Polyester Concrete Overlay & Expansion Dams

This attachment includes information to assist SC Staff when verifying the contract requirements are met during the placement of polyester concrete overlays and expansion dams.

1 - What is Polyester Concrete?

A very durable composite material made of hardened polyester resin and aggregate. The polymerized resin serves as the binding agent – similar to hydrated Portland Cement in Portland Cement Concrete (PCC).

2 - What are the Differences Between PCC and Polyester Concrete?

a. Polyester Concrete aggregates must have a moisture content less than 0.5% of the absorption capacity of the aggregates.

b. Polyester Concrete cannot tolerate moisture in the concrete matrix.

c. Polyester Concrete hardens much more quickly than PCC

d. Some materials used in Polyester Concrete are volatile and must be handled properly and safely.

3 - What are Typical uses of Polyester Concrete?

a. Bridge deck overlay

b. Expansion dam headers

c. PCC Repair

4 - What are Placement Methods of Polyester Concrete?

a. Drop-In or Brookhaven Method- This was a very old method that was used in 1950 to place Polyester concrete. It was also known as broom-and-seed method where the resin was broomed to the bridge deck first and afterwards the bridge deck was seeded with aggregate. This method exhibited poor performance and the overlay would fail early than expected by delamination.

b. Pre-mix or Oregon Method- In this method the resin and aggregate is premixed prior to the placement on bridge deck. This is the method that was initially developed by Oregon DOT in 1970s, later modified by Caltrans and currently being used on Caltrans projects.

5 - What are Advantages of Polyester Concrete?

a. Superior mechanical properties - Durable: 10 times abrasion resistance of PCC.
b. Impermeable to chloride penetration.
c. Best alternative for repair and rehabilitation of structures. Can be placed in thin sections, i.e., reduced dead load, and under a wide range of conditions.
d. Rapid return to service, 3 hours. Minimal delay to traffic.
e. Non-skid wearing surface.
f. Longevity, replaceable, not soluble in fuel, will not sustain fire.

6 - What are Mechanical Properties of Polyester Concrete?

Table 1 shows mechanical properties of polyester concrete.

Table 1. Mechanical Properties of Polyester Concrete

	Polyester Concrete	Portland Cement Concrete (8 sack)	Latex-modified Concrete	Silica-fumed Concrete
Compressive strength, psi	8,000	7,000	9,000	7,000
Flexural strength, psi	2,200	800	900	1,100
Abrasion (weight loss, grams)	1-2	15	14	9
Return to service	3 hours	5 days	4-5 days	2-4 days
Chloride permeability, coulombs	0	1,000	500	500

7 - Unique Specification Requirements

a. Mix the resin and catalysts thoroughly before adding the aggregates.

b. Specified resin content is 12%, low resin= too many voids, too high = thermal incompatibility with the PCC substrate.
c. Compaction
d. Immediately after placement and before gelation of the resin:
    i. Finishing should be done
    ii. Apply sand on exposed polyester concrete
e. Curing polyester concrete is not necessary.

8 - Unique Aggregate Specification Requirements

a. Aggregate quality same as PCC aggregate
b. Crushed particle counts less than 45% (based on retained #8 fraction
c. Gradation requirement on “combined” aggregate
d. Must be Very Dry: Absorption less than 1%
e. Moisture content is less than half the absorption
f. Sand must be natural

9 - What is the definition of Polymers?

Polymers are hard glassy solids made up of long-chain molecules formed by joining together of simple monomer molecules. Nearly all polymers are organic (carbon-based molecules). Synthetic polymers are more commonly known as “Plastic”.

10 - What is Polymerization?

a. Process of converting liquid monomer resin into solid polymer.
b. Chemical reaction - typically using catalyst - in which a large number of relatively simple molecules combine to form a chain-like macro-molecule (polymer).
c. Long-chain polymer molecules are formed by repeated linking of monomer molecules typically using the process shown in Figure 1.

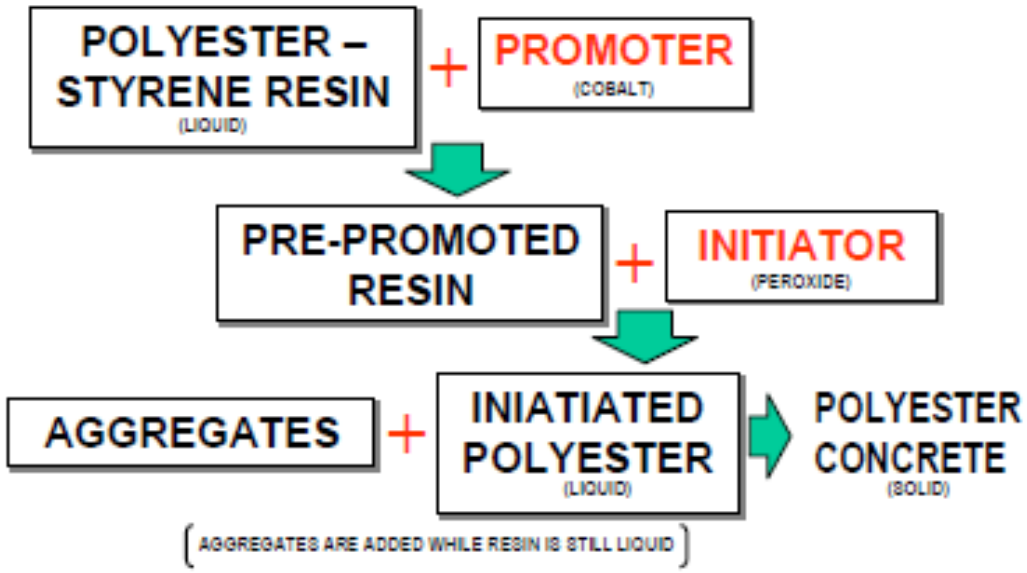

Figure 1. Mix Components of Polyester Concrete

Alternatively, the component may be mixed as shown in Figure 2.

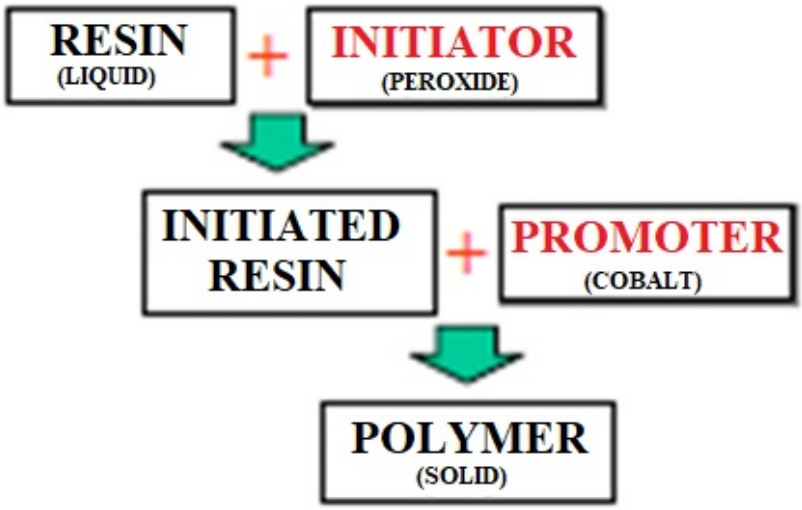

Figure 2. Critical Two-Step Mixing Process

The free-radical process of polymerization (using initiators/promoter systems) is an independent reaction (that is, independent of the resin) where the peroxide is catalyzed by the cobalt. Consider the independent reaction between cobalts and peroxides - if they are combined directly, they decompose very rapidly, resulting in fire or explosion as depicted in Figure 3. The resin is used to insulate or dilute this effect.

Figure 3. Risk of Explosion Due to Incorrect Mixing Sequence

11 - Resin Delivery, Storage, Measurement and Payment

Resin is delivered in tank trucks in drums and is tagged at the source. Resin can be off-loaded from the tank truck into 500-gallon poly tanks for storage in the yard as shown in Figure 4. The resin amount is tracked for measurement and payment.

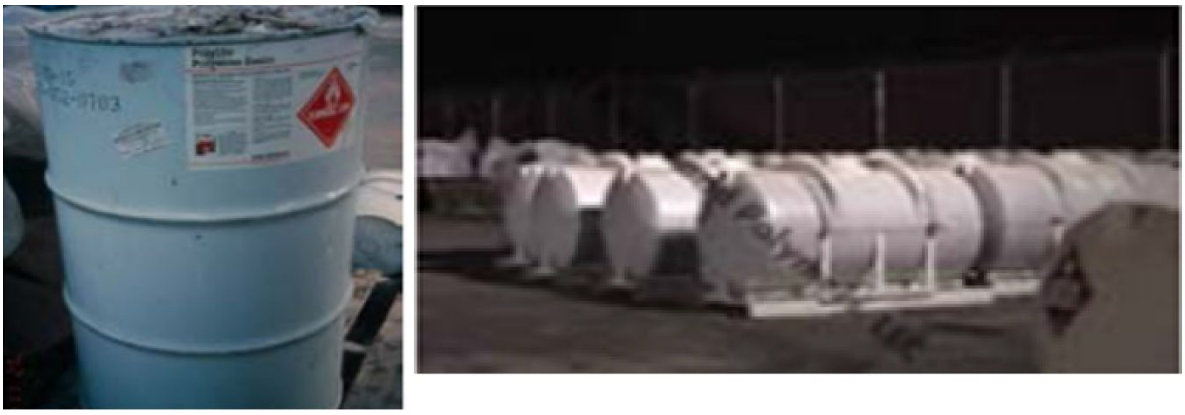

Figure 4. Polyester Resin Delivery, Storage, Measurement, and Payment

12 - Polyester Resin Additives

a. Silane Coupling Agent used to improve bond between polymer and mineral surfaces. Organosilane ester gammamethacryloxypropyltrimethoxsilane

b. Wax specified to lower emission levels. Specification limit emission to static Volatile Emission of 60 gr/sq mtr max. Rule 1162 SCAQMD. Paraffin wax BYK-S740

c. Accelerator is an additive used to accelerate polymerization. Must be compatible with initiators.

d. Antioxidants used to stop or slow oxidation and its degrading effect

e. Other additives such as Antistatic Agents, Colorants, etc.

12.1 - Promoter

a. Chemicals that accelerate the chemical reaction.

b. These chemical compounds reduce the critical temperatures of peroxide initiators, thus forming free radicals at ambient temperatures.

c. Not consumed by the reaction. Also known as Catalysts.

d. Metallic soaps are generally used as promoter such as Cobalt Napthenate (CoN) or Cobalt Octoate (CoO).

12.2 - Initiators

a. Chemicals that start the polymerization process

b. These compounds initiate the polymerization by decomposing into free radicals, which actually starts the polymer chain growth

c. Normally consumed in the reaction

d. Also known as “Hardeners”

e. Generally used initiators are: Cumene Hydroperoxide (CHP) or Methyl Ethyl Ketone Peroxide

13 - Construction Sequence

a. Set up Lane Control

b. Deck Preparation

c. Identify & remove unsound concrete

d. Shot blast deck

e. Block out joints

f. Clean deck - Air Sweep

g. Set Grade Control

h. Apply methacrylate primer

i. Mix and place polymer concrete

j. Saw cut overlay over joints

k. Sweep deck

l. Pick up grade control

m. Open to public

14 - Trial Slabs

Trial slabs are required in contract so that the contractor can demonstrate that his overlay operation would be completed with the time allowed given the temperature and other environmental conditions specific to the time and place of operation. Figure 5 is a photo of a trial slab construction.

Figure 5: Trial Slab Construction

15 - Quality Assurance

Schmidt hammer shown in Figure 6 can be used as an NDT for concrete strength, but it is for reference only since it is not accurate. As such the contract specification does not reference using this tool. Additional testing will be needed to verify the actual strength of concrete when result from Schmidt hammer testing might suggest insufficient concrete test strength. In placing polyester concrete, the Standard Special Provisions (referred to as the SSPs) requires that PCC to have reached specific strength before it can be overlayed. This tool can used to make a preliminary assessment of the concrete strength.

Figure 6. Schmidt Hammer

16 - Compaction Test

a. Specification: 97%
b. Taken while overlay is wet - immediately behind paving machine
c. Might get inconsistent compaction test results, from low 90's to above 100%
d. Function of density
e. This test should be used as a guide
f. If low compaction results are obtained, examine the area of low compaction result with other areas with good test results for difference in appearance. Test other areas looking similar to the low compaction result area.
g. Resin flushed to the surface is usually a good indication of adequate compaction

17 - Material Testing

If corrective actions do not result in higher compaction numbers and overlay appears to be compacted, coring or pull-out test as shown in Figure 7 may be necessary.

Figure 7. Pull-Out Test

Pull-out Test Cores as shown in Figure 8 should be examined for uniformity from top to bottom. Unit weight should be investigated.

Figure 8. Pull-Out Test Cores