin materials having met the following performance criteria based on a single application of the solution in accordance with the manufacturer's recommended rate of coverage. Compounds with forty percent (40%) by weight solution of alkyltrialkoxy silane or isobutyltrimethoxy silane in an anhydrous alcohol solvent, and waterborne compounds have worked successfully although other percentages may also provide satisfactory results, although environmental regulations may limit use of alcohol based sealers.

The following performance requirements must be met or exceeded for bridge applications , as reported by a certified independent lab:

Water Absorption Test (ASTM C 642)

In 48 hours 1% by weight (maximum)
In 50 days 2% by weight (maximum)

Chloride Ion Penetration (AASHTO T 259 and T 260) (based on non-abraded specimens)

In 90 days: Maximum at 1/16 inch to 1/2 inch = 1.50 lbs./c.y.
Maximum at 1/2 inch to 1 inch = 0.75 lb./c.y.

Penetrating water repellent treatment shall be able to penetrate the concrete surface a minimum fifteen one-hundredths (0.15) inch. Treated concrete shall retain its moisture vapor permeability.

3. Criteria

Silane sealers may be used on concrete surfaces where water repellant protection is desirable. This would include all superstructure and substructure components subject to deicing chemicals and/or corrosive environments.

4. Construction Specifications

All concrete surfaces prepared for treatment shall be thoroughly cleaned prior to the application of the penetrating water repellent treatment solution. The method of cleaning shall remove all traces of curing compound, laitance, dirt, dust, salt, oil, asphalt, other foreign materials and deleterious substances.

If necessary, solvents and hand tools shall be used as required to remove bonded materials detrimental to the treatment of the concrete surface.

The cleaning process shall not cause any undue damage to the concrete surface, remove or alter the existing surface finish, or expose the coarse aggregate of the concrete. The method of cleaning shall be performed in such a manner as to provide a reasonable uniform appearing surface color.

The penetrating water repellent treatment solution shall not be applied when the ambient air or concrete surface temperature is less than 40°F (4°C) or above 100°F (38°C) of otherwise below or above the manufacturer's recommended application temperature range. The solution shall not be sprayed when blowing winds or other conditions prevent proper application.

The solution shall not be applied to bridge decks when the rate of evaporation from the deck surfaces exceed 0.20 pounds per square foot per hour.

All concrete surfaces shall be substantially dry prior to application of the penetrating water repellent treatment. The penetrating water repellent treatment solution shall be used as supplied by the manufacturer and not diluted or altered in any way. The solution shall be sprayed onto concrete surfaces at the manufacturer's recommended rate of coverage as approved. Surfaces shall be lightly water wetted 12 to 24 hours following treatment.

Surface treatment of new concrete prior to 28 days of curing will not be permitted.

Traffic shall be kept off treated surfaces until the solution has completely penetrated and is surface dry.

5. Maintenance Requirements

No special maintenance is required except periodic reapplication may be required to provide continued protection. Ordinary maintenance such as the annual washing and cleaning of chlorides (salts) and the removal of debris and/or vegetation from the structure should be performed.

6. References\ Other Information

Sil-Act
Advanced Chemical Technologies Company
260 N.W. Expressway
Oklahoma City, Oklahoma 73112

Special Provisions from the following Departments of Transportation:

South Carolina, Bridge Deck Sealer, April 16, 1990.
Nevada, Bridge Deck Waterproofing (Section 643), March 3, 1989.
California, Substructure Concrete Sealer, "Silaseal," May 14, 1990.

NCHRP Report #244 ibid.

E. High Molecular Weight Methacrylate

1. Description

This sealer shall consist of a high molecule weight methacrylate HMWM monomer furnished and applied in accordance with this provision and in reasonably close conformity with the details and locations indicated on the plan.

2. Material Specifications

The materials used for sealing concrete surfaces shall be a low viscosity, non-fuming, HMWM resin conforming to the following:

Physical Properties of Resin:

Viscosity*: 25 cps maximum; ASTM D2393 (Brookfield Model LVT viscometer, Spindel I at 60 RPM) Test Method for Viscosity of Epoxy resins and Related Components.

Specific Gravity: 0.90 minimum @ 77°F;

Tensile Elongation: 5% minimum (ASTM D638)

Volatile content: 30% maximum; ASTM D 2369-87; Test Methods for Volatile Content of Coatings.

Vapor Pressure: 1.0 mm Hg maximum @ 77° F; ASTM D 323

*for application as a mortar resin

Performance Properties of Resin

Cure Speed: Gel time, 20 - 50 minutes @ application temperature (50 ml sample).

Tack free time: 400 minutes @ 77°F (Calif. test method #557)

Flash point: 180°F minimum; ASTM D 3278 Test Methods for Flash Point of Liquids by Setaflash-Closed-Cup Apparatus.

PCC SSD Bond strength: 500 psi @ 24 hours, 70°F (Calif. test method # 55).

The Contractor shall have a qualified technical representative on-site to provide expert advice to the Contractor on storage, mixing, application, clean-up and disposal of materials.

The promoter and initiator, if supplied separately shall not contact each other directly. Containers of promoters and initiators shall not be stored together in a manner that will allow leakage or spillage from one to contact the containers or material of the other.

A Material Safety Data Sheet (MSDS) shall be furnished for the HMWM resin (promoter, and initiator) to be used on this project. A certification showing conformance to these specifications shall be provided with each batch of resin.

3. Criteria

A methacrylate sealer may be used on concrete surfaces where water blocking protection is desirable. This would include all superstructure and substructure components subject to deicing chemicals and/or corrosive environments.

4. Construction Specifications

Concrete surfaces shall be prepared by air cleaning the entire deck surface using sufficient air pressure to remove all loose material from visible cracks. All accumulations of dirt and debris shall be removed from the surface. The surface and cracks to be treated shall be dry (visual inspection). The concrete deck temperature shall be not less than 50°F, and rising, and not more than 100°F at the time of resin application.

Resin shall be applied to cracks at a rate of 200 linear feet per gallon. The curing period will be determined by the Owner's representative, in consultation with the manufacturer's technical representative. Additional applications will be made by increase quantities at the unit bid price for crack sealing. Equipment to apply resin shall be a container with a nozzle or an approved roller not more than 3" in width. Resin shall be applied within 10 minutes after mixing. Excess resin shall be swept to untreated areas not less than 10 minutes and not more than 20 minutes after resin application.

Excess resin for the purpose of this specification is that which does not fill the cracks and is not absorbed by the concrete surface but fills or partially fills the grooves in the deck surface.

After completion of crack sealing, resin shall be applied to entire deck at a rate of 100 square feet per gallon. Excess resin shall be swept to untreated areas not less than 10 minutes and not more than 20 minutes after resin application.

The entire treated area of the bridge deck shall have dry (less than 0.2% moisture) silica sand broadcast to effect a visually uniform coverage of 1 pound per square yard. Sand shall be placed before any gelling of the resin occurs. Excess sand shall be removed after the curing period as determined by the technical representative.

5. Maintenance Requirements

No special maintenance is required. Ordinary maintenance such as the annual washing and cleaning of chlorides (salts) and the removal of debris and/or vegetation from the structure should be performed.