Polyester Polymer Concrete Overlay Final Report

WA-RD 797.2

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Special Project Report

Final Report
Special Project

Polyester Polymer Concrete Overlay Final Report

I-90, Contract 8018
Vic Geiger RD to Spokane Viaduct – PCCP Rehab.




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This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. ABSTRACT

Polyester polymer concrete (PPC) was used in a trial application as a possible repair strategy on a section of concrete pavement that suffered from extensive studded tire wear.

The PPC was applied in three methods; (1) as a 1 inch thick inlay of the entire lane that was diamond ground to remove all rutting from studded tire wear, (2) as an inlay of just the wheel paths that were diamond ground, and (3) as a feathered overlay of the existing pavement which had no diamond grinding to remove rutting. The completed overlay required diamond grinding to mitigate an unacceptable ride quality adding to the cost of the installation.

The PPC performed very well over a six year evaluation period with no cracking or spalling noted and good friction resistance. The amount of wear on the PPC is similar to that of the adjacent concrete pavement diamond ground under the same project. Based on the measurements taken so far the wear rates for each lane on the PPC test section appears to be almost double that of the Diamond Ground test section. While the rate of wear appears to be greater in the PPC, additional years of testing will be necessary to determine whether the trend found in the first 73 months remains the same or if the wear rates even out for both the PPC and Diamond Ground sections.

PPC appears to be an option to fill ruts in concrete pavements particularly where diamond grinding is not a solution.

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DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Washington State Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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Executive Summary

This special project evaluates the performance and cost effectiveness of polyester polymer concrete (PPC) as a possible solution for studded tire wear on rutted concrete pavements in the Spokane area. Previous experiments with a number of possible solutions to the wear problem did not find a viable strategy. Projects were evaluated that used; (1) combined aggregate gradation, (2) whitetopping[1] using a high flexural strength mix, and (3) higher flexural strength mixes, hard-Cem additive and higher cement content mixes. This project continues the search for a solution.

Portland cement concrete is a mixture of cement, aggregate, sand and water. PPC is a mixture of polyester resin and aggregate. The PPC has a rapid cure time (2-4 hours) and can attain over 4000 psi in compressive strength within 24 hours. It also has greater flexural strength than conventional concrete, 1,500 to 2,000 psi, as compared to 650 to 800 psi for WSDOT mix designs. Kwikbond Polymers located in Benicia, California provided the PPC.

The trail installation was placed in July of 2012 on I-90 in between MP 275.55 and 275.85. The PPC was placed in three 60 foot sections in the westbound lanes. Each section represented one possible method that could be used in the future to repair a rutted concrete pavement. In the first section the overlay material was used to fill the existing ruts by using a roller screed to strike off the material. In the second section 3-foot wide strips were ground in each wheel path to remove the rutting. The polyester overlay was then placed as an inlay. In the third section the pavement was diamond ground shoulder to shoulder and the polyester overlay was placed 1 inch deep over the entire lane.

The construction was completed without major problems except that the finished surface did not meet WSDOT standards for smoothness which specifies there be no variations exceeding 1/8 inch under a 10-foot straight edge. The entire surface of the overlay did not meet the 10-foot straight edge specification and as a result the Contractor diamond ground all three sections on October 18 and 19, 2012.

The actual cost of the trial installation would not be representative of costs to overlay extensive sections of mainline pavement due to the disproportionately high installation costs

[1] Whitetopping is what a bonded concrete overlay was called in the past.

associated with the small material quantities used on the project. Discussions with Dan Uldall, KwikBond Polymers' representative, indicated that $10.00 per square foot is a reasonable price for PPC overlays of larger bridge decks. This cost includes mobilization and demobilization, shot blasting, and slip form paving. The bid tabulation cost of the diamond grinding of the concrete pavement on the project was $1.22 per square foot.

Wear, ride and friction measurements were made over the 6-year monitoring period on both the polyester concrete test section and a one mile section of the diamond ground pavement located east of the polyester concrete. Initial measurement of these parameters began in April of 2013. The amount of wear on the PPC is similar to that of the adjacent concrete pavement diamond ground under the same project. Based on the measurements taken so far the wear rates for each lane on the PPC test section appears to be almost double that of the Diamond Ground test section. While the rate of wear appears to be greater in the PPC, additional years of testing will be necessary to determine whether the trend found in the first 73 months remains the same or if the wear rates even out for both the PPC and Diamond Ground sections.

The ride for the PPC can be generalized as increasing roughness over time. The ride on the Diamond Ground section has remained unchanged over the evaluation period. The friction resistance of the PPC was equal to or better than most conventional concrete pavements.

The performance of the PPC as an overlay was excellent for the six year evaluation period with no cracking, spalling or delamination noted.

It is concluded that the PPC is a viable method of filling ruts in concrete pavements particularly where diamond grinding is not an option.

Introduction

Wear on concrete pavements is a major source of concern for the Eastern Region of Washington which includes the Spokane urban area. This wear is due primarily to studded tires which are legal between November 1 and March 31. The damage from studded tires ranges from a slight dishing of the pavement in the wheel paths to ruts that are over 1/2 inch deep. Figure 1 shows a concrete pavement that was constructed in 1995 on SR 395 just south of Interstate 90 near Ritzville. At the time of this photo, this pavement had been in service for seven years. The traffic on this route is approximately 6,800 vehicles per day. The transverse tining in the wheel paths has been completely worn away due to studded tires (note that the tining is still visible on either side of the wheel paths).

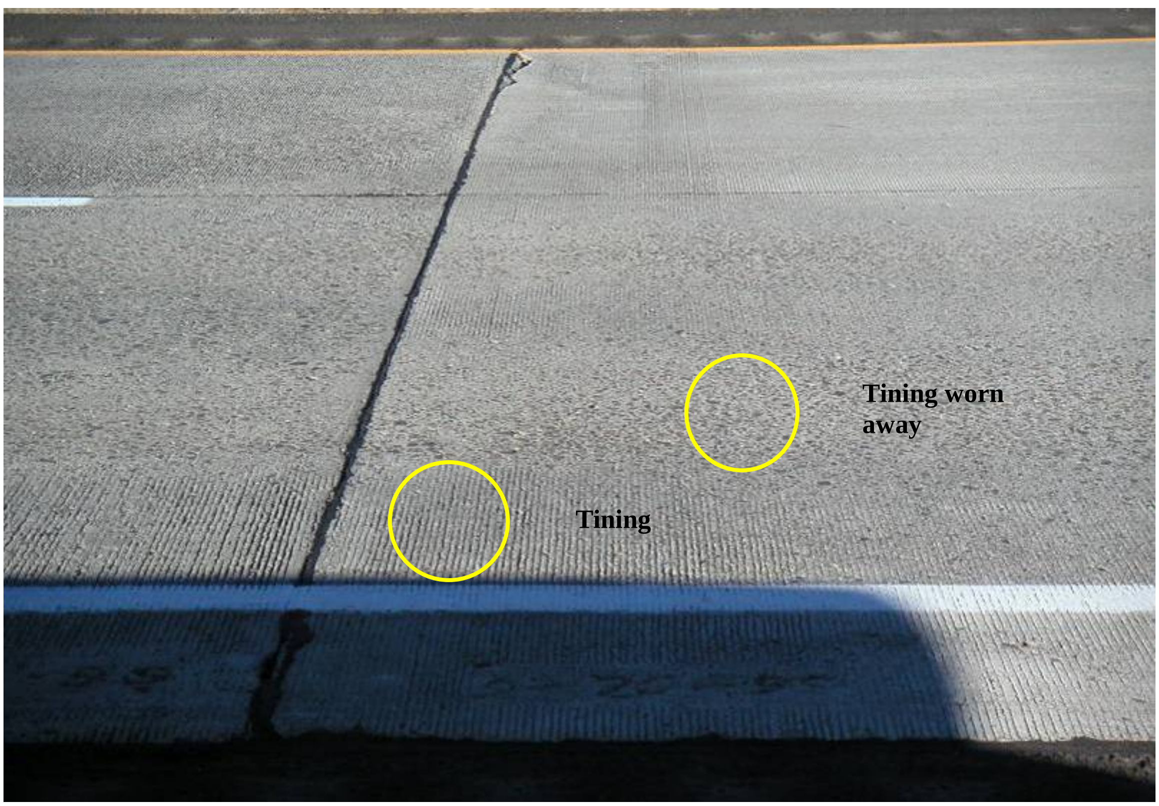

Figure 1. Concrete pavement on SR-395 south of Interstate 90 interchange at Ritzville.

Figure 2 shows a 13 year old concrete pavement located on Interstate 45 in Houston, Texas. Note the clear pattern of tine marks across the entire width of the lane. The traffic on this section is 178,000 vehicles per day. Studded tires are legal in Texas, however, their mild climate does not typically warrant their use. The damaging effects of studded tires is clearly observable in this comparison which is made even more dramatic when considering that the Texas pavement has received more than 26 times the daily traffic volume (178,000 versus 6,800) and has been in service for almost twice the number of years (thirteen years versus seven years at the time of these photos) as the pavement on SR 395.

Figure 2. Concrete pavement on Interstate 45 in Houston, Texas after thirteen years of traffic.

An even more dramatic example of studded tire wear is shown in Figure 3. The wear has formed 1-1/2 inch deep ruts in the concrete pavement. This type of rutting is especially prevalent in the Spokane urban area, which has the highest use of studded tires in the entire state.

Figure 3. Studded tire wear on a concrete pavement (I-90 Spokane).

Studded Tire Wear Mitigation Projects

A series of experimental features have been built in Eastern Washington (Table 1) using various strategies to mitigate the type of wear noted previously. The projects are all on I-90 in the Spokane urban area. The first project is Sprague Avenue I/C Phase III completed in 2001. This project constructed westbound lanes between Milepost (MP) 284.00 and MP 287.00 using a combined aggregate gradation to see if a different aggregate structure would reduce studded tire wear. It is compared to a project constructed a year earlier on the eastbound lanes at the same mileposts using the WSDOT's standard aggregate gradation. A 650 psi flexural strength mix design and transverse tined finish were used on both projects. The study concluded that the combined aggregate gradation provided no measurable improvement in the resistance of the pavement to studded tire wear.

The second project, Sullivan Road to Idaho State Line, was completed in 2003. Various pavement treatments were installed on a section of HMA pavement to mitigate deep rutting from studded tires. The pavement treatments included micro/macro resurfacing, modified Class D

HMA, whitetopping, and standard Class ½ inch Superpave HMA. The whitetopping is the treatment of interest for this study. Sections 500 feet in length of 3-inch, 4-inch, and 5-inch thick concrete were constructed in the westbound travel lane between MP 293.20 and 293.53. The flexural strength requirement for the mix design was increased from 650 psi to 800 psi. Polypropylene fibers were incorporated into the mix at the rate of 3 pounds per cubic yard to provide extra strength and hold any cracks together that might form as a result of the much thinner pavement section. The concrete was finished with a very light carpet drag texture. The whitetopping sections with the higher flexural strength mix design did not prove to be any more resistant to studded tire wear than our conventional concrete pavement.

The third project, Argonne Road to Sullivan Road, was completed in 2005. This project was built primarily with higher flexural strength mix (800 psi) but it also included short sections with 650 psi flexural strength mix, 650 psi mix with concrete hardener additive and mix with higher cement content, all designed to potentially mitigate studded tire wear. The mixes used were:

- 650 psi flexural strength with both carpet drag and transverse tined texture (WSDOT standard design strength)
- 650 psi flexural strength with Hard-Cem hardener additive with carpet drag texture
- 800 psi flexural strength with both carpet drag and transverse tined texture
- 925 lbs/cy yard cement content with carpet drag texture

The eastbound lanes were opened to traffic in 2004 and the westbound in 2005. Carpet drag texture was applied to most of the project with the exception of two short sections of transverse tined texture. The study concluded that higher flexural strength, concrete hardeners, and higher cement contents do not make pavements more resistant to studded tire wear than our conventional 650 psi mix pavements.

Table 1 lists the projects and the features installed to reduce studded tire wear.

Table 1. Mitigation of studded tire wear experimental features.

Feature Used to Mitigate Wear	Title	Location
Combined Aggregate Gradation	Combined Aggregate Gradation as a Method for Mitigating Studded Tire Wear on PCCP, Final Report	I-90, Sprague Ave I/C Phase III, C6947
Whitetopping	Wear Resistant Pavement Study, Final Report	I-90, Sullivan Road to Idaho State Line, C6582
High Flexure Strength Mix, Hard-Cem Additive Mix, High Cement Content Mix	Studded Tire Wear Resistance of PCC Pavements, Final Report	I-90, Argonne Road to Sullivan Road, C6620

Note: See the report by clicking on the link.

WSDOT Polyester Polymer Concrete Experience

WSDOT's Bridge Office has had considerable experience using polyester polymer concrete (PPC) on bridge decks. Twenty-three bridge decks were overlaid between 1989 and 2007 with a total of 868,076 square feet of PPC. The smallest deck was 4,536 sq. ft. (SR 12, Gibson Creek Bridge in Grays Harbor County) and the largest 407,750 sq. ft. (I-5, NB Viaduct Bridge in King County). The PPC overlays were intended to; (1) provide a waterproofing cover to prevent the intrusion of deicing salts into the deck and corroding the rebar, (2) repair deteriorated deck surfaces, and (3) provide a smoother riding surface at a minimum addition of dead load to the structure.

A review of the condition of the PPC decks from the bridge inspection reports indicated that most are in very good to excellent condition (17 out of 22) (see Appendix A for a listing of the bridges). Most of the inspection reports indicated only moderate amounts of wear in the wheel paths on the newer installations (2002 to 2007). The older installations (1989 to 2001) had some spalling and delamination of the PPC overlays down to the underlying deck, but this was the exception, not the rule.

The good experience of the Bridge Office using PPC on bridge decks would seem to indicate that this material may be able to stand up to studded tires, however, with only one of the bridges in the group of 23 located in Eastern Washington, it is still unknown if this is a possible mitigation strategy for areas that receive excessive studded tire wear. This experimental feature will seek to answer that question

Project Location

The experimental application of PPC was included in Contract 8018, Vic Geiger Road to Spokane Viaduct on I-90 in Spokane (Figure 4). The contract called for the replacement of damaged panels and the diamond grinding of all lanes to remove rutting between Milepost 275.40 and Milepost 280.16. A very short portion of the project between MP 275.55 and 275.58 was selected for the experimental installation. The configuration of I-90 where the trial was to take place is two lanes in each direction. The average daily traffic for this section of I-90 is 33,254 with 13 percent trucks.

Figure 4. Vicinity map of Contract 8018, Vic Geiger RD to Spokane Viaduct.

Polyester Polymer Concrete Mix Design

Portland cement concrete is a mixture of cement, aggregate, sand and water. PPC is a mixture of polyester resin and aggregate. The PPC has a rapid cure time (2-4 hours) and can attain over 4000 psi in compressive strength within 24 hours. It also has greater flexural strength than conventional concrete, 1,500 to 2,000 psi, as compared to 650 to 800 psi for WSDOT mix designs.

The polyester-based polymer overlay system supplied by KwikBond for this project is designed for use on bridge decks to create a durable wearing surface and seal the deck against intrusion of deicing salts (Appendix B). When used on bridge decks the surface is cleaned by shot blasting to remove loose aggregate and clean the surface of any contaminants such as oil or grease for either option before the primer is applied. A primer is used to promote adhesion of the overlay to the existing concrete. The high molecular weight methacrylate (HMWM) primer is applied immediately after the surface is blown dry and clean with high pressure air. A mobile mixer is used to mix the polyester polymer and aggregate. Slip-form paving equipment or pre-level screed rails are used on the deck to level the PPC and produce the desired grade and cross slope of the finished surface. An abrasive sand top dressing is applied to the overlay when the PPC is still wet.

Two mix designs were used on the project, one for the diamond ground full lane and wheel path sections and one for the rut fill section (see Appendix B). The only difference in the two mix designs was the gradation of the aggregates. The mix design used for the full lane and wheel path inlay sections used a 3/8 inch top size gradation. The smaller size aggregate used for the rut fill section had a No. 4 sieve top size gradation as noted in Table 2. The finer aggregate gradation was chosen to facilitate feathering of the material at the outside edges of the wheel paths in the rut fill section.

Table 2. Aggregate gradations for inlay sections and rut fill section.

Screen Size	Full Lane and Wheel Path Inlay Sections	Rut Fill Section
	% Passing	% Passing
3/8”	100	100
No.4	70	100
No. 8	60	98
No. 16	40	60
No. 30	25	35
No. 50	10	21
No. 100	0-2	5
No. 200	T	T

T = Trace

Construction

The PPC was placed on I-90 in three 60 foot sections in the westbound lanes (Figure 5). Each section represented one possible method that could be used in the future to repair a rutted concrete pavement. In the first section (A) the overlay material was used to fill the existing ruts by using a roller screed to strike off the material. In the second section (B) 3-foot wide strips were ground in each wheel path to remove the rutting. The polyester overlay was then placed as an inlay. In the third section (C) the pavement was diamond ground shoulder to shoulder and the polyester overlay was placed 1 inch deep over the entire lane.

The paving contractor, ACC West Coast, Inc., provided a paving plan to the Eastern Region for the PPC installation (see Appendix C, Contractor’s Paving Plan). A summary is included below:

- Grind sections B and C.
- Shot blast all three sections.
- Sandblast areas in all three sections that are not accessible to the shot blaster.
- Clean each area with high pressure air just prior to paving.
- Apply Methacrylate resin primer coat a minimum of 30 minutes before placing the polymer concrete.
- Use mobile mixer to mix and deposit polymer concrete on the pavement.

- Use roller screed to compact and strike off the material in inlay section and roller screed fill section.
- Broadcast sand top dressing over each section.
- Use a Schmidt Hammer to determine if the cured PPC has attained the compressive strength required for opening to traffic (2,500 psi).

The Contractor's paving plan could not be followed to the letter. The roller screed was used for the full width inlay and rut fill sections (A and C) but not in the wheel path inlay section (B). A wooden 2x4 just over 3' long was used on this section to finish the PPC level with the ground out wheel paths. The roller screed would have high centered on the center of the lane and not been able to finish the surface of the wheel paths. The other deviation from the plan was that sand blasting was used in place of the shot blaster to prep all of the sections due to the unavailability of a working shot-blaster.

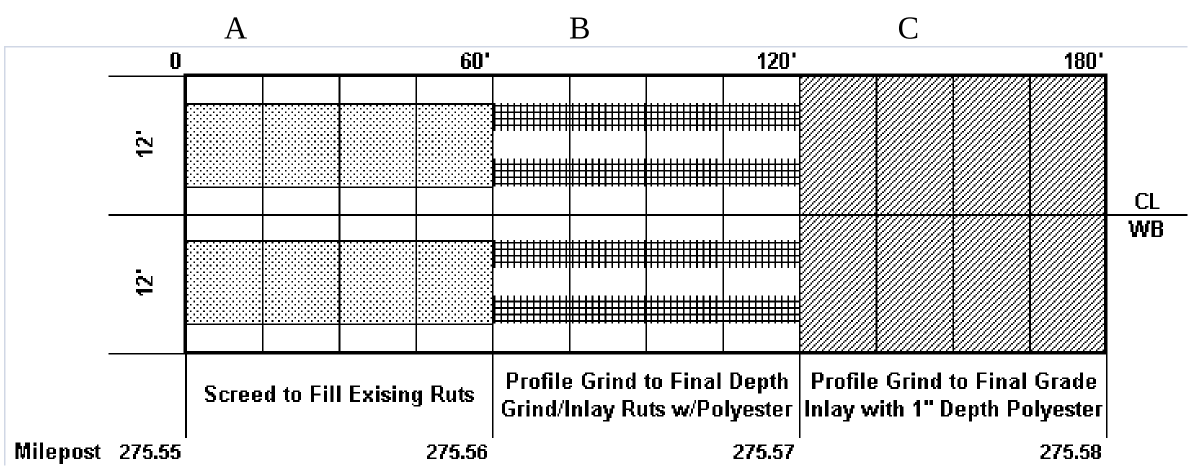

Figure 5. Plan map of the PPC sections.

Trial Installation

The Contract Special Provision (Appendix D) required that the Contractor place a trial overlay of PPC using the equipment, production mix and procedures intended to be used on the project. The trial overlay was to be placed on a previously cast and cured concrete pad with a minimum width of 12 feet and minimum length of 15 feet. Figures 6 through 9 show the construction of the trial overlay.

Figure 6. Rolling of high molecular weight methacrylate (HMWM) prime coat.

Figure 7. Mobile mixer moving into place to distribute PPC.

Figure 8. PPC being placed.

Figure 9. Finished trial application.

The special provisions also required pull-off tests to verify the bond between the PPC and the underlying pavement. A two inch diameter core drill was used to drill through the overlay and an inch into the existing concrete pavement. A steel cap was bonded to the overlay with epoxy. A hydraulic jack with a pressure gauge was attached to the steel cap and force was applied in a vertical direction to separate the overlay from the existing pavement. Failure in the concrete of the existing pavement is a passing test since the strength of the polyester overlay exceeded the strength of the existing pavement (Tests No. 1 and 3). Test No. 2 was also a passing test since the PPC did not fail. The average pull off stress for the three passing tests was 419 psi. A copy of the test results submitted on behalf of the Contractor by Budinger & Associates is available in Appendix E.

Table 3. Pull off test results.			
Test No.	**Load (lbs.)**	**Stress (psi)**	**Failure Type**
1	**1512**	**481.5**	**Passing test – failure in the existing concrete.**
2	**1278**	**407.0**	**Passing test - failed at the bond between the steel cap and the epoxy (bond between the PPC and existing concrete did not fail).**
3	**1161**	**369.8**	**Passing test – failure in the exiting concrete.**
4	**464**	**147.7**	**Bad test - failure at the bond between the steel cap and the epoxy.**
5	**N/A**	**N/A**	**Bad test - failed prior to testing (test was disturbed).**
6	**810**	**258.0**	**Bad test - failure in both the epoxy bond between the epoxy and cap and the epoxy and overlay.**

Note: The Bridge Office special provisions require that the pull-off tests average 300 psi.

Figure 10. Pull off test 1.

Figure 11. Pull off test 3.

Construction

Construction of the polyester overlay began with diamond grinding operations at 10:00 pm on Monday night July 7 and was concluded at 10:15 am Friday morning, July 13, 2012. A summary of the Inspector’s Daily Report’s (IDR’s) provides a history of the preparation of the existing pavement and the application of the overlay (Table 3). The only problems encountered were equipment breakdowns (pavement grinder) and a rain shower that briefly interrupted the paving of Lane 1. Figures 12 through 35 illustrate the paving operations for each of the three sections.

Table 4. Inspector's Daily Report summary.

Date	Time	Event
7/9	10:00 pm	Begin diamond grinding of Lane 2.
	1:55 am	Diamond grinding ends due to equipment breakage
7/10	9:00 pm	Diamond grinding resumes on Lane 2
	5:00 am	Diamond grinding ended for the night, still on Lane 2
7/11	9:00 pm	Diamond grinding of Lane 2 completed, shifting to Lane 1.
	4:30 am	Diamond grinding of full lane inlay section completed on Lane 1
7/12	7:25 pm	Diamond grinding of Lane 1 continues, briefly interrupted by a breakdown of the grinder.
	10:20 pm	Diamond grinding of Lane 1 completed, paving postponed until Friday due to threat of rain
7/13	9:30 pm	Paving of the polyester overlay begins on Lane 2
	11:55 pm	Paving of Lane 2 completed.
	2:15 am	Lane 2 polyester overlay reaches strength and traffic switched
	3:45 am	Paving of Lane 1 begins.
	5:00 am	Rain shower halts paving, wheel path section covered with plastic, primer coat on rut fill covered with sand and plastic for protection against the rain
	6:00 am	Rain shower passed, sand removed from rut fill section, primer is reapplied and paving resumes
	6:10 am	Paving completed on Lane 1
	10:15 am	Lane 1 overlay has attained required strength, traffic control being picked up.

Full Lane Inlay Section

Figure 12. Diamond grinding machine.

Figure 13. West end of full lane section.

Figure 14. Full lane inlay section.

Figure 15. HMWM prime coat being applied. Wheel path inlay section is in the background

Figure 16. Roller screed finished PPC.

Figure 17. Finished PPC after top dressing with aggregate.

Wheel Path Inlay Section

Figure 18. Diamond grinding wheel path inlay section.

Figure 19. End view of wheel path inlay section from full lane inlay section.

Figure 20. Side view of wheel path inlay section.

Figure 21. HMWM prime coat applied in wheel paths.

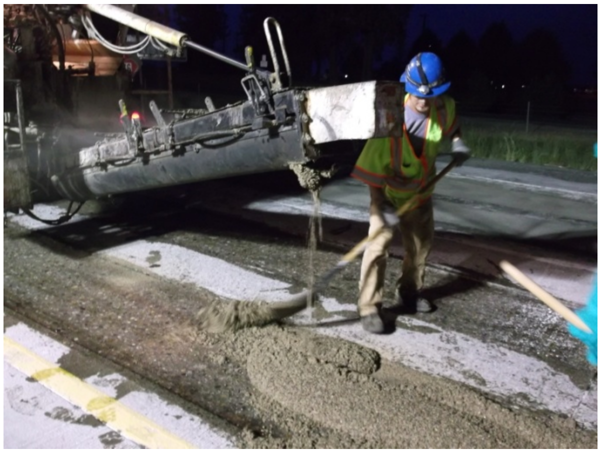

Figure 22. Placing PPC into wheel paths.

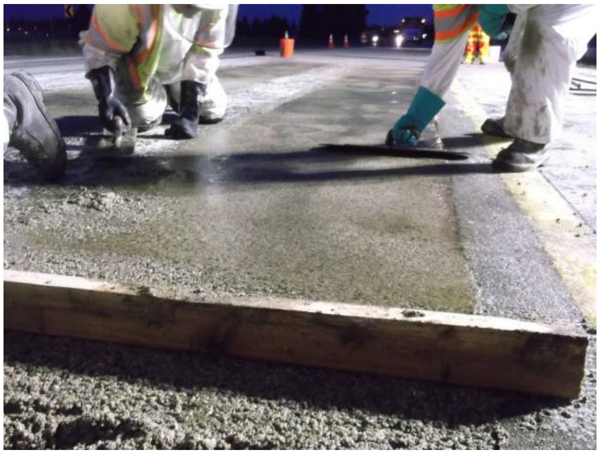

Figure 23. Using 2x4 to screed PPC.

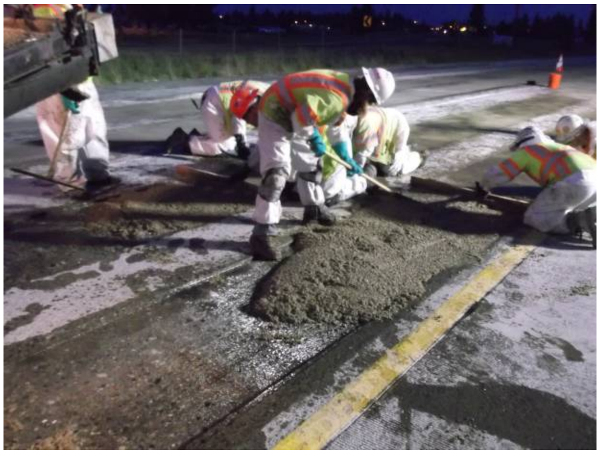

Figure 24. Spreading and striking off PPC in wheel path inlay section.

Figure 25. Final hand toweling of the wheel path inlay section.

Figure 26. Top dressing wheel path inlay section.

Figure 27. Finished wheel path section.

Rut Fill Section

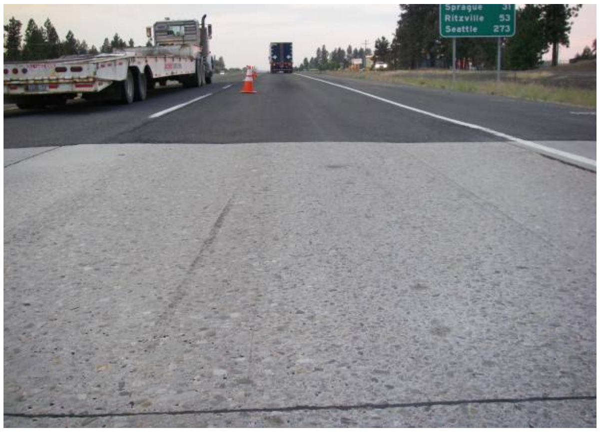

Figure 28. Rut fill section prior to overlay.

Figure 29. Close-up of rut fill section.

Figure 30. Amount of wear in rut fill section.

Figure 31. HMWM prime coat application.

Figure 32. Close-up of finished PPC prior to top dressing with aggregate.

Figure 33. Finished PPC in the rut fill section.

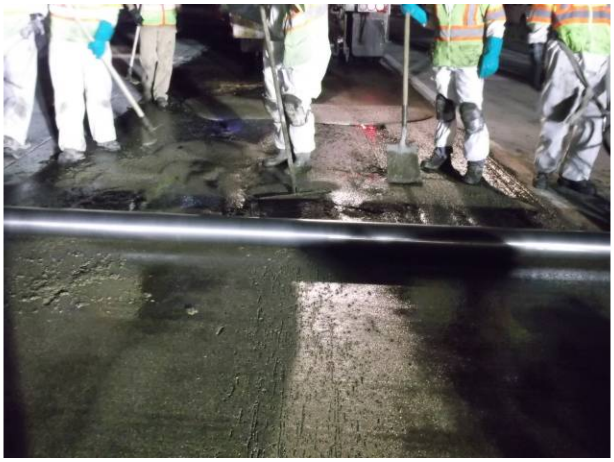

Figure 34. Distributing PPC in front of roller screed in rut fill section.

Figure 35. Finished rut fill section prior to application of top dressing.

Post-Construction Testing

The only testing performed on the finished PPC sections were Schmidt Hammer tests to determine if the compressive strength was adequate to open the lanes to traffic. The special provisions also state that all PPC that fails to achieve a minimum compressive strength of 3000 psi in six hours as verified by the rebound hammer was to be removed and replaced. The IDR's indicate that each of the lanes reached the required compressive strength and were open to traffic within the six hour window.

Photos of each of the sections taken approximately one month after construction are included as Figures 36 through 44. It appears that the inlay sections were more uniform in appearance than the rut fill section which looks streaky. The streaks are due to the roller screed dragging the sand between the wheel paths where the feathered rut fill day lighted at the center of the lane.

Full Lane Inlay Section

Figure 36. Both lanes of the full lane section of PPC.

Figure 37. Close-up of the full lane section of PPC.

Figure 38. Side view of both lanes of the full lane section of PPC.

Wheel Path Inlay Section

Figure 39. Close-up of wheel path inlay section of PPC.

Figure 40. Wheel path inlay section of PPC.

Figure 41. Side view of wheel path inlay section of PPC.

Rut Fill Section

Figure 42. End view of rut fill section of PPC.

Figure 43. End view of rut fill section of PPC.

Figure 44. Side view of both lanes of the rut fill section of PPC.

Post-Construction Diamond Grinding

Addendum No. 1 required that the finished surface of the PPC overlays conform to Section 6-02.3(10) of the WSDOT Standard Specifications which specifies no variations exceeding 1/8 inch under a 10-foot straight edge (Appendix D). It further states that after initial finishing the polyester overlay may require diamond grinding of rough areas. The entire surface of the overlay did not meet the 10-foot straight edge specification and as a result the Contractor diamond ground all three sections on October 18 and 19, 2012. The fact that the entire overlay had to be diamond ground is in contrast to other projects where the PPC has been applied to bridge decks which have not required grinding to achieve an acceptable ride. Figures 45 through 57 show the sections after the corrective action. While the completed diamond grinding provided an acceptable ride, Figure 58 shows an uneven transverse slope that was ground into the right wheel path for portions of the polyester concrete section. The uneven surface appears to have influenced WSDOT's periodic wear measurements that will be discussed under the Post Construction Testing section.

Full Lane Inlay Section

Figure 45. Full lane inlay section after diamond grinding.

Figure 46. Full lane inlay section after diamond grinding.

Figure 47. Close-up of full lane inlay section after diamond grinding.

Figure 48. Full lane inlay section after diamond grinding in foreground, other sections in background.

Figure 49. PPC texture of full lane inlay section after diamond grinding.

Wheel Path Inlay Section

Figure 50. Wheel path inlay section after diamond grinding.

Figure 51. Wheel path inlay section after diamond grinding.

Figure 52. Wheel path inlay section after diamond grinding.

Figure 53. Wheel path inlay section after diamond grinding.

Figure 54. Close-up of wheel path inlay section after diamond grinding.

Rut Fill Section

Figure 55. Rut fill section on the left, wheel path inlay section on the right after diamond grinding.

Figure 56. Rut fill section after diamond grinding.

Figure 57. Rut fill section after diamond grinding.

Figure 58. Wheel path inlay section after diamond grinding.

Cost

The actual cost of the trial installation would not be representative of costs to overlay extensive sections of mainline pavement due to the disproportionately high installation costs associated with the small material quantities used on the project. Discussions with Dan Uldall, KwikBond Polymers' representative, indicated that $10 per square foot is a reasonable price for PPC overlays of larger bridge decks. This cost includes mobilization and demobilization, shot blasting, and slip form paving. Dan also indicated that Caltrans has been aggressively pursuing the use of PPC for bridge deck rehabilitation and they are seeing costs reduced to as low as $7 per square foot.

Cost data for recent WSDOT PPC bridge deck overlays are similar to the data supplied by Dan Uldall. The cost of material and installation for five projects built between 2003 and 2007 ranged from $8.60 to $17.00 per square foot with a weighted average of $10.73 (source WSDOT Bridge Office).

The bid tabulation cost of the diamond grinding of the concrete pavement on the project was $11.00 per square yard or $1.22 per square foot.

Post-Construction Testing

Wear, ride and friction measurements were made over the 6-year monitoring period on both the polyester concrete test section and a one mile section of the diamond ground pavement from MP 275.58 to 276.59 located east of the polyester concrete done under the same contract.

Wear

Wear measurements were initiated in Spring of 2013 following the diamond grinding of the PPC to address the rough ride of the PPC. Table 5 provides the six years of measurements for both the PPC and Diamond Ground sections. The amount of wear on the PPC is similar to that of the adjacent concrete pavement diamond ground under the same project.

Table 5. Wear measurements in millimeters for the PPC and Diamond Ground sections.

Section/Lane	Spring 2013	Fall 2013	Fall 2014	Spring 2015	Fall 2016	Fall 2017	Fall 2018
Polyester L1	3.0	2.8	2.9	3.6	6.4	7.4	7.4
Polyester L2	2.0	2.5	2.6	3.0	2.4	5.1	5.1
Diamond Grinding L1	4.0	4.3	4.0	4.7	5.8	6.2	7.2
Diamond Grinding L2	3.0	3.2	3.6	3.3	3.4	4.3	4.4
Age (months)	9	13	24	33	50	62	73

Linear regression was used to estimate the rate of wear for the PPC and Diamond Ground sections. Figures 59 and 60 shows the plots for the average of both wheel paths in each lane for the PPC and Diamond Ground sections. Table 6 provides a summary for PPC and Diamond Ground section wear rates.

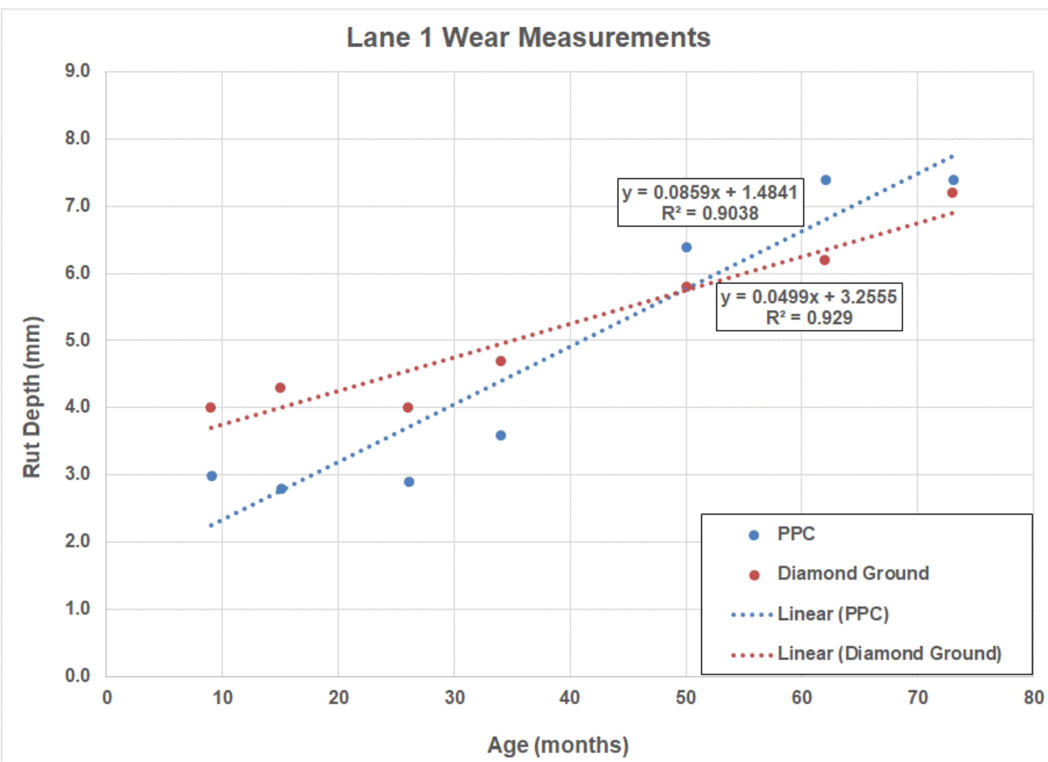

Figure 59. Lane 1 wear measurements for the PPC and Diamond Ground sections.

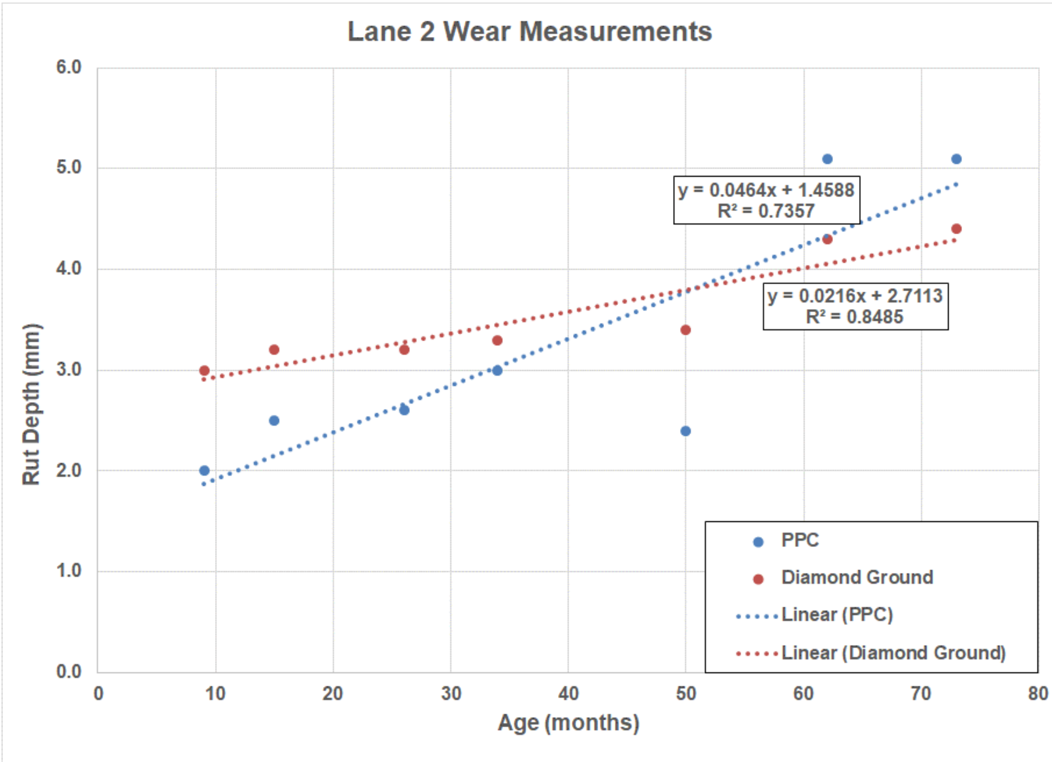

Figure 60. Lane 2 wear measurements for the PPC and Diamond Ground sections.

Table 6. Wear rates for the PPC and Diamond Ground sections.

Section/Lane	Wear Rate (millimeter per year)
PPC Lane 1	1.03
PPC Lane 2	0.56
Diamond Ground Lane 1	0.60
Diamond Ground Lane 2	0.26
Age (months)	73

Based on the measurements taken so far the wear rates for each lane on the PPC test section appears to be almost double that of the Diamond Ground test section. While the rate of wear appears to be greater in the PPC, additional years of testing will be necessary to determine whether the trend found in the first 73 months remains the same or if the wear rates even out for both the PPC and Diamond Ground sections.

Performance

Spalling of the PPC at joints or along the edges of the overlay is detrimental to long- term performance as are cracking or delaminations. Figures 58-63 show the condition of the PPC in September 2017, 62 months after it was installed.

Figure 61. Longitudinal view of the full lane mill and fill section. Note the absence of spalling at the transverse joints or along the longitudinal edges of the slabs. No cracking or delaminations are visible (September 27, 2017).

Figure 62. Longitudinal view of the wheel path mill and fill section. Note the sharp edges with no evidence of spalling of the PPC. No cracking or delaminations are visible (Sept. 27, 2017).

Figure 63. Longitudinal view of the section that was applied with a screed. No cracking or delaminations are visible (September 27, 2017)

Figure 64. Side view of the full lane mill and fill section. The discoloration has been present from day one. No cracking or delaminations are visible (September 27, 2017).

Figure 65. Side view of the wheel path mill and fill section. Note the sharp edges. The darker spots on the left wheel path appear to be polyester binder that overlapped the edges of the milled concrete. No cracking or delaminations are visible (September 27, 2017).

Figure 66. Side view of the section that was applied with a screed. No cracking or delaminations are visible (September 27, 2017).

The following set of photos from the WSPMS video from 2014 show no change in the foot prints of the three sections with no spalling or erosion at the edges of the PPC.

Figure 67. 2014 WSPMS views of the three PPC sections.

Ride

The ride measurements, Table 6, are difficult to interpret for the polyester concrete as the section seemingly gets rougher and smoother from one measurement to the next. Because the section is so short there are only three readings for each year’s measurements; therefore, one very high reading or low reading can greatly influence the average for the section as noted for the Spring 2015 and Fall 2018 PPC L2 readings. The difference in readings from year to year may also be due to whether the bump between the HMA and PPC is included in the measurement. The trend for the PPC can be generalized as increasing roughness initially and then a leveling over time to a fair IRI of 120 inches/mile. The ride on the Diamond Ground section is very good and has remained unchanged over the evaluation period.

Table 7. Ride measurements in IRI (inches per mile) for the PPC and Diamond Ground sections.

Section/Lane	Spring 2013	Fall 2013	Fall 2014	Spring 2015	Fall 2016	Fall 2017	Fall 2018
PPC L1	72	68	84	101	126	124	120
PPC L2	61	54	120	64	119	124	60
Diamond Ground L1	59	54	41	57	47	52	53
Diamond Ground L2	47	44	45	49	43	48	49
Age (months)	9	13	24	33	50	62	73

Friction

The fiction data from the polyester section is listed in Table 7. The PPC friction resistance is equal to or better than most conventional concrete pavements.

Table 8. Friction data.

Section/Lane	Fall 2016	Fall 2017
PPC L1	40.3	44.9
PPC L2	45.1	49.4
Age (months)	50	62

Observations

The PPC section is performing very well with no spalling, cracking or delamination noted after 6 plus years of service. The friction values are good and the ride, which was initially not acceptable, is in the good to fair range as compared to other concrete pavements. The wear per year of the PPC is currently higher than the wear per year for the adjacent concrete, however, additional years of testing will be necessary to determine if the rates of wear remain the same.

Recommendations/Conclusions

- PPC appears to be an option to fill ruts in concrete pavements particularly where diamond grinding is not a solution.
- Provisions should be provided to diamond grind PPC repairs if smoothness requirements are not met.

Appendix A

WSDOT PPC Bridge Deck Overlay Performance

Table 9. WSDOT bridges with polyester concrete overlays.

Bridge Number	Bridge Name	Year Built	Length (ft.)	Width curb-curb (ft.)	Deck Area (sf)	County Name	ADT	Lanes	Milepost	Overlay Year	Polyester Overlay Condition
005/539E	NB VIADUCT STA 2085	1966	5,825	70	407,750	King	110,940	5	163.24	2007	Excellent
005/503E	SR 18 OC	1959	206	100	20,600	King	86,972	6	142.00	2007	Excellent
005/503W	SR 18 OC	1959	213	100	21,800	King	86,972	6	142.00	2007	Excellent
005/504E	S 336TH ST OC	1959	198	80	15,840	King	80,016	5	142.79	2006	Excellent
005/504W	S 336TH ST OC	1959	156	80	12,480	King	80,016	5	142.79	2005	Fair
005/506E	MILITARY RD OC	1959	299	73.4	14,607	King	87,063	5	144.65	2005	Very Good
005/509E	SR 524 (44TH AVE W) OC	1963	245	68	16,660	Snohomish	83,830	4	180.71	2003	Very Good
005/593W	NE 155TH ST OC	1964	147	68	9,996	King	97,290	4	175.11	2003	Excellent
005/595W	NE 175TH ST OC	1964	163	63.5	10,350	King	87,401	4	176.13	2003	Excellent
005/456W	PUYALLUP R BR SR 167 OC	1962	1,455	57	82,935	Pierce	93,429	5	135.17	2003	Very Good
005/588W	NORTHGATE WAY OC	1964	166	72	11,952	King	93,899	5	172.76	2003	Excellent
522/030E-N	E-N RAMP BR	1968	210	30	6,300	King	606	1	11.10	2003	Very Good
005/593E	NE 155TH ST OC	1964	147	76	11,172	King	97,290	5	175.11	2002	Excellent
005/595E	NE 175TH ST OC	1964	163	63.5	10,350	King	87,401	4	176.13	2002	Excellent
005/588E	NORTHGATE WAY OC	1964	166	72	11,952	King	93,899	5	172.76	2002	Excellent
195/034	BDRR (ABANDONED) OC (GN)	1958	193	31.5	6,080	Whit.	4,704	2	48.45	1991	Fair
303/012	PORT WASHINGTON CS1940	1958	1,717	55	94,435	Kitsap	40,253	4	0.73	1991	Good
0099/500	SR518 OC RIVERTON HTS	1962	324	65	21,060	King	30.167	5	20.38	1991	Very Good
520/016	108TH AVE NE OC	1966	271	141.8	38,428	King	78,929	7	6.27	1991	Very Good
509/123	GLENDALE WAY OC	1968	200	94	18,800	King	49,302	5	27.85	1991	Very Good
002/233A	WENATCHEE R	1957	317	26	8,242	Chelan	4,100	2	111.09	1990	Good
018/031N	HOLDER CR HOBART RD OC	1961	304	40.3	12,251	King	9,000	2	20.34	1989	Fair
012/068	GIBSON CR	1937	189	24	4,536	Grays Harbor	4,594	2	29.93	1989	Chip Sealed in 2000

Appendix B

KwikBond Product Data Sheets

BRIDGE DECK & ROADWAY REHABILITATION SYSTEMS

923 Teal Drive
Benicia, California 94510

(866) 434-1772
(707) 746-7981 Fax
contact@kwikbondpolymers.com

PRODUCT DATA SHEET: PPC™ — 1121 MM MIX

PRODUCT DESCRIPTION

PPC™ - 1121 MM is Kwik Bond's polyester-based polymer overlay and patching system designed to meet Oregon DOT and Washington DOT specifications. It is specifically designed to seal bridge deck surfaces, develop high mechanical strengths, have the ability to pave variable depth cross sections, and return traffic quickly. PPC™-1121 MM achieves over 4000 psi in compressive strength within 24 hours as well as over 800 psi in tensile strength. Because of its strength gain curve, traffic can be safely returned within 1.5-3 hours at temperatures of down to 40 F. In direct adhesion testing to Portland cement concrete used for bridge deck applications, the failure mode is cohesion within the Portland cement concrete.

PPC™ -1121 has the following performance advantages:

- PPC™ - 1121 MM conforms to all WSDOT and ODOT specifications for polyester polymer concrete
- PPC™ - 1121 has high strength properties in both compression and tensile
- PPC™ - Binder Resin has a long history of performance (In use since 1983)
- PPC™ - 1121, when mixed and applied properly, can return traffic safely within 1.5-3 hours.

For today's congested bridges and highways, PPC™ - 1121 MM is the right material for patching, repairing, and rehabilitating Portland cement concrete, latex modified concrete, or silica fume modified concrete.

SPECIAL FEATURES

- Low viscosity for easy mixing
- KBP 204 "healer/sealer" primer re-bonds cracks in Portland cement concrete base and promotes adhesion to the polyester polymer concrete
- Traffic can be returned within 2 hours of finishing
- Superior adhesion to Portland cement concrete, latex modified concrete, silica fume concrete even under damp conditions

PHYSICAL PROPERTIES	
PPC™ Binder Resin (32-043-15)	
Weight per gallon(resin binder only)	9.0-9.4 lbs./gal.
Viscosity	75-200 cps
Flash Point (Seta flash)	90 F
Adhesion (Cal-Trans Test Method 551)	>500 psi
Tensile Strength (ASTM D-638, ¼" specimen)	>2500 psi
Tensile Elongation (ASTM D-638, ¼" specimen)	35%, min.
Meets CARB	
Styrene content	40-50%

TYPICAL AGGREGATE GRADATION*	
Screen Size	% Passing
**3/8"	100
**No. 4	70
No. 8	60
No. 16	40
No. 30	25
No. 50	10
No. 100	0-2
No. 200	T

PHYSICAL PROPERTIES-PPC™ 1121MM	
Compressive Strength (ASTM C-39) 7 days at Room Temperature	7000 psi
Tensile Strength (ASTM C-307)-PPC™-system)	800 psi
Cured Density (ASTM C905)	135-lbs./ cu. ft

*Combined average moisture absorption of the aggregates is less approximately 1.2%. Crushed aggregate particle retained on the No. 8 screen and above is less than 45%.
** Aggregate from Washington State Approved PIT 335

SURFACE PREPARATION

Shot-blasting, sandblasting, scarifying, chipping, or other cleaning processes are required to provide proper surface preparation for a long-lasting polymer overlay and/or patching system. The final surface should be clean, free of oils, dirt, curing compounds, and other materials that may affect the adhesion of the polymer system. Unsound concrete areas should be located by using a chain-drag or hammer. The unsound areas must be removed until a sound concrete base is established.

Patch all unsound bridge deck concrete with KBP ***Easy Patch***. Patches can be filled to 3" depth and more. Areas up to 5' x 5' can be patched deep without, normally, impacting stiffness of the PCC bridge deck. Design engineers should consider the semi-rigid nature of Polyester Polymer Concrete in those calculations. If design factors require a rigid patch system, utilize high alumina concrete patch systems. Properly placed high alumina concrete patch systems may be overlayed with PPC 24 hours after placement.

Note: For patching PCC on-grade pavement, joint must be isolated using polyethylene foam or equivalent material. The integrity of the joint must be maintained. Transverse cracks, typically, behave as joints and must be isolated from one side of the crack to the other. Accomplishing that task may be difficult since PCC behaves as a crystal and will follow a three-dimensional plane, difficult to observe from the surface.

PPC™ 1121 SYSTEM INSTALLATION

KBP 204 Primer: Mix 1 gallon KBP 204 "healer/sealer" primer with 3 fluid ounces of 6% Cobalt Drier (Dark Blue Material). Stir for 10 seconds. Add 3 fluid ounces of Cumene Hydro Peroxide and stir for another 30 seconds. Immediately dump the entire pail contents onto the PCC surface Application rate ranges from 70-100 sf/gal depending on porosity and surface texture of the deck. Re-distribute the primer using a paint brush for small area or rollers, squeegees, brooms for larger areas, wet-out the entire surface of the area to be repaired. KBP 103/204 is very fluid and will wet the surface quickly. The excess will rapidly build-up at the lowest points in the prepared area. Excess primer is undesirable. Apply primer carefully to have as little excess build-up as possible. Some build-up is unavoidable. Note: This mix design represents a starting point for anticipated temperatures of 70 F during daytime conditions. Modifications may be required for working under different temperature conditions or during night time application. For very warm temperatures, night time application should be considered. Reducing CHP levels to 1 fl oz per gallon during elevated temperatures should be evaluated. During cold night time application, both catalyst and accelerator concentrations will need to be increased.

PPC™ -1121 MM Mix: To a clean 9 cubic foot mortar mixer, add 4 gallons of PPC Binder Resin. Add 7-12 fl oz of DDM 9(MEKP). ***Note: for faster strength gain at low temperatures add .1-.4% Z Cure accelerator to resin.*** While mortar mixer is turning with PPC Binder Resin™ and catalyst, add 2-50 lb bags of A-3038 rock and 4-50 lb bags of B-11 sand. Rock can be added first to reduce mixer splashing. Mix for 2 minutes depending on temperature. Dump catalyzed patching compound into a wheelbarrow or similar transfer device. Immediately recharge mixer with proper volume of PPC Binder Resin™. Continue mixing procedure ONLY if crew is ready for another mix. The agitating mortar mixer with Binder Resin™ only, without catalyst, will keep your mixer clean and reduce build-up. Mix design modifications are required for changes in temperature or nighttime application. Higher or lower catalyst additions may be required for meeting traffic control requirements. Temperature and application timing have a definite effect upon set time of the polyester polymer concrete and the ultimate return to service.

Volumetric mixers may also be utilized for high output applications. The utilization of volumetric equipment is almost essential for projects requiring rapid return to surface on major Interstate projects.

FINISHING

Mixed PPC™ 1121 MM material is placed utilizing a vibratory strike off screed or a slip form paving machine. For small areas an aluminum straight edge or a vibrastrike screed may be acceptable to develop appropriate surface finish and compaction. After strike-off to final surface grade, apply topping sand in slight excess plus mechanically texture the surface utilizing spring steel tines 1/8" deep spaced ¾"-1" apart. Typical work time is 30 minutes. UV light accelerates the set time. PPC™- 1121 MM is best used at temperatures between 40-90F. Adjustments to catalyst types and concentrations are necessary when working outside the optimum temperature range. Trial batches are required to determine work times and set time based on anticipated application temperatures, conditions, and lane closure timing.

STANDARD PACKAGING

- PPC Binder Resin™ 4 gal pail, 55 gal drum, 4400 gal tank truck
- B-11 Sand-50 lb bags, 2 ton Super Sacks
- A-3038 Rock- 30 lb bags, 1.5 ton Super Sacks
- Top Sand 10 x 30- 50 lb bags
- DDM-9- 1 gallon bottles
- KBP 103/204 primer- available in 4 gallon pails 50 gallon drums, 250 gallon Tote Tanks
- 6% Cobalt Drier- available in pre-packaged bottles, 1-gallon cans, 4 gallon pails
- Cumene Hydro Peroxide- available in 1-gallon bottles, or 4-gallon cases
- Z Cure- pre-packaged bottles, 1 gal cans, 5 gal bottle

SAFETY

PPC™ 1121 MM system consists of polymer materials that have been used safely for over 20 years. However, there are certain safety issues that need to be readily understood. PPC™ Binder Resin is FLAMMABLE! NO SMOKING is allowed! Fire extinguishers must be available as well as plans for emergency situations. Emergency situations are unlikely, but preparation is always SMART!

The KBP 103/204 primer is a three-component system. The 6% Cobalt Drier and the Cumene Hydro Peroxide are INCOMPATIBLE materials. They must NEVER be mixed together by themselves! A FLASH FIRE WILL OCCUR! To safely mix the KBP 103/204 primer, follow the mixing instructions EXACTLY! Follow the mixing instructions outlined in this product data sheet and safety will be maintained.

For emergency situations, always have available clean water for accidental contact in the eyes, fire extinguishers, and emergency center addresses, phone numbers.

Wear protective clothing, eye protection, and chemical resistant gloves. Organic vapor respirators are not normally required. For individuals highly sensitive to chemical vapors, organic vapor respirators are suggested.

STORAGE

Aggregates, PPC™ Binder Resin, and KBP 103/204 should be stored in a cool, dry location and in their original containers. The shelf life for these materials stored at temperatures 80 F and below is 12 months. PPC™ Binder Resin and KBP 103/204 contain reactive polymers. At elevated temperature, storage shelf life is reduced. Store all bagged aggregates in a clean, dry location away from moisture. Aggregates must absolutely be protected from any moisture.

KWIKBOND POLYMERS

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BRIDGE DECK & ROADWAY REHABILITATION SYSTEMS

PRODUCT DATA SHEET: PPC™ — 1121 FINE MIX

PRODUCT DESCRIPTION

PPC™ - 1121 is Kwik Bond's polyester-based overlay and patching system designed to meet Oregon DOT and Washington DOT specifications. It is specifically designed to seal bridge deck surfaces, develop high mechanical strengths, have the ability to pave variable depth cross sections, and return traffic quickly. PPC™-1121 achieves over 4000 psi in compressive strength within 24 hours as well as over 800 psi in tensile strength. Because of its strength gain curve, traffic can be safely returned within 2 hours at temperatures of down to 40 F. In direct adhesion testing to Portland cement concrete used for bridge deck applications, the failure mode is cohesion within the Portland cement concrete.

PPC™ -1121 has the following performance advantages:

- PPC™ - 1121 conforms to all WSDOT and ODOT specifications for polyester polymer concrete
- PPC™ - 1121 has high strength properties in both compression and tensile
- PPC™ - Binder Resin has a long history of performance (In use since 1983)
- PPC™ - 1121, when mixed and applied properly, can return traffic safely within 1.5-3 hours.

For today's congested bridges and highways, PPC™ - 1121 is the right material for patching, repairing, and rehabilitating Portland cement concrete, latex modified concrete, or silica fume modified concrete.

SPECIAL FEATURES

- Low viscosity for easy mixing
- KBP 204 "healer/sealer" primer re-bonds cracks in Portland cement concrete base and promotes adhesion to the polyester polymer concrete
- Traffic can be returned within 2 hours of finishing
- Superior adhesion to Portland cement concrete, latex modified concrete, silica fume concrete even under damp conditions

kwikbondpolymers.com

PRODUCT DATA SHEET: PPC™ – 1121 FINE MIX KWIK BOND POLYMERS, LLC

PHYSICAL PROPERTIES	
PPCTM Binder Resin (32-043-15)	
Weight per gallon (resin binder only)	9.0-9.4
Viscosity	75-200 cps
Flash Point (Seta flash)	90 F
Adhesion (Cal-Trans Test Method 551)	>500 psi
Tensile Strength (ASTM D-638, ¼")	>2500 psi
Tensile Elongation (ASTM D-638, ¼")	35%, min.
Meets CARB	
Styrene content	40-50%

TYPICAL AGGREGATE GRADATION*	
Screen Size	% Passing
No. 4	100
No. 8	98
No. 16	60
No. 30	35
No. 50	21
No. 100	5
No. 200	T

*Combined average moisture absorption of the aggregates is less approximately 1.2%.
Crushed aggregate particle is less than 45%.

SURFACE PREPARATION

Shot-blasting, sandblasting, scarifying, chipping, or other cleaning processes are required to provide proper surface preparation for a long-lasting polymer overlay and/or patching system. The final surface should be clean, free of oils, dirt, curing compounds, and other materials that may affect the adhesion of the polymer system. Unsound concrete areas should be located by using a chain-drag or hammer. The unsound areas must be removed until a sound concrete base is established.

Patch all unsound bridge deck concrete with KBP *Easy Patch*. Patches can be filled to 3" depth and more. Deep areas up to 5' x 5' can be deep without normally impacting stiffness of the PCC bridge deck. Design engineers should consider the semi-rigid nature of Polyester Polymer Concrete in those calculations. If design factors require a rigid patch system, utilize high alumina concrete patch systems. Properly placed high alumina concrete patch systems may be overlayed with PPC 24 hours after placement.

PPC™ 1121 SYSTEM INSTALLATION

KBP 204 Primer: Mix 1 gallon KBP 204 "healer/sealer" primer with 3 fluid ounces of 6% Cobalt Drier (Dark Blue Material). Stir for 10 seconds. Add 3 fluid ounces of Cumyl Hydro Peroxide and stir for another 30 seconds. Immediately empty the entire pail contents onto the PCC surface. Application rate ranges from 70-100 sf/gal depending on porosity and surface texture of the deck. Re-distribute the primer using a paint brush for small area or rollers, squeegees, brooms for larger areas, wet-out the entire surface of the area to be repaired. KBP 103/204 is very fluid and will wet the surface quickly. The

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PRODUCT DATA SHEET: PPC™ – 1121 FINE MIX KWIK BOND POLYMERS, LLC

excess will rapidly build-up at the lowest points in the prepared area. Excess primer is undesirable. Apply primer carefully to have as little excess build-up as possible. Some build-up is unavoidable. Note: This mix design represents a starting point for anticipated temperatures of 70 F during daytime conditions. Modifications may be required for working under different temperature conditions or during night time application. For very warm temperatures, night time application should be considered. Reducing CHP levels to 1 fl oz per gallon during elevated temperatures should be evaluated. During cold night time application, both catalyst and accelerator concentrations will need to be increased.

PPC™-1121 Fine Mix: To a clean 9 cubic foot mortar mixer, add approximately 5.3 gallons of PPC Binder Resin. (This will yield 16% resin content. The range for this mix should be 14.5-17.5% resin or 4.8 - 5.8 gallons of resin per 300lb of B-11 sand) Add approx 11 fl oz of DDM 9(MEKP). Note: for faster strength gain at low temperatures add 0.1-0.4% Z Cure accelerator to resin. While mortar mixer is turning with PPC Binder Resin™ and catalyst, add 6-50 lb bags of B-11 sand. Rock can be added first to reduce mixer splashing. Mix for 2 minutes depending on temperature. Empty catalyzed patching compound into a wheelbarrow or similar transfer device. Immediately recharge mixer with proper volume of PPC Binder Resin™. Continue mixing procedure ONLY if crew is ready for another mix. The agitating mortar mixer with Binder Resin™ only, without catalyst, will keep your mixer clean and reduce build-up. Mix design modifications are required for changes in temperature or nighttime application. Higher or lower catalyst and or accelerator additions may be required for meeting traffic control requirements. Temperature and application timing have a definite effect upon set time of the polyester polymer concrete and the ultimate return to service.

Volumetric mixers may also be utilized for high output applications. The utilization of volumetric equipment is almost essential for projects requiring rapid return to surface on major Interstate projects.

FINISHING

Mixed PPC™ 1121 Fine material is placed utilizing a vibratory strike off screed, a slip form paving machine, or standard hand finishing tools for smaller patches. For small areas an aluminum straight edge or a vibrastrike screed may be acceptable to develop appropriate surface finish and compaction. After strike-off to final surface grade, apply topping sand in slight excess plus mechanically texture the surface utilizing spring steel tines 1/8" deep spaced ¼"-1" apart. Typical work time is 30 minutes. UV light accelerates the set time. PPC™- 1121 is best used at temperatures between 40-90F. Adjustments to catalyst and concentrations are necessary when working outside the optimum temperature range. Trial batches are required to determine work times and set time based on anticipated application temperatures, conditions, and lane closure timing.

STANDARD PACKAGING

- PPC Binder Resin™ 4 gal pail, 55 gal drum, 4400 gal tank truck
- B-11 Sand-50 lb bags, 2 ton Super Sacks
- Top Sand 10 x 30- 50 lb bags
- DDM-9- 1 gallon bottles

kwikbondpolymers.com

PRODUCT DATA SHEET: PPC™ — 1121 FINE MIX

KWIK BOND POLYMERS, LLC

- KBP 103/204 primer- available in 4 gallon pails 50 gallon drums, 250 gallon Tote Tanks
- 6% Cobalt Drier- available in pre-packaged bottles, 1-gallon cans, 4 gallon pails
- Cumyl Hydro Peroxide- available in 1-gallon bottles, or 4-gallon cases
- Z Cure- pre-packaged bottles, 1 gal cans, 5 gal bottle

SAFETY

PPC™ 1121 system consists of polymer materials that have been used safely for over 20 years. However, there are certain safety issues that need to be readily understood. PPC™ Binder Resin is FLAM- MABLE! NO SMOKING is allowed! Fire extinguishers must be available as well as plans for emergency situations. Emergency situations are unlikely, but preparation is always SMART!

The KBP 103/204 primer is a three-component system. The 6% Cobalt Drier and the Cumyl Hydro Peroxide are INCOMPATIBLE materials. They must NEVER be mixed together by themselves! A FLASH FIRE WILL OCCUR! To safely mix the KBP 103/204 primer, follow the mixing instructions EXACTLY! Follow the mixing instructions outlined in this product data sheet and safety will be maintained.

For emergency situations, always have available clean water for accidental contact in the eyes, fire extinguishers, and emergency center addresses, phone numbers.

Wear protective clothing, eye protection, and chemical resistant gloves. Organic vapor respirators are not normally required. For individuals highly sensitive to chemical vapors, organic vapor respirators are suggested.

STORAGE

Aggregates, PPC™ Binder Resin, and KBP 103/204 should be stored in a cool, dry location and in their original containers. The shelf life for these materials stored at temperatures 80 F and below is 12 months. PPC™ Binder Resin and KBP 103/204 contain reactive polymers. At elevated temperature, storage shelf life is reduced. Store all bagged aggregates in a clean, dry location away from moisture. Aggregates must absolutely be protected from any moisture.

Appendix C

Contractor's Paving Plan

Paving Plan
I-90 Vic Geiger Road to Spokane Viaduct
WashDOT

American
Civil
Constructors

Paving Plan for the
I-90 Rut Fill- Vic Geiger Road to Spokane Viaduct
WashDOT

Prepared By: ACC West Coast, Inc.

Purpose:

This plan is provided, in accordance with Contract Provisions section 5-01, to describe the equipment, material, manpower and working procedure for constructing a polyester concrete overlay/infill section with methacrylate prime coat on I-90 between Vic Geiger Road and Spokane viaduct.

Equipment:

Polyester Mobile Mixers:
ACC's Polyester mobile mixers are custom built by our mechanics and engineers. A typical concrete mobile mixing truck is modified to hold two large containers for sand and gravel, a 500-gallon tank for Polyester resin, a 15-gallon tank for initiator and a 10-foot mixing auger screw/chute. Each mobile mixer is equipped with a metering device that automatically measures and records volumes and the corresponding resin volumes.

Shotblaster:
Acme Concrete will be providing shotblasting of the surface to be overlaid prior to placement.

Manpower:

Polyester Mixing Crew:
The mixing crew is in charge of loading the polyester mixers with sand and gravel, polyester resin and admixtures at the staging area away from the job site. This crew will consist of approximately 2 workers.

Polyester Paving Crew:
The polyester paving crew is in charge of applying the Methacrylate prime coat to the work area, setting up and operating the polyester mixer, setting up and form for cross section E and pouring and finishing the polyester concrete and installing the joint seal. This crew will consist of approximately 9 workers (from ACC and Acme). For the paving operation, there will be 1 skilled operator with experience operating polyester equipment (who will operate the mobile mixer) as well as one skilled foreman in charge of mixing the methacrylate prime coat and coordinating the placement operation.

Polyester Concrete Paving Procedure:

This project consists of placing polyester concrete into 3 different trial sections utilizing 2 different mix designs. A sand mix or screed fill mix (PPC 1121 MM Fine) will be used in the trial section shown by cross section A and B. A rock/sand polyester concrete mix (PPC 1121 MM) will be used in the other section which will be ground out prior to placement. The methacrylate will only be placed in the area to where each paving pass is being placed at a time. Each lane on this project has an approximate 12-foot from centerline of the traveled way.

The paving procedure will be as follows:

Paving Operation:

1) The prime contractor (Acme) will grind the inlay areas in cross sections C-E and perform the shotblasting of the treated area to prepare for polyester placement one or more shifts in advance of the polyester placement.
2) All drains, inlets, manholes etc. will be covered with a layer of plastic sealed with duck tape to prevent any shot blasting material, HMWM resin, or PPC mixture from entering foreign bodies.
3) Edges or detail areas inaccessible to shotblasting will be prepped with sandblasting prior to placement.
4) A 1" inch form will be secured along the edge of placement in section E to contain polyester concrete on the first lane to be installed.
5) Immediately prior to placement the area to be treated will be blown off by high pressure air.
6) A Methacrylate resin will be used as the prime coat for the bridge deck and will be placed a minimum of 30 minutes before placing PPC. A sample point of material will be set aside. Methacrylate will be placed using squeegees or rollers before placing the polyester overlay. Methacrylate primer will be placed on the area at a rate of 75-100 SF per gallon. All Methacrylate is placed the same shift as the polyester concrete is placed.
7) Once the Methacrylate is applied to the area, the polyester mixer and rolling finisher will be placed in position.
8) One operator will work behind the mobile mixer controlling the rate of polyester concrete dispensing from the auger chute and checking the consistency of the polyester concrete mix. Two workers will be shoveling and guiding the polyester concrete into place.
9) A rolling tube finisher (bunyan) will be used to place, compact and strike off the polyester concrete in the inlay areas and the screed fill section. At least two workers will be in charge of watching the grade of the polyester concrete and guiding the finishing tube.
10) Finally, two or three workers will work at least 10 feet behind the tube finisher repairing minor divots, hand finishing the edges and applying sand surface treatment at a rate of 1.8 pounds per square yard.
11) Each lane will be placed in a single night moving in the direction of traffic.
12) A Schmidt Hammer will be used to determine when to open traffic after cure of the polyester concrete. Sawcutting of existing paving joints will take place following initial cure.

Curing:

No vehicles or personnel will be allowed to travel on the finished polyester concrete overlay during the curing process. After placement, a 30 to 90 minute set time will be produced by implementing initiators. Depending on environmental conditions such as weather, accelerators or inhibitors may be added to the mix to help produce the specified cure time. ACC will utilize a Schmidt Hammer to determine the proper time to open the roadway to traffic. In order to open the roadway to traffic, a 3,000 psi reading on the rebound hammer will be achieved in order to open to traffic. Prior to placing polyester, the rebound hammer (Schmidt Hammer) will be calibrated onsite in conformance to ASTM C805.

Trial Overlay:
The trial overlay for the project will be placed at Acme's yard in Airway Heights. Pull off tests per specification will be taken 12 hours later to confirm bond strength.

Appendix D

Addendum No. 1 and Contract Special Provisions

Department of Transportation
Spokane, Washington 99207

September 23, 2010

ATTENTION: All Bidders and Planholders

I-90
VIC GEIGER RD TO SPOKANE VIADUCT
PCCP REHAB
F .A. No. IM-0906(225)

Addendum No. 1

The Special Provisions for this project are amended as follows:

Special Provisions
1. Page 135, line 9 through page 136, line 41 are deleted and replaced with the following:

(BSP January 4, 2010)
Materials for Polyester Concrete
Polyester Resin Binder
The resin shall be an unsaturated isophthalic polyester-styrene co-polymer.

Prior to adding the initiator, the resin shall conform to the following requirements:

Viscosity:	75 to 200 cps (20 rpm at 77F, RVT No.1 spindle)	ASTM D 2196
Specific Gravity:	1.05 to 1.10 at 77F	ASTM D 1475
Styrene Content:	45% to 50% by weight of polyester styrene resin	ASTM D 2369

After adding the initiator, the resin shall conform to the following requirements:

Elongation:	35% minimum *w/* thickness 0.25" ± 0.04"	ASTM D 638
Tensile Strength:	2,500 psi minimum *w/* thickness 0.25" ± 0.04"	ASTM D 638
Conditioning:	18 hours/77F/50%+ 5 hours/158F	ASTM D 618
Silane Coupler:	1.0% minimum (by weight of polyester-styrene resin)	

The silane coupler shall be an organosilane ester, gammamethacryloxypropyltrimethoxysilane. The promoter/hardeners shall be compatible with suitable methyl ethyl ketone peroxide (MEKP) and cumene hydroperoxide (CHP) initiators.

Note: This set of plans and specifications does not have this addendum incorporated in it.
Acknowledge of receipt of this addendum is required.

MEKP initiators shall be used when the surrounding concrete temperatures are above 60F. A blend of initiators may be used as approved by the Engineer when the surrounding concrete temperature is 50F to 60F.

Polyester resin binder will be accepted based on submittal to the Engineer of a Manufacturer's Certificate of Compliance conforming to Section 1-06.3.

High Molecular Weight Methacrylate (HMWM) Resin
In addition to the viscosity and density properties, and the promoter/initiator system, already specified in this Section, the HMWM resin for polyester concrete overlays shall conform to the following requirements:

Flash Point:	180F minimum	ASTM D 3278
Tack-Free Time:	400 minutes maximum	California Test 551

Prior to adding initiator, the HMWM resin shall have a maximum volatile content of 30 percent, when tested in conformance with ASTM D 2369.

HMWM resin will be accepted based on submittal to the Engineer of a Manufacturer's Certificate of Compliance conforming to Section 1-06.3.

Aggregate
The aggregate shall be from Washington State Pit Site B-335 located near Steilacoom, Washington and shall be thoroughly washed and kiln dried.

The aggregate shall conform to Section 9-03, and one of the following combined aggregate gradings:

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

Aggregate retained on the U.S. NO. 8 sieve shall have a maximum of 25 percent crushed particles. Fine aggregate shall consist of natural sand only.

Aggregate absorption shall not exceed 1.0 percent. The moisture content of the aggregate shall not exceed one half of the aggregate absorption at the time of mixing with the polyester resin binder. The aggregate temperature shall be between 45F and 100F at the time of mixing.

Sand for Abrasive Finish
The sand for abrasive finish shall conform to Section 6-09.2, and the aggregate moisture content requirements specified above.

2. Page 136, line 46 through page 140, line 19 are deleted.
3. Page 145, line 41 through 43 are deleted and replaced with the following:

(BSP August 1, 2005)
Finishing Polyester Concrete Overlay

The finished surface of the polyester concrete overlay shall conform to Section 6-02.3(10).

The polyester concrete shall be struck off to the established grade and cross section and consolidated to the required compaction. No further texturing and grooving of the finish overlay surface will be required. Forms shall be coated with suitable bond release agent to permit ready release of forms.

The polyester concrete overlay shall receive an abrasive sand finish. The sand finish shall be applied immediately after overlay strike-off and before gelling occurs.

The surface texture of polyester concrete surface shall be uniform and shall have a friction number of not less than 35 as determined by ASTM E 274.

After initial finishing, the polyester overlay may require grinding of rough areas as determined by the Engineer. The grinding shall be done in a manner that will not damage the existing bridge deck. Rotary milling machines are not allowed.

The Contractor shall demonstrate to the satisfaction of the Engineer that the method and equipment for grinding the polyester overlay are adequate for the intended purpose and will provide satisfactory results. The removal shall not commence until the Contractor receives the Engineer's approval of the grinding equipment.

The bridge deck areas specified by the Engineer to receive grinding shall be ground in a longitudinal direction. The grinding equipment shall use diamond tipped saw blades mounted on a power driven, self-propelled machine that is specifically designed to texture concrete surfaces. The grinding equipment shall have a blade spacing to provide grooves that are between 0.10 and 0.15 inches wide. The land area between the grooves shall be approximately 0.125 inches.

The Contractor shall contain, collect, and dispose of all concrete debris generated by the grinding operation in accordance with Item 2 of the polyester concrete submittal in Section 6-09.3(2) as supplemented in these Special Provisions.

Prior to opening the overlay area to vehicular traffic the finished overlay shall be power swept to remove excess loose aggregate and abrasive sand. The Contractor shall demonstrate to the satisfaction of the Engineer that the power broom equipment will not damage the finished overlay. Any damage to the finished overlay caused by the power broom shall be repaired at no additional expense to the Contracting Agency.

4. Page 147, line 38 and 39 are revised to read:

(******)
"Polyester Concrete Overlay ______", per square yard.
The unit contract price per square yard for "Polyester Concrete Overlay___" shall be full pay.

Bidders shall furnish the Secretary of Transportation with evidence of receipt of this Addendum. This addendum will be incorporated in and made a part of the contract when awarded and when formally executed.

Keith A. Metcalf, P.E.
Regional Administrator

DIVISION 5
SURFACE TREATMENTS AND PAVEMENTS
CEMENT CONCRETE PAVEMENT REHABILITATION

Materials

Section 5-01.2 is supplemented with the following:

(BSP January 4, 2010)
Polyester Concrete
Polyester Resin Binder
The resin shall be an unsaturated isophthalic polyester-styrene co-polymer.

Prior to adding the initiator, the resin shall conform to the following requirements:

Viscosity:	75 to 200 cps (20 rpm at 77F, RVT No.1 spindle)	ASTM D 2196
Specific Gravity:	1.05 to 1.10 at 77F	ASTM D 1475
Styrene Content:	45% to 50% by weight of polyester styrene resin	ASTM D 2369

After adding the initiator, the resin shall conform to the following requirements:

Elongation:	35% minimum *w/* thickness 0.25" ± 0.04"	ASTM D 638
Tensile Strength:	2,500 psi minimum w/ thickness 0.25" ± 0.04"	ASTM D 638
Conditioning:	18 hours/77F/50% + 5 hours/158F	ASTM D 618
Silane Coupler:	1.0% minimum (by weight of polyester-styrene resin)	

The silane coupler shall be an organosilane ester, gammamethacryloxypro-pyltrimethoxysilane. The promoter/hardeners shall be compatible with suitable methyl ethyl ketone peroxide (MEKP) and cumene hydroperoxide (CHP) initiators. MEKP initiators shall be used when the surrounding concrete temperatures are above 60F. A blend of initiators may be used as approved by the Engineer when the surrounding concrete temperature is 50F to 60F.

Polyester resin binder will be accepted based on submittal to the Engineer of a Manufacturer's Certificate of Compliance conforming to Section 1-06.3.

High Molecular Weight Methacrylate (HMWM) Resin
In addition to the viscosity and density properties, and the promoter/initiator system, specified in Section 6-09.2, the HMWM resin for polyester concrete shall conform to the following requirements:

Flash Point:	180F minimum	ASTM D 3278

Tack-Free Time:	400 minutes maximum	California Test 551

Prior to adding initiator, the HMWM resin shall have a maximum volatile content of 30 percent, when tested in conformance with ASTM D 2369.

HMWM resin will be accepted based on submittal to the Engineer of aManufacturer's Certificate of Compliance conforming to Section 1-06.3.

Aggregate

The aggregate shall be from a WSDOT approved pit site and shall be thoroughly washed and kiln dried.

The aggregate shall conform to Section 9-03.1, and one of the following combined aggregate gradings:

	Combined Aggregate	
Sieve Size	1/2" Max. % Passing	3/8" Max. %Passing
1/2"	100	100
3/8"	83-100	100
U.S. No.4	65-82	62-85
U.S. No.8	45-64	45-67
U.S. No. 16	27-47	29-50
U.S. No. 30	12-30	16-36
U.S. No. 50	6-17	5-20
U.S. No. 100	0-7	0-7
U.S. No. 200	0-3	0-3

Aggregate retained on the U.S. No.8 sieve shall have a maximum of 25 percent crushed particles. Fine aggregate shall consist of natural sand only.

Aggregate absorption shall not exceed 1.0 percent. The moisture content of the aggregate hall not exceed one half of the aggregate absorption at the time of mixing with the polyester resin binder. The aggregate temperature shall be between 45F and 100F at the time of mixing.

Sand for Abrasive Finish

he sand for abrasive finish shall conform to Section 6-09.2, and the aggregate moisture content requirements specified above.

Construction Requirements

Section 5-01.3 is supplemented with the following:

(BSP May 2, 2005)

Polyester Concrete

Mix Design

Polyester concrete shall be composed of the following three components -polyester resin binder, high molecular weight methacrylate (HMWM) resin, and aggregate, in accordance with Section 6-02.2 as supplemented in these Special Provisions.

The Contractor shall prepare and submit the polyester concrete design mix and mixing procedure, including samples of all components for each lot, to the WSDOT Materials Laboratory for testing. The mix design shall include a recommended initiator percentage for the expected application temperature. The Contractor shall not begin ordering materials for application of the polyester concrete until receiving the Engineer's approval of the polyester concrete design mix and mixing procedure.

Delivery and Storage of Materials
All materials shall be delivered in their original containers bearing the manufacturer's label, specifying date of manufacturing, batch number, trade name brand, and quantity. Each shipment of polyester resin binder and HMWM resin shall be accompanied by a Materials Safety Data Sheet (MSDS).

The material shall be stored to prevent damage by the elements and to ensure the preservation of their quality and fitness for the work. The storage space shall be kept clean and dry, and shall contain a high-low thermometer. The temperatures of the storage space shall not fall below nor rise above that recommended by the manufacturer. Every precaution shall be taken to avoid contact with flame.

Stored materials shall be inspected prior to their use, and shall meet the requirements of these Special Provisions at the time of use.

Any material which is rejected because of failure to meet the required tests or that has been damaged so as to cause rejections shall be immediately replaced at no additional expense to the Contracting Agency.

Sufficient material to perform the entire polyester concrete application shall be in storage at the site prior to any field preparation, so that there shall be no delay in procuring the materials for each day's application.

Material Health and Safety Training and Precautions
The Contractor shall arrange to have the material supplier furnish technical service relating to application of material and health and safety training for personnel who are to handle the polyester concrete and the HMWM resin prime coat.

Appropriate impermeable protective garments shall be used by all workers who may contact the resin or initiators to prevent skin contact. If skin contact occurs, the resin or initiators shall be immediately washed off. Clothing that becomes saturated with resin shall be removed immediately.

Equipment and Containment
All equipment for cleaning the concrete and steel surfaces, and mixing and applying the polyester concrete, shall be submitted to the Engineer for approval.

The HMWM resin, and abrasive blasting materials, shall be contained and restricted to the surface receiving the polyester concrete only, and shall not escape to the surrounding environment. The Contractor shall submit the method and materials used to collect and contain the HMWM resin, and abrasive blasting materials, to the Engineer for approval.

The Contractor shall not begin polyester concrete work, including surface preparation, until receiving the Engineer's approval of the equipment, and the collection and containment system.

Surface Preparation
Using the equipment, material, technique, and procedures established for surface preparation, the concrete and steel surfaces shall be prepared by removing all material which may act as a bond breaker between the surface and the polyester concrete. Surface cleaning shall be by abrasive blasting.

Precautions shall be taken to ensure that no dust or debris leaves the roadway deck and that all traffic is protected from rebound and dust. Appropriate shielding shall be provided as required at no additional expense to the Contracting Agency and shall be as approved by the Engineer.

If the concrete or steel surfaces become contaminated, the contaminated areas shall be recleaned by abrasive blasting at no additional expense to the Contracting Agency.

Application of Prime Coat
Application of the HMWM prime coat and the polyester concrete shall not begin if rain is expected. The area receiving the prime coat shall be dry and had no rain within the past 12 hours. Immediately prior to applying the prime coat, the surfaces shall be swept clean by compressed air to remove accumulated dust and any other loose material.

The concrete bridge deck surface shall be between 50F and 85F when applying the prime coat.

The Contractor shall apply one coat of promoted/initiated wax-free HMWM resin to the prepared concrete and steel surfaces immediately before placing the polymer concrete. The promoted/initiated resin shall be worked into the concrete in a manner to assure complete coverage of the area receiving polyester concrete. A one pint sample of each batch of promoted/initiated HMWM resin shall be retained and submitted to the Engineer at the time of primer application to verify proper catalyzation.

The prime coat shall cure for 30 minutes minimum before beginning placement of the polyester concrete. Placement of the polymer concrete shall not proceed until the Engineer verifies that the HMWM resin was properly promoted and initiated, as evidenced by the HMWM batch sample.

If the primed surface becomes contaminated, the contaminated area shall be cleaned by abrasive blasting and reprimed at no additional expense to the Contracting Agency.

Under no circumstances shall any resin run into drains or expansion joints, or otherwise escape the Contractor's collection and containment system.

Mixing Equipment for Polyester Concrete
Polyester concrete shall be mixed in mechanically operated mixers in accordance with the mix design as approved by the Engineer. The mixer size shall be limited to a nine cubic yard maximum capacity, unless otherwise approved by the Engineer.

The aggregate and resin volumes shall be recorded for each batch along with the date of each recording. A printout of the recordings shall be furnished to the Engineer at the end of each work shift.

The Contractor shall prevent any cleaning chemicals from reaching the polyester mix during the mixing operations.

Mixing Components
The polyester resin binder in the polyester modified concrete shall be approximately 12 percent by weight of the dry aggregate. The Contractor shall determine the exact percentage as approved by the Engineer.

The amount of peroxide initiator used shall result in a polyester concrete set time between 30 and 120 minutes during placement as determined by California Test 551, Part 2, "Method of Test For Determination of Set Time of Concrete Overlay and Patching Materials", by Gilmore Needles. Accelerators or inhibitors may be required as recommended by the polyester resin binder supplier and as approved by the Engineer.

The polyester resin binder shall be initiated and thoroughly blended just prior to mixing the aggregate and binder. The polyester concrete shall be thoroughly mixed prior to placing.

Polyester Concrete Placement
The polyester concrete shall be placed on the liquid or hardened prime coat within two hours of placing the prime coat.

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

The surface temperature of the area receiving the polyester concrete shall be the same as specified above for the HMWM prime coat.

Under no circumstances shall any polyester mixture run into drains or expansion joints, or otherwise escape the Contractor's collection and containment system.

The polyester concrete shall be consolidated to a relative compaction of not less than 97 percent.

Finished Polyester Concrete Surface
The finished surface of the polyester concrete shall conform to the requirements of Section 6-02.3(10).

The polyester concrete shall be consolidated by means approved by the Engineer. Finishing equipment used shall strike off the polyester concrete to the established grade and cross section. Forms shall be coated with suitable bond release agent to permit ready release of forms.

The polyester concrete shall receive an abrasive sand finish. The sand finish shall be applied by hand immediately after strike-off and before gelling occurs. Sand shall be broadcast onto the surface to affect a uniform coverage of a minimum of 0.8 pounds per square yard.

The surface texture of polyester concrete surface shall be uniform. The polyester concrete shall be impervious to moisture.

Curing

Traffic and equipment shall not be permitted on the polyester concrete until it has achieved a minimum compressive strength of 2,500 psi as determined by the rebound number per ASTM C 805.

Areas of the polyester concrete that do not totally cure or that fail to attain the specified minimum compressive strength in six hours shall be removed and replaced by the Contractor at no additional expense to the Contracting Agency.

(BSP December 2,2002)

Mobile Mixer for Polyester Concrete

The mixer shall be equipped to be calibrated to automatically proportion and blend all components of the specified mix on a continuous or intermittent basis as required by the finishing operation, and shall discharge mixed material directly into the finishing machine.

The mixer shall be equipped with a metering device that automatically measures and records the aggregate volumes and the corresponding resin volumes. The metering device shall have a readout display gage visible at all times, and shall be capable of printing out the volumes being recorded for each material.

The aggregate and resin volumes shall be recorded at no greater than five minute intervals along with the date of each recording. A printout of the recordings shall be furnished to the Engineer at the end of each work shift.

The Contractor shall prevent any cleaning chemicals from reaching the polyester mix during the overlay applications.

(BSP April 7, 2008)

Submittals for Polyester Concrete

The Contractor shall submit the following items to the Engineer for approval in accordance with Section 6-01.9:

1. The type of shot blasting machine selected by the Contractor for use in this project to scarify concrete surfaces.

2. The method and materials used to contain, collect, and dispose of all concrete debris generated by the scarifying process, including provisions for protecting adjacent traffic from flying debris.

3. The qualifications of on-site supervisors, mobile mixer operators, and finishing machine operators, in accordance with Section 6-09.3(8) as supplemented in these Special Provisions.

4. The polyester concrete mix design in accordance with Section 6-09.3(3) as supplemented in these Special Provisions.

5. Samples, as specified below, shall be submitted to the Engineer at least 15 working days prior to placing the polyester overlay:

   a. One gallon minimum of the polyester resin binder.

   b. One pint minimum of the HMWM resin.

   c. 100 pounds minimum of aggregate.

   d. Representative samples from each lot of prepackaged deck repair material and aggregate extenders, if selected for use in this project, as specified in Section 6-09.3(3) as supplemented in these Special Provisions.

6. The method and materials used to contain HMWM resin and polyester concrete within the deck area specified to receive the overlay.

7. Paving equipment specifications and details of the screed rail support system, including details of anchoring the rails and providing rail continuity.

The Contractor shall not begin scarifying operations until receiving the Engineer's approval of Items 1 and 2. The Contractor shall not begin placing polyester concrete overlay until receiving the Engineer's approval of Items 3 through 7.

(BSP December 2, 2002)
Polyester Concrete
The Contractor shall use polyester concrete for the total concrete overlay operation. Use of latex modified concrete (LMC), fly ash modified concrete (FMC) or microsilica modified concrete (MMC) will not be allowed.

Polyester concrete shall consist of the following three components - polyester resin binder, HMWM resin, and combined aggregate, in accordance with Section 6-09.2 as supplemented in these Special Provisions. The Contractor shall submit the mix design for the polyester concrete to the Engineer for approval. The mix design shall include a recommended initiator percentage for the expected application temperature. The polyester resin binder shall be approximately 12 percent by weight of the dry combined aggregate. The Contractor shall not begin the trial overlay of the polyester concrete, as specified in Section 6-09.3(8) as supplemented in these Special Provisions, until receiving the Engineer's approval of the polyester concrete mix design.

(BSP December 2, 2002)
Deck Repair Concrete for Polyester Concrete Overlays

Patching concrete for further deck preparation in accordance with Section 6-09.3(6) shall be the polyester concrete mix used for the overlay.

(BSP December 2, 2002)
Storing and Handling of Polyester Concrete Materials
All materials shall be delivered in their original containers bearing the manufacturer's label, specifying date of manufacturing, batch number, trade name brand, quantity, and mixing ratio. Each shipment of polyester resin binder and HMWM resin shall be accompanied by a Materials Safety Data Sheet (MSDS).

The material shall be stored to prevent damage by the elements and to ensure the preservation of their quality and fitness for the work. The storage space shall be kept clean and dry, and shall contain a high-low thermometer. The temperatures of the storage space shall not fall below nor rise above that recommended by the manufacturer. Every precaution shall be taken to avoid contact with flame.

Stored materials shall be inspected prior to their use, and shall meet the requirements of these Special Provisions at the time of use.

Any material which is rejected because of failure to meet the required tests or that has been damaged so as to cause rejections shall be immediately replaced at no additional expense to the Contracting Agency.

Sufficient material to perform the entire polyester concrete overlay application shall be in storage at the site prior to any field preparation, so that there shall be no delay in procuring the materials for each day's application.

Appropriate impermeable protective garments shall be used by all workers who may contact the resin or initiators to prevent skin contact. If skin contact occurs, the resin or initiators shall be immediately washed off. Clothing that becomes saturated with resin shall be removed immediately.

All personnel working with the polyester concrete shall be issued suitable approved organic vapor respirators in addition to other appropriate protection equipment.

(BSP September 9, 2002)
The Contractor shall use a shot blasting machine for scarifying concrete surfaces. The use of a rotary milling or hydro-demolition machines will not be allowed. The Contractor shall inform the Engineer of the type of machine selected in accordance with Item 1 of Section 6-09.3(2).

(BSP December 2, 2002)
The scarification depth for all concrete decks receiving polyester concrete overlay shall be *1/4* inch, and all references to scarification depth in Sections 6-09.3(5)A and 6-09.3(5)8 shall be revised accordingly.

(BSP September 9, 2002)
Steel reinforcing bars used in deck repair operations, in accordance with Sections 6-09.3(5)F and 6-09.3(6)8, shall be epoxy-coated in accordance with Section 6-02.3(24)H.

(**BSP December 2, 2002)**
Placing Patching Concrete For Polyester Concrete Overlay
Patching concrete shall be polyester concrete, as specified in Section 6- 09.3(3) as supplemented in these Special Provisions. Concrete Class M shall not be used.

Polyester concrete for deck repair shall be placed and cured in accordance with Sections 6-09.3(11) and 6-09.3(13), respectively, as supplemented in these Special Provisions.

All deck repair material that fails to achieve a minimum compressive strength of 3,000 psi in six hours as verified by the rebound number determined in accordance with ASTM C 805 shall be removed and replaced with new deck repair material by the Contractor, at no additional expense to the Contracting Agency.

(BSP December 2, 2002)
Quality Assurance For Polyester Concrete Overlay
The Contractor shall arrange to have the suppliers of the polyester resin binder and HMWM resin furnish technical service relating to application of material and health and safety training for personnel who are to handle the polyester concrete and the HMWM resin prime coat.

On-site supervisors, and all personnel operating the mobile mixer and finishing machines, shall have successful previous experience in mixing and placing polyester concrete overlay. Documentation of project experience with polyester concrete overlay shall include the name and location of the project, the Contracting Agency of the project, the area quantity of overlay placed, and the name and current phone number of the Contracting Agency's contact person for the referenced project.

(BSP January 27, 2003)
Polyester Concrete Trial Overlay
The Contractor shall place a trial overlay of polyester concrete using the equipment selected by the Contractor and the production mix and procedure as approved by the Engineer in accordance with Section 6-09.3(3). The Contractor shall notify the Engineer of the time and location of the trial overlay at least seven calendar days prior to the scheduled trial overlay.

The trial overlay shall be placed on a previously cast and cured concrete pad at a location selected by the Contractor. The plan area of the concrete pad shall be 12 feet minimum in width and 15 feet minimum in length.

The Contractor shall clean the concrete pad surface, mix, place, finish, and cure the polyester concrete overlay, and check the trial overlay for bond, in accordance with Section 6-09.3 as supplemented in these Special Provisions, except as otherwise noted. The Contractor need not scarify the concrete surface and perform further deck preparation on the concrete pad surface provided that all other conditions of Section 6-09.3(7) are satisfied. The trial overlay shall be 12 feet wide, 15 feet long, and *3/4* inches thick.

The Contractor shall perform three pull-off tests on the trial overlay in accordance with American Concrete Institute 503R - 9999999 A. The Contractor shall record the pull-off test results and the amount of (if any) failure into the base concrete, and shall provide written documentation of the test results to the Engineer.

The Contractor shall not begin placing polyester concrete overlay at the bridge site(s) receiving the polyester concrete overlay until receiving the Engineer's approval of the completed trial overlay.

After receiving the Engineer's approval of the completed trial overlay, the concrete pad and trial overlay shall become the Contractor's property and shall be removed and disposed of in accordance with Section 2-02.3.

(BSP January 27, 2003)
Mixing Polyester Concrete
Polyester concrete shall be mixed in mobile mixers conforming to Section 6-09.3(1) as supplemented in these Special Provisions, and in accordance with the mix design approved by the Engineer.

The polyester resin binder in the polyester concrete shall be approximately 12 percent by weight of the dry aggregate. The Contractor shall determine the exact percentage as approved by the Engineer.

The amount of peroxide initiator used shall result in a polyester concrete set time between 30 and 120 minutes during placement as determined by California Test 551, Part 2, "Method of Test For Determination of Set TIme of Concrete Overlay and Patching Materials", by Gilmore Needles. Accelerators or inhibitors may be required as recommended by the polyester resin binder supplier and as approved by the Engineer.

The polyester resin binder shall be initiated and thoroughly blended just prior to mixing the aggregate and binder. The polyester concrete shall be thoroughly mixed prior to placing.

(BSP January 27, 2003)
The minimum thickness of polyester concrete overlay shall be *3/4* inches, except as otherwise shown in the Plans or adjusted by the Engineer.

(BSP April 7, 2008)
Placing Polyester Concrete Overlay
Application of the HMWM prime coat and the polyester concrete overlay shall not begin if rain is expected. The area receiving the prime coat shall be dry and had no rain for at least 24 hours. Immediately prior to applying the prime coat, the surface receiving the prime coat shall be swept clean by compressed air to remove accumulated dust and any other loose material. If the surface receiving the HMWM prime coat and polyester concrete has been exposed to moisture within the previous 12 hours, it shall be thoroughly dried using a heat lance prior to placement of the HMWM prime coat.

The concrete bridge deck surface temperature shall be between 50F and 85F when the prime coat is applied.

The prepared concrete surface shall receive one coat of promoted/initiated waxfree HMWM resin. The promoted/initiated HMWM resin primer shall be worked into the concrete in a manner to effect complete coverage of the area. A one pint sample of each batch of promoted/initiated HMWM resin shall be retained and submitted to the Engineer at the time of primer application to verify proper catalyzation. Under no circumstances shall any resin be allowed to run into drains and expansion joints, or otherwise escape the Contractor's collection and containment system.

If the HMWM primed surface becomes contaminated, the contaminated area shall be cleaned by abrasive blasting and reprimed at no additional expense to the Contracting Agency.

The HMWM prime coat shall cure for a minimum of 30 minutes before placing the polyester concrete overlay. Placement of the polymer concrete shall not proceed until the Engineer verifies that the HMWM resin was properly promoted and initiated, as evidenced by the HMWM batch sample.

The polyester concrete shall be placed on the liquid or hardened HMWM prime coat within two hours of placing the prime coat. Polyester concrete shall be placed prior to gelling and within 15 minutes following initiation, whichever occurs first. Polyester concrete that is not placed within this time shall be discarded.

If, for any reason, polyester concrete is not placed over the prime coat within the two hour time limit, the Contractor shall apply a fresh coat of HMVM resin primer immediately followed by an abrasive sand finish coating. The abrasive sand finish shall be broadcast onto the surface to affect a uniform coverage of a minimum of 0.8 pounds per square yard. Prior to applying the polyester concrete overlay, the surface shall be re-cleaned in accordance with Section 6-09.3(7).

Expansion joints shall be adequately isolated prior to placing the overlay as approved by the Engineer. Saw cutting at bridge expansion joints will not be allowed.

The surface temperature of the area receiving the polyester concrete shall be the same as specified above for the HMWM prime coat.

The polyester concrete shall be consolidated to a relative compaction of not less than 97 percent.

(BSP September 9, 2002)
Neither latex admixture nor water shall be applied to the surface of the rapid set latex modified concrete overlay to assist in finishing the top surface.

(BSP December 2, 2002)
Curing Polyester Concrete
Traffic and equipment shall not be permitted on the polyester overlay for at least four hours and until the polyester overlay has reached a minimum compressive strength of 3,000 psi as verified by the rebound number determined in accordance with ASTM C 805.

Areas in the polyester concrete that do not totally cure, or that fail to attain the minimum compressive strength specified above, shall be removed and replaced with new polyester concrete material by the Contractor, at no additional expense to the Contracting Agency.

(BSP December 2, 2002)
Checking Polyester Concrete For Bond
After the requirements for curing have been met, the entire overlaid surface shall be sounded by the Contractor, in a manner approved by and in the presence of the Engineer, to ensure total bond of the concrete to the bridge deck. Polyester concrete in unbonded areas shall be removed and replaced with polyester concrete by the Contractor, at no additional expense to the Contracting Agency.

All cracks, except those that are significant enough to require removal as determined by the Engineer, shall be thoroughly filled and sealed with HMWM resin. Cracks 1/16 inch and greater in width shall receive two applications of HMWM resin. Immediately following the application of HMWM resin, the wetted surface shall be coated with sand for abrasive finish.

Equipment
Section 5-01.3(1)B is supplemented with the following:

(******)
A Pavement Breaker (Guillotine hammer type) shall not be allowed for use as a method for breaking PCCP.

Replace Portland Cement Concrete Panel
Section 5-01.3(4) is supplemented with the following:

(******)
The Contractor shall replace ATB that gets removed or damaged as a result of PCCP slab removal with crushed surfacing base course or HMA.

(******)
Tie bars shall not be installed on this contract. All reference to tie bar installation for Replace portland cement concrete panel is deleted.

Portland Cement Concrete Pavement Grinding
The last sentence in the first paragraph of Section 5-01.3(9) is revised to read:

(******)
For each roadway section the lane with the deepest ruts shall be ground first. Grinding shall be to the bottom of the ruts at a minimum. Additional information on rut depths is available for review at the Project Engineer's Office.

Measurement
Section 5-01.4 is supplemented with the following:

(BSP December 2, 2002)
Polyester concrete overlay will be measured by the square yard of overlay surface actually placed, finished, and cured.

Payment

The third paragraph of Section 5-01.5 is to read:

(******)
The unit Contract price per square yard shall be full payment for all costs to complete the Work as specified, including saw cutting full depth, removal and disposal of the existing panels off of the Contracting Agency's Right of Way, preparing the surfacing below the new panel, provide, place and compact the crushed surfacing or hot mix asphalt, furnishing and placing polyethylene film or building paper, furnishing and placing the portland cement concrete, drilling the holes, providing and anchoring the dowel bars and for all incidentals required to complete the Work as specified.

The third paragraph of Section 5-01.5 is supplemented with the following:

(******)
All pavement removal and disposal, HMA, CDF, joint adhesive, incidentals, and all work associated with repairing adjacent HMA ramps and shoulders at panel replacement areas shall be included in the unit contract price for "Replace Cement Concrete Panel", per square yard.

(BSP December 2, 2002)
"Polyester Concrete Trial Overlay", lump sum.
The lump sum contract price for "Polyester Concrete Trial Overlay" shall be full pay for performing the work as specified, including establishing a location for the trial overlay, and construction, removal, and disposal of the concrete pad and trial overlay.

(BSP December 2, 2002)
"Force Account Grinding Polyester Conc. Overlay", force account.
Grinding polyester concrete overlay as specified will be paid by force account in accordance with Section 1-09.6. For the purpose of providing a common proposal for all bidders, the Contracting Agency has entered an amount for the item "Force Account Grinding Polyester Conc. Overlay" in the bid proposal to become a part of the total bid by the Contractor.

(BSP December 2, 2002)
"Polyester Concrete Overlay", per square yard.
The unit contract price per square yard for "Polyester Concrete Overlay" shall be full pay for performing the work as specified, including placing, finishing, and curing the overlay, and checking for bond.

Appendix E

Pull Test Results

Budinger & Associates

Geotechnical Engineering
Environmental Engineering
Construction Materials Testing
Subsurface Exploration
Special Inspection

Proudly serving the Inland Northwest for over 30 years

Robert Seghetti
ACME Concrete & Paving
4124 East Broadway
Spokane, WA 99202

July 12, 2012

Project Number L12028

PROJECT: ACME 2012 Materials
Spokane, WA

SUBJECT: Results of Surface Soundness and Adhesion Testing

At your request, we provided testing services for the subject project. Services were limited to the performance of specific tests, selected at your discretion.

For this period our involvement was limited to surface soundness and adhesion testing on polyester overlay mix. Tests were performed in general accordance with ACI 503R-93-Appendix A.

SURFACE SOUNDNESS — PULL TESTING

We pull tested 6 surface soundness tests on the test pad located at ACME Concrete Paving (Airway Heights). Results indicate stress values of 370psi to 482psi on tests 1 to 3. With test 2 failing at the bond between the overlay and the epoxy securing the cap.

TEST #	LOAD (lbs)	STRESS (psi)	FAILURE TYPE
1	1512	481.5	1.5" subsurface concrete failure
2	1278	407.0	Epoxy bond between the overlay and epoxy
3	1161	369.8	Subsurface 1" concrete failure
4	464	147.7	Epoxy bond between the cap and epoxy
5	N/A	N/A	Failed prior to testing (test was disturbed)
6	810	258.0	Failed at both the epoxy bond between the epoxy and cap and the epoxy and overlay

If you have any questions, please call.

Respectfully Submitted,
BUDINGER & ASSOCIATES, INC.

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