

APPENDIX 2

Sample

specifications with

commentary

PROPOSED PREMIXED POLYESTER STYRENE CONCRETE OVERLAY SPECIFICATIONS FOR AASHTO POLYMER CONCRETE COMMITTEE, TASK FORCE 34

INTRODUCTION

The premixed polyester styrene concrete overlay is a method by which aggregate and polyester resin are mixed, in predetermined ratios, either by continuous mixing equipment or batched and mixed in a stationary mixer, placed on a prime coated substrate, and struck-off to the desired profile grade. The pre-mixed system will protect bridge deck reinforcing steel from corrosion and restore the rideability of the deck. Having predetermined ratios allows for consistent engineering properties throughout the entire overlay. Conventional PCC mixing and placement equipment can be used with some modifications.

Safety is always an issue. MSDS sheets should be readily available, and a plan for proper clean up and disposal of unpolymerized resins, empty peroxide containers and any clean up solvents. Air monitoring may be advisable to ensure low levels of styrene emissions. Additives such as BYK S740 and Dow are available that keep emissions low.

PREMIXED POLYESTER CONCRETE OVERLAY SPECIFICATION

This work shall consist of constructing a polyester concrete overlay in accordance with the details shown on the plans and these special provisions. The entire area to receive polyester concrete overlay shall be cleaned by steel shotblast cleaning not more than 36 hours prior to placement of primer. All laitance and surface contaminants including but not limited to rust, oil, paint, joint material, and other foreign material shall be removed from the surface of the existing concrete deck.

Water may be used to aid in the cleaning prior to steel shotblasting but the concrete deck shall have been dry for not less than 24 hours before the primer is placed.

Equipment shall be fitted with suitable traps, filters, drip pans or other devices to prevent oil, fuel, grease or other deleterious material from being deposited on the existing deck.

COMMENTARY ON POLYESTER CONCRETE OVERLAY SPECIFICATION

The intent is to remove any materials that inhibit the prime coat from being in direct contact with the PCC and compromising the bond. Shotblasting the surface to a uniformly whitish-gray color has been the practice. Streaks appearing where the passes overlap is an indication that the surface is not clean. An alternative to the cleaning specification would be a removal specification. 1/8" removal is generally adequate.

Sandblasting or carbide tip grinders may be used near edges of surface where shotblaster is inaccessible.

Any water use must be done before shotblasting, since any washing of the substrate would be deleterious.

SPECIFICATION (cont'd)

Any area that becomes contaminated after shotblasting shall be recleaned at the Contractor's expense. Recleaning may be done by sandblast. Just prior to placing primer, the surface shall be cleaned by compressed air blasting to remove dust and any other loose material.

A prime coat shall be applied to the surfaces to be covered with polyester concrete.

COMMENTARY (cont'd)

A prime coat is applied to both wet out the substrate and to form a barrier to prevent saponification of the isophthalic polyester resin that is in contact with a potentially alkaline substrate. Two types of prime coats are currently in use, high molecular weight methacrylate and a fumarate polyester resin.

Fumarate polyester is less expensive than HMWM. HMWM is a much lower viscosity and provides a crack filling and healing function as well as a prime coat. Fumarate and HMWM should not be bid competitively, they are not equivalent.

SPECIFICATION (cont'd)

The prepared surface shall receive a prime coat which shall be either:
(1)

A wax free high molecular weight methacrylate resin with a maximum volatile content of 30%, when tested in accordance with ASTM Designation D2369, and conforming to the following:

| High Molecular Weight Methacrylate (HMWM) Resin | | |
|---|---|---------------------|
| PROPERTY | REQUIREMENT | TEST METHOD |
| Viscosity | 25 cps, maximum, (Brookfield RVT with UL Adaptor, 50 RPM at 77 °F.) | ASTM D2393 |
| Specific Gravity | .99 .95 to 1.10 at 77°F | ASTM D2849 |
| Flash Point | 180° minimum | ASTM D3278 |
| Vapor Pressure | 1.0 mm Hg, maximum at 77°F. | ASTM D323 |
| Tack Free Time | 400 minutes maximum at 77°F. | California Test 551 |
| PCC Saturated Surface-Dry Bond Strength | 500 psi, minimum at 24 hours and 70±2°F. | California Test 551 |

A compatible promoter/initiator system shall be capable of providing a resin gel time of not less than 10 minutes nor more than 2¹/₂ hours at the temperature of application. Gel time shall be adjusted to compensate for the changes in temperature throughout treatment application.

COMMENTARY (cont'd)

The maximum volatile content of 30% specifies a low odor material. This is normally desirable in urban areas where many people will be exposed to the objectionable odor. In areas where public exposure will be low, the volatile spec can be deleted.

The saturated surface dry bond strength can be performed by mixing a sufficient quantity of promoted and initiated methacrylate resin with a 1:1 ratio of dry pea gravel and dry PCC sand (10-15% flyash or portland cement can also be added to the aggregate) to produce a flowable concrete. This concrete is then poured against a saw cut PCC face and tested as per California Test Method 551.

SPECIFICATION (cont'd)

COMMENTARY (cont'd)

or (2)

A 100 percent reactive wax-free unsaturated diaromatic oxide glycol fumarate modified polyester resin with the following unfilled resin characteristics:

Unfilled Resin Characteristics
Fumarate Polyester Resin

| PROPERTY | REQUIREMENT | TEST METHOD |
|------------------|--|--------------------|
| Viscosity | 100 to 200 cps (RVT No. 1 Spindle, 20 RPM at 77°F) | ASTM D2393 |
| Specific Gravity | 1.01 to 1.02 1.00 to 1.03 at 77°F | ASTM D2849 |
| Elongation | 12 percent maximum Type I at 0.45 in./min. Thickness = 0.25" ± .03 (8± 1 mm) | ASTM D638 |
| | Sample Conditioning: 18/25/50 + 5/70 | ASTM D618 |
| Tensile Strength | 5,000 psi minimum Type I at 0.45 in./min. Thickness = 0.25" ± .03 (8± 1 mm) | ASTM D638 Modified |
| | Sample Conditioning: 18/25/50 + 5/70 | ASTM D618 |
| Styrene Content | 45 to 55 percent (by weight) | |
| Silane Coupler | 1.0 percent minimum (by weight of polyester styrene resin) | |
| Heat Distortion | 220°F. to 240°F. at 264 psi. | ASTM D648 |
| Barcol Hardness | 30 to 45 at 77°F. | ASTM D2583 |

18/25/50 + 5/70 means 18 hours at 25°C. and 50% relative humidity, plus 5 hours at 70°C.

2.0% is recommended for placement during cold, damp conditions.

The silane coupler for the prime coat shall be an organosilane ester, gammamethacryloxypropyltrimethoxysilane. The promoter shall be compatible with suitable peroxide initiators.

The prime coat shall be uniformly applied to completely cover the surface to receive the polyester concrete. The rate of spread shall be approximately one gallon per 80 square feet of surface.

The spread rate will vary depending on the condition of the deck surface. On lightweight decks one gallon may cover only 50 square feet, but on a hard, sound surface 110 square feet per gallon may be achieved.

SPECIFICATION (cont'd)

If the primed surface becomes contaminated, the contaminated area shall be cleaned by abrasive blasting and reprimed at the Contractor's expense.

The prime coat shall be covered with the polyester overlay during the same workshift that the prime coat is applied.

Polyester concrete shall consist of polyester binder and dry aggregate. The resin shall be an unsaturated isophthalic polyester-styrene copolymer conforming to the following:

COMMENTARY (cont'd)

SPECIFICATION (cont'd)

COMMENTARY (cont'd)

POLYESTER RESIN BINDER

| PROPERTY | REQUIREMENT | TEST METHOD |
|---|--|---|
| Viscosity | 75 to 200 cps (RVT No. 1 Spindle, 20 RPM at 77°F) | ASTM D2393 |
| Specific Gravity | 1.05 to 1.10 at 77°F | ASTM D2849 |
| Elongation | 35 percent minimum Type I at 0.45 in./min. Thickness = 0.25" ± .03 (8± 1 mm) | ASTM D638 |
| | Sample Conditioning: 18/25/50 + 5/70 | ASTM D618 |
| Tensile Strength | 2,500 psi minimum Type I at 0.45 in./min. Thickness = 0.25" ± .03 (8± 1 mm) | ASTM D638 |
| | Sample Conditioning: 18/25/50 + 5/70 | ASTM D618 |
| Styrene Content | 40 to 50 percent (by weight) | |
| Silane Coupler | 1.0 percent minimum (by weight of polyester styrene resin) | |
| PCC Saturated Surface-Dry Bond Strength | 500 psi, minimum at 24 hours and 70±2°F. | California Test 551 |
| Static Volatile Emission | 60 grams per square meter, loss, maximum | California South Coast Air Quality Management District, Standard Method |

The PCC SSD bond strength is facilitated by mixing and adequate amount of resin with the proposed aggregate to produce a mix that when vibrated into molds will be self leveling and resin will flush to the surface. This polyester concrete is then tested per California Test 551.

To meet the Static Volatile emissions requirements, an additive such as BYK S740 or Dow-2 is necessary.

SPECIFICATION (cont'd)

The silane coupler shall be an organosilane ester, gammamethacryloxypropyltrimethoxysilane.

The promoter shall be compatible with suitable peroxide initiators.

Aggregate for polyester concrete shall conform to the requirements of ASTM C33-90 "Standard Specification for Concrete Aggregates" with either of the following aggregate gradings:

COMBINED AGGREGATE

| Sieve Size | 3/8" Max. Percent Passing | No.4 Sieve Max. Percent Passing |
|------------|------------------------------|------------------------------------|
| 1/2" | 100 | 100 |
| 3/8" | 83-100 | 100 |
| No. 4 | 65-82 | 62-85 |
| No. 8 | 45-64 | 45-67 |
| No. 16 | 27-48 | 29-50 |
| No. 30 | 12-30 | 16-36 |
| No. 50 | 6-17 | 5-20 |
| No. 100 | 0-7 | 0-7 |
| No. 200 | 0-3 | 0-3 |

COMMENTARY (cont'd)

The promoter is generally a metallic dryer, and the initiator is generally a peroxide. Cumene Hydro Peroxide has worked well when overlays are placed during hot weather (greater than 90°F.). There are various grades of Methyl Ethyl Ketone Peroxides that can be used. Also there are blends of different peroxides. 2, 4-pentanedione peroxide has been used successfully at temperatures below 45°F. The cultured marble industry is a source of information for choosing promoter/initiator systems.

SPECIFICATION (cont'd)

Aggregate retained of the No. 8 sieve shall have a maximum of 25 percent crushed particles as tested in accordance with California Test 205. Fine aggregate shall consist of natural sand only.

Aggregate absorption shall not exceed one percent as determined by AASHTO T 84 and T 85.

At the time of mixing with the resin, the moisture content of the aggregate shall not exceed one half of the aggregate absorption.

Polyester concrete shall be mixed in:

(1) A mechanically operated mixer. Mixer size shall be limited to a nine cubic foot capacity, unless approved by the Engineer. The resin binder shall be initiated and thoroughly blended just prior to mixing with aggregate. The polyester concrete shall be mixed a minimum of 2 minutes prior to placing.

or (2) A continuous mixer, employing an auger screw/chute device, with self-contained separate aggregate, resin, and peroxide compartments. The aggregate shall be accurately metered to within 2 1/2 percent of the specified weight for the aggregate. The promoted resin shall be metered into the aggregate to within 2 percent of the specified volume for resin. The peroxide shall be injected or introduced to the promoted resin flow prior to mixing with the aggregate in such a manner as to effect thorough blending of promoted resin and peroxide. The peroxide unit shall be capable of injecting from 1/2 percent to 2 1/2 percent peroxide to volume of resin within an accuracy of 10 percent. The volume of peroxide may be varied by the operator from time to time as field conditions warrant.

COMMENTARY (cont'd)

Aggregate characteristics are important because they influence the properties of the composite. Low absorption, roundness of the aggregate, and gradation are controlled to minimize the resin content of the composite for a given workability. The thermal coefficient of expansion of the composite is related to resin content. The thermal coefficient of the polymer is higher than the aggregate and the PCC substrate. Therefore, the higher the resin content, the larger the relative strain due to temperature above and below the bond line. However, a higher resin content lowers the modulus of elasticity, and thus stress is reduced for a given strain. High resin content has not been a major engineering concern, at least up to 14%. The cost of the polyester concrete material is most affected by the resin content, though, since the resin is the most costly component. This is an incentive to keep the resin content as low as possible.

Volume of mixers should be minimized to avoid "large mass polymerization" and lower the explosive hazard of transit mixers.

The appropriate resin content may be affected by environmental conditions or slight variations in gradation. The intent is to ensure equipment is capable of producing the desired mix proportions on a continuous basis.

SPECIFICATION (cont'd)

The peroxide unit shall have a flow cut off sensing unit capable of stopping the mixer or providing sound and or visual notice upon loss of peroxide flow below the volume setting. ~~A manual override shall be provided to allow removal of remaining material prior to hardening in the mixer auger and components.~~ The peroxide metering system, including, but not limited to, tanks and pumps, shall not contain any materials which will deteriorate or react with the peroxides. No less than four each, minimum 5 pound, Class "B", fire extinguishers, in good working order, shall be mounted approximately equidistant around the perimeter of each mixer unit.

The capacity, operating speed, and all mix control constants shall be clearly and prominently mounted on the unit by the manufacturer on a durable metal plate or plates.

Calibration and general mixer operation shall be demonstrated on a site a minimum of 5 working days prior to anticipated use. The calibration will consist of a weight/volume determination made in a 1/4 cubic yard container, filled with the polyester concrete to be used, struck off, and the volume compared to the mixer output record or reading. When no longer required as determined by the Engineer, the container and contents shall be disposed of by the contractor.

The polyester resin binder in the concrete shall be approximately 10 percent by weight, the exact percentage will be determined by the Engineer.

Expansion joints shall be adequately isolated prior to overlaying, as approved by the Engineer.

The amount of initiator used in polyester concrete shall be sufficient to produce during placement initial set time between 20 and 120 minutes. Accelerators or inhibitors may be required to achieve proper set times and shall be used as recommended by the resin supplier.

COMMENTARY (cont'd)

Reduction of peroxide will cause the polyester to cure slowly or not at all. Since polyester concrete sets up rapidly, early traffic use may be expected. Soft spots would be undesirable repairs.

10% is for bidding purposes. The exact amount will depend heavily on the aggregate chosen. Aggregates that have met this specification have generally produced workable polyester concrete (± 5 " slump) with resin from 9.5% to 11%.

The overlay is ready for traffic when it will resist penetration of a screwdriver.

SPECIFICATION (cont'd)

Polyester concrete shall be placed prior to gelling and within 15 minutes following addition of initiator, whichever occurs first. Polyester concrete that is not placed within this time shall be discarded.

The finishing equipment used shall strike off the polyester concrete to the established grade and cross section. Finishing equipment shall be fitted with vibrators or other means of consolidating the polyester to the required compaction.

The polyester concrete shall be consolidated to a relative compaction of not less than 97 percent in accordance with California Test 552. Should any area fall below 97 percent, then corrective action should be taken immediately.

The finished surface of the polyester concrete overlay shall conform to the requirements of the Owner for new bridge decks or new roadways.

The profile smoothness shall conform to the requirements of the Owner for new bridge decks or new roadways.

COMMENTARY (cont'd)

Placing includes any texturing that may be applied, and broadcast sand as below.

Pneumatic vibrators tend to be louder than electric vibrators. This might be specified if noise is a concern.

This test should be used as a guide. If a low compaction reading is obtained, the surface of the suspect area should be immediately examined to see if there is a difference in appearance between it and other areas that have attained the required compaction values. Resin flushed to the surface is usually an indication of adequate compaction.

Corrective action might include:

- (A) Slow strike-off velocity,*
- (B) Check vibrator,*
- (C) Check resin content,*
- (D) Check gradation,*
- (E) Check time between resin initiation and strike-off to be sure that strike-off is occurring before any gelling of resin.*

If corrective actions do not result in higher compaction numbers, and mat appears to be compacted (resin flushing to top) then the area should be marked for future coring. A visual examination of the core and unit weight test should be performed. The examination should check for any "pop-corn" areas, and uniformity from top to bottom. The unit weight should not be less than 3 lb/ft^3 less than the unit weight taken to determine yield.

SPECIFICATION (cont'd)

Polyester concrete surfaces shall receive an abrasive sand finish. The sand shall be No. 8/20 commercial quality blast sand conforming to the dryness requirements for polyester concrete aggregate as specified in these special provisions.

The sand finish shall be applied immediately after overlay strike-off and before gelling occurs to provide a minimum coverage of 0.8 pounds per square yard.

The surface texture of polyester concrete surfaces shall be uniform and shall have a coefficient of friction of no less than that required by the Owner.

Prior to constructing the overlay, one or more trial overlays shall be placed on a previously constructed concrete pad to be used as a base to demonstrate the effectiveness of the mixing placing and finishing equipment proposed. Each trial overlay shall be 12 feet wide, at least 10 feet long, and the same thickness as the overlay to be constructed. Conditions during the construction of the overlay and equipment used shall be similar to those expected and to be used for the construction of the polyester concrete overlay.

All materials used in the trial overlays, including the concrete pad to be used as a base shall become the property of the Contractor and shall be removed and disposed of at his expense.

Furnish polyester concrete overlay will be measured by the cubic foot. The volume to be paid for will be determined by calculations based on the quantity of the resin binder used and the yield of the in-place polyester concrete per ASTM C138.

The Contractor shall furnish suitable measuring devices to assure correct proportioning of materials and accurate measurements for pay quantities. The pay quantity shall be the calculated quantity of polyester concrete overlay used in the work, exclusive of material used in trial overlays, and any wasted or unused material.

Place polyester concrete overlay will be measured by the square foot. The area to be paid for will be based on the dimensions as shown on the plans.

COMMENTARY (cont'd)

In California friction must be 0.35. Tining the surface and sanding the surface have made acceptable textures. Alternative textures may also work.

The trial slab is also beneficial to the Owner by providing experience in performing the necessary tests and developing inspection procedures.

The twelve foot width is meant to conform to the normal single lane paving width. If a wider or narrower width will be required on the structure, that width should be used. The length is intended to be sufficient to demonstrate production-run construction techniques. Continuous mixers may require a trial run up to 30 feet.

The nature of polyester concrete does not lend itself to tamping with a tamping rod when doing yield measurements, so extra care is required. It is suggested to vibrate the concrete into the unit weight bucket.

When continuous mixers are used, quantity can be determined by calibrated measuring devices recording the amount of aggregate and resin. When stationary mixers are used, weights of each batch used should be tabulated.

Having two pay quantities compensates for variations in thicknesses of the overlay.

SPECIFICATION (cont'd)

The contract price paid per cubic foot for furnish polyester concrete overlay shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all the work involved in furnishing polyester concrete, including polyester resin binder, promoter/initiator and aggregate, as shown on the plans, as specified in standard specifications and these special provisions, and as directed by the Engineer.

The contract price paid per square foot for place polyester concrete overlay shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all the work involved in ~~furnishing~~ placing polyester concrete overlay, complete in place, including application of prime coat and furnishing, constructing and disposing of trial overlays and base.

COMMENTARY (cont'd)

Surface preparation may be included or paid as a separate item by square foot.