Experimental Feature Report

Post Construction & Performance Report
Experimental Feature WA03-02

Wear Resistant Pavement Study

Contract 6582
I-90
Sullivan Road to Idaho State Line, Phase I
MP 292.10 to 299.82




Washington State
Department of Transportation

1. REPORT NO. WA-RD 657.1	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
4. TITLE AND SUBTITLE Wear Resistant Pavement Study		5. REPORT DATE October 2006
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Keith W. Anderson, Jeff Uhlmeyer, Linda Pierce, and Jim Weston		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Washington State Department of Transportation Materials Laboratory, MS-47365 Olympia, WA 98504-7365		10. WORK UNIT NO.
		11. CONTRACT OR GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Washington State Department of Transportation Transportation Building, MS 47372 Olympia, Washington 98504-7372 Project Manager: Kim Willoughby, 360-705-7978		13. TYPE OF REPORT AND PERIOD COVERED Post Construction & Performance Report
		14. SPONSORING AGENCY CODE
15. SUPPLEMENTARY NOTES This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.		

16. ABSTRACT

This report documents the construction of three special pavement test sections on I-90 east of Spokane, Washington. The test sections included ultra-thin and thin whitetopping, Modified Class D open graded asphalt concrete, and micro/macro surfacing treatment. The majority of the project was built with a ½ inch Superpave mix. The test sections were built to assess their potential as mitigation measures for studded tire wear.

Initial data collect on the sections indicate a rate of rutting of 1.8 mm per year on the whitetopping, 2.2 on the Modified Class D, and Superpave sections and a rate of 2.6 mm per year on the micro/macro surfacing section. Extensive cracking was noted in the section of whitetopping with a three inch thickness.

17. KEY WORDS Ultra-thin whitetopping, thin whitetopping, open graded asphalt, micro surfacing, macro surfacing, pavement wear, rutting, friction resistance.	18. DISTRIBUTION STATEMENT No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22616

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
None	None	113	

DISCLAIMER

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INTRODUCTION

Experimental rut resistant sections of pavement were placed in July of 2003 on the I-90 Sullivan Road to Idaho State Line pavement rehabilitation project. This section of hot-mix asphalt (HMA) roadway was chosen because of a chronic rutting problem due to excessive wear from studded tires. HMA roadways in the eastern part of the state typically average 12.7 years of performance before resurfacing is required. This particular section of I-90 had experienced rutting that approached a depth of 1 inch in only six years since construction. The WSDOT criteria call for resurfacing of a roadway when the rut depth exceeds 0.40 inches (10 mm). This experimental feature will provide an excellent opportunity to evaluate the wear resistant qualities of three asphalt sections and one portland cement concrete section in an area with high studded tire usage. This report summarizes the construction of these experimental sections and documents their performance through year two of their five year evaluation period as an experimental feature.

OBJECTIVE

The primary objective of this experimental feature is to evaluate the performance of a PCC whitetopping overlay, a modified Class D HMA overlay, and a micro/macro surfacing section in reducing studded tire wear. Studded tire wear is a problem throughout the state, but it is particularly severe in the Spokane metropolitan area as evidenced by the rutting shown in Figure 1. A survey conducted by WSDOT during the winter of 1996-1997 revealed that, on the average, 10 percent of passenger vehicles use studded tires in Western Washington and 32 percent use them in Eastern Washington. The survey also indicated that the highest stud usage was in the Spokane area at 56 percent and the lowest in the Puyallup area at 6 percent.

Figure 1. Studded tire wear in HMA pavement on I-90 near the Idaho border.

LOCATION INFORMATION

The project containing the experimental sections is Contract 6582, Sullivan Road to Idaho State Line, Phase I. It is located on I-90 east of the urban area of Spokane and consists of four lanes, two in each direction between mileposts 292.10 and 299.82. This portion of Interstate 90 has a directional average daily traffic volume of 30,881 with more than 10 percent truck traffic and is classified as urban interstate.

The experimental sections were constructed between mileposts 293.15 and 293.55. The thin and ultra-thin test sections of whitetopping were placed in the outside truck lane in the eastbound direction. The Modified Class D HMA section was placed next to the whitetopping in the inside passing lane in the eastbound direction. The micro/macro resurfacing was placed in the westbound lanes opposite the whitetopping and Modified Class D as noted in Figure 2. The control section of Superpave ½ inch HMA was used on the remainder of the contract.

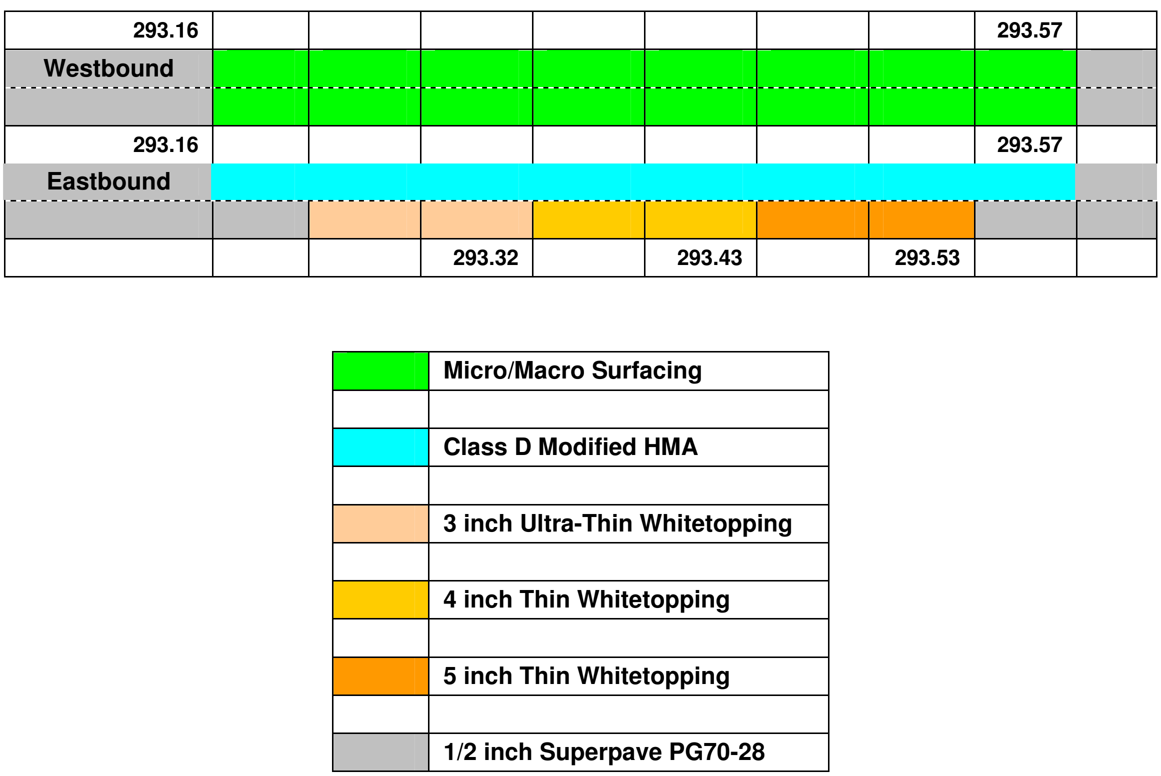


Figure 2. Location of test sections.

DESIGN AND CONSTRUCTION

Ultra Thin Whitetopping (UTW) and Thin Whitetopping (TWT)

Whitetopping is a thin layer of Portland cement concrete placed over an existing asphalt pavement as a method of rehabilitating the asphalt pavement. The thin PCC is bonded to the underlying asphalt to create a composite pavement section. The bonding is facilitated by milling the asphalt to produce a rough texture. This rough surface is thoroughly cleaned to remove any remaining dust or debris left from the milling operation prior to the placement of the concrete. Placing the whitetopping is no different from paving any other PCC pavement. Conventional slip-form and fixed-form pavers as well as small equipment such as vibrating screeds are used. Conventional finishing and curing techniques are also used, although proper curing is critical to avoid shrinkage cracking and to prevent debonding between the overlay and the asphalt.

The two types of whitetopping are ultra-thin and thin. Ultra-thin whitetopping is 2-4 inches thick and thin whitetopping is classified as an overlay that is 4 inches or greater in thickness. Three 500 foot test sections of whitetopping were planned with one each of 3, 4, and 5 inch thickness.

The flexural strength requirement for the whitetopping mix design was increased from our standard PCCP mix design requirement of 650 psi to 800 psi. This change reflected our experience with high strength mixes from the SHRP (Strategic Highway Research Program) SPS (Special Pavement Studies) test sections constructed on SR 395 (see Appendix A).

The design of the mix to achieve the 800 psi flexural strength resulted in the following changes. The minimum cementitious content was increased from the standard 565 pounds per cubic yard to 800 pounds per cubic yard. The water/cement ratio was decreased from 0.44 to 0.33. Polypropylene fibers were incorporated into the mix at the rate of 3 pounds per cubic yard. The purpose of the fibers is to hold together any cracks that might develop. Details of the actual mix design are included in Appendix B.

The preparation for the paving of the whitetopping section began with rotomilling and overlaying the inside lane with the Modified Class D and the outside lane with Superpave 1/2 inch mix. The Superpave overlay was then rotomilled to remove material to allow for the 3, 4 and 5 inch whitetopping to be placed flush with the adjacent Modified Class D and the

Superpave on either end. This sequence was dictated by a requirement that all work be done at night or on weekends. It was impossible to rotomill, pave the whitetopping, and pave the Superpave on both ends and shoulder of the whitetopping section in one weekend.

Rotomilling was started and completed on the night of July 18. The surface was then swept and dried in preparation for the placement of the whitetopping. A problem was encountered during the rotomilling and cleaning of the 3 inch section. The rotomilling did not remove all of the fresh Superpave 1/2 inch HMA from the roadway. It left residual amounts of the mix in the ruts present in the original HMA surface. This mix was porous and not well bonded to the underlying asphalt pavement. There was an attempt to remove this with a blade, but this was not entirely successful. Images A and B of Figure 3 show the material left in the ruts.

Paving began at noon on July 19th and was completed by 4:00 pm. The wet concrete was placed directly on the cleaned and dried rotomilled surface. Placing the whitetopping on a dried surface rather than a moist surface was based on recommendations from the American Concrete Paving Association (ACPA). It should be noted that ambient temperature during the pour reached 100 degrees F or higher.

A carpet drag finish was applied to the wet concrete in two stages, one directly behind the paver, and one propelled by hand several feet behind the first stage. White curing compound was applied by a hand held spraying wand. The 5’ x 6’ joint pattern used for all three sections was formed by diamond sawing. The sawing began at 3:15 pm and was not completed until 10:00 pm. There were many delays in the sawing due to spalling at the joints caused by a tender mix or the embedded fibers or a combination of both. Image C of Figure 4 shows the spalling of the joints due to the sawing operation. Sealing of the joints was completed on the 20th and the sections were opened to traffic on the 22nd. Opening to traffic was delayed because cylinder breaks from the last load of concrete were at 4000 psi compressive strength. Although this converts to a flexural strength of 690 psi and would probably meet or exceed the 14 day requirement of 800 psi written into the Special Provisions (Appendix C), the Contractor elected to play it safe and not open the section to traffic. Images of the whitetopping construction sequence are shown in Figures 3 and 4.

One of the other problems encountered with the placement of the whitetopping, in addition to the spalling problems during joint sawing, was that a vehicle drove inside the traffic control and put 1/8 to 1/4 inch deep ruts in the last 100 feet of the wet mix. The Contractor diamond ground the last 100 feet to remove the tracks, see Image E of Figure 4, but the tire tracks are still visible even after the diamond grinding.

Image A. Existing pavement after grinding operation. Note remnants of the Superpave overlay in the wheelpaths.

Image B. Cleaning of the existing pavement surface. Note remnants of the Superpave overlay in the wheelpaths.

Image C. Truck delivering the wet concrete to the paver.

Image D. Double carpet drag treatment.

Image E. Close-up of weights use to keep the carpet in contact with the wet concrete.

Image F. The finished texture after the carpet drag.

Figure 3. Images of the whitetopping paving from grinding to carpet drag.

Image A. Hand application of curing compound.

Image B. Joint sawing operation.

Image C. Spalling of joints due to tender mix or fibers or a combination of both.

Image D. Surface of whitetopping showing fiber reinforcement.

Image E. Diamond grinding to remove the ruts from the vehicle that entered the construction zone.

Image F. Ruts caused by vehicle that entered the construction zone during paving.

Figure 4. Whitetopping paving operation from curing to joint sawing and diamond grinding.

Modified Class D

Modified Class D is WSDOT's version of an open-graded friction course pavement. It has a coarser aggregate gradation than conventional Superpave mixes with a nominal maximum aggregate size (NMAS) of 1 inch. This coarser aggregate structure is designed to provide an aggregate skeleton that is more resistant to heavy traffic loading and may also be more resistant to studded tire wear. Modified D pavements have performed well in areas outside of Spokane; however, the Modified D has not been subjected to the high studded tire use as is experienced in this location.

Modified D is typically placed 2 inches thick. Binders are usually modified with a polymer or recycled rubber to increase the film thickness on the aggregate and decrease the possibility of drain down. Drain down happens when the asphalt binder drains off of the aggregate structure and collects at the bottom of the mix as it is being transported from the plant to the job site. The polymer or rubber that is added to the binder also enhances the bond strength between the binder and the aggregate which is a necessary property in a mix that does not have as much interlocking of particles as a dense graded mix.

Modified Class D HMA is placed the same as any other HMA pavement, however, compaction is not controlled by density testing but by roller pattern. Density requirements are not feasible for an open-graded mix due to the resistance the mix has to compaction because it is made up of a predominance of the same size aggregates. Details of the mix design are included in Appendix B.

Paving of the Modified Class D followed rotomilling to remove 2 inches of the existing pavement. An equal amount of Class D mix was then inlaid on the 2,100 foot test section. One of the concerns with the compaction of open graded mixes is that they lose heat rapidly due to the additional void space that exposes more surface area to the air than a dense graded mix. This did not appear to be a problem with this overlay because the Eastern Region recommends that the Contractor use vibration during breakdown compaction. WSDOT Special Provisions state that HMA Class D shall be compacted to the satisfaction of the Engineer and they do not require the use of pneumatic rollers. Figures 5 and 6 show the placement of the Modified Class D pavement.

Figure 5. Paving of Modified Class D mix.

Figure 6. Close-up of Modified Class D mix.

Micro/Macro-Surfacing

Micro-surfacing is comprised of a mixture of finely graded high quality aggregate, asphalt, mineral filler and water. Micro-surfacing is applied as slurry by a specialty contractor using self-contained mixing and lay down equipment. It is commonly used to fill the ruts in asphalt pavements prior to the application of a full width pass called macro- surfacing.

Macro-surfacing is a surface treatment designed to place both the asphalt emulsion and the aggregate in one pass. The surface treatment is approximately ½ inch thick and consists of hard and durable aggregates bonded together with a high strength asphalt emulsion binder. Macro-surfacing is used to restore the surface characteristics of pavements or to preserve a pavement. It is a thin surface treatment that is not appropriate for resolving any structural deficiencies. Details of the mix design are included in Appendix B.

The application of the micro-surfacing to fill the ruts in the westbound lanes began on July 9, 2003, see Figures 7 and 8. The outside lane was completed first, but not without problems with rough joints caused by the starting and stopping of the operation and aggregate segregation problems caused by material that was left in the machine from a previous job. A lot of hand work was required to fill the ruts that were 1 ¼ inch deep throughout most of the section. This entailed men pushing squeegees behind the lay down machine to concentrate the micro-surfacing into the deep ruts in the wheel paths. Due to these difficulties a second application of micro-surfacing was placed on July 14th. The macro-surfacing was placed on August 16th. No problems were encountered with the placement of the macro-surfacing (see Figure 9).

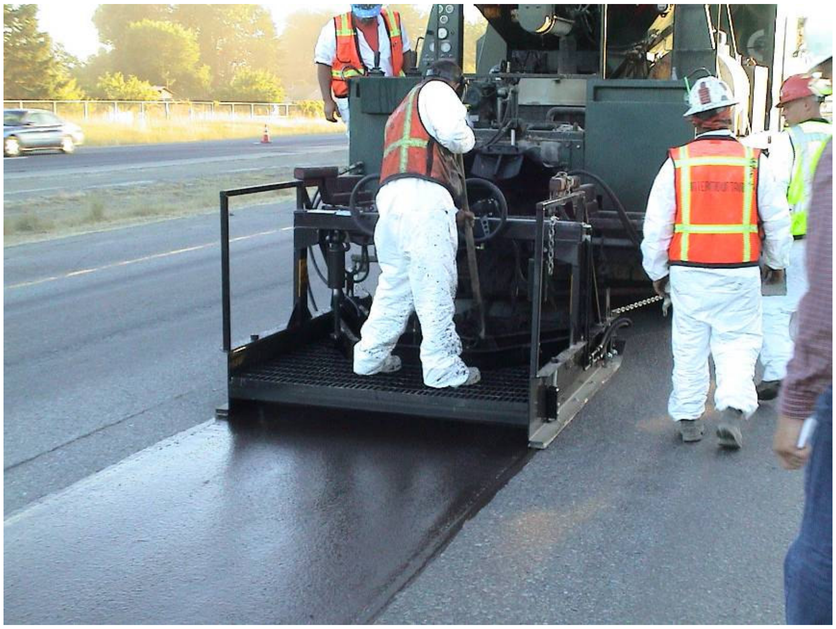


Figure 7. Micro-surfacing being applied to the rut in the left wheel path of the outside line westbound.

Figure 8. Micro-surfacing placed as a rut fill prior to macro-surfacing within the two westbound lanes of I-90 (MP 293.15 to MP 293.55).

Image A. Paving train for macro-surfacing.

Image B. Macro-surfacing paver.

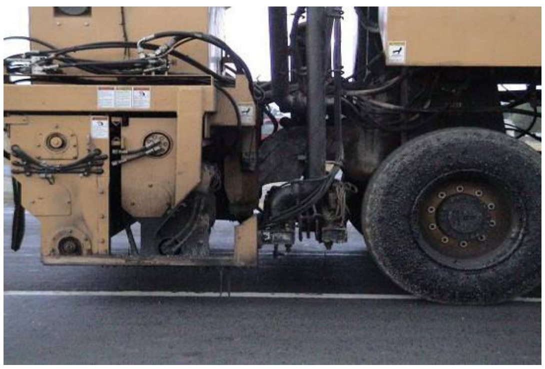


Image C. Paving machine showing spray bar for binder in the center of the photo. Aggregate is spread from the box behind the spray bar.

Image D. Aggregate truck with asphalt storage tank below. The hose rotates to connect to the paving machine to transfer the binder.

Image E. Completed macro-surfacing overlay.

Image F. Macro-surfacing overlay on the right and existing pavement on the left.

Figure 9. Macro surfacing paving sequence.

Superpave Class ½ Inch

A conventional ½ inch Superpave mix was used on the remainder of the project and serves as the control section for the experimental test sections. The Superpave was placed 2 inches thick following the grinding of 2 inches of the existing pavement. Two mix designs were used. The initial mix design, G30654 was used for some initial paving and the test sections. The remainder of the project mix design G30654R. Details of the mix design are included in Appendix B.

Special Provisions

There were a number of special provisions written into the contract for the whitetopping, Modified Class D, and micro/macro surfacing. They are included as Appendix D in order to make them available for future reference.

CONSTRUCTION TEST RESULTS

Ultra-Thin and Thin Whitetopping

Test results from the cylinders taken during the production of the ultra-thin and thin whitetopping mix are tabulated in Table 1. The results for the breaks taken at 3 and 14 days were information only. All of the 28 day samples exceeded the beam strength requirement of 800 psi. Concrete cylinders are normally made and tested in pairs which accounts for the two columns of compressive strengths and beam strengths.

Table 1. Strength test results for Ultra-Thin and Thin whitetopping.

Cylinder #	Strength (psi)	Average Strength (psi)	Date	Break	Beam Strength (psi	Beam Strength (psi)
PCCP-A1	5,840		7/19/2003	28 day	834	
PCCP-B1	6,010	5,925	7/19/2003	28 day	846	840
PCCP-A2	6,920		7/19/2003	28 day	908	
PCCP-B2	7,110	7,015	7/19/2003	28 day	920	914
PCCP-A3	6,360		7/19/2003	28 day	870	
PCCP-B3	6,410	6,385	7/19/2003	28 day	873	872
PCCP-C1	5,400		7/19/2003	14 day		802
PCCP-C2	6,100		7/19/2003	14 day		852
PCCP-C3	5,800		7/19/2003	14 day		831
PCCP-D1	4,210		7/19/2003	3 day		708
PCCP-D2	4,540		7/19/2003	3 day		735

Profilograph measurements were taken on the completed pavement and the results are summarized in Table 2. One area exceeded the 7.0 inches per mile smoothness specification and it was diamond ground. A rerun of this section resulted in a measurement of 4.5 inches per mile, thus meeting the specification. A bonus of $632.08 was paid to the contractor for achieving the required pavement smoothness specification.

Table 2. California type profilograph results for Ultra-Thin and Thin whitetopping.								
Station	Station	In./Mi. Left	In./Mi. Right	Average	Length	Dollars	Must Grinds Left	Must Grinds Right
0+00	5+28	0.3	0.6	0.5	528.0	$844.80	7+92	6+14
5+28	10+56	4.7	5.5	5.1	528.0	$ -	12+35	12+36
10+56	15+84	7.4	7.0	7.2	528.0	($422.40)	none	none
15+84	17+18	2.0	2.4	2.2	134.0	$209.68	none	none
					Bonus	$632.08		

Modified Class D

A total of 366 tons of Modified Class D was placed on the test section. Results from the three gradation tests that were performed are shown in Table 3. Two of the three samples were above the upper specification limit on the ½ inch or No. 4 sieves. This resulted in a lower pay factor for those two sieves which lower the overall pay factor to 1.01 resulting in a bonus payment of $253.44 to the Contractor.

Table 3. Modified Class D gradation results.							
Item	JMF Factor	Upper Spec Limit	Lower Spec Limit	Pay Factor	JMF	Average	Standard Deviation
1	1.0	100.0	99.0	1.05	100.0	100.0	0.00
¾	1.0	96.0	85.0	1.05	92.0	93.0	1.00
½	10.0	71.0	60.0	.88	66.0	71.0	4.58
No. 4	25.0	27.0	16.0	.99	22.0	25.3	3.06
No. 8	15.0	20.0	8.0	1.05	14.0	16.0	1.73
No.200	20.0	5.1	1.1	1.05	3.1	3.9	0.69

Screen Size						
Sublot No.	1	3/4	½	No. 4	No. 8	No. 200
1	100.0	93.0	**72.0**	**28.0**	17.0	4.3
2	100.0	92.0	66.0	22.0	14.0	3.1
3	100.0	94.0	**75.0**	26.0	17.0	4.3

Bold red numbers indicate sample is out of the specification limits.

A plot of the 0.45 power curve (Figure 10) shows that the mix was slightly finer than the job mix formula.

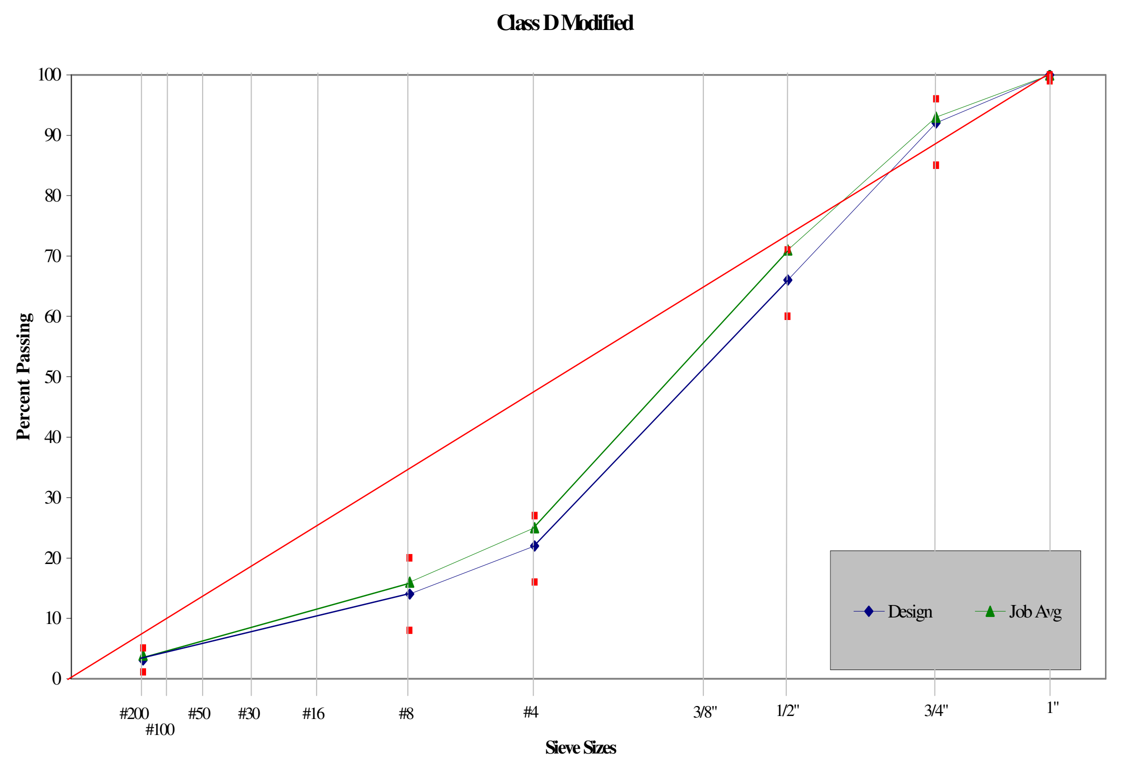


Figure 10. Modified Class D 0.45 power curve.

Micro/Macro-Surfacing

A total of 188 tons of micro/macro surfacing was placed on the test section. Results from the 2 gradation tests that were performed on the micro/macro-surfacing are shown in Table 4.

Table 4. Gradation test results for macro-surfacing.				
Sieve Size	**1/2"**	**3/8**	**No. 4**	**No. 200**
Acceptance Sample No.				
1	100.0	99.1	2.5	0.3
2	100.0	98.7	2.1	0.3
Specification	100.0	97.0 min.	12.0 max.	1.0 max.

Superpave Class ½ Inch

Mix design G30654 was used for the start-up paving, the tests sections used to test the job mix formula, and for pavement repairs. Adjustments to achieve density or volumetric properties wee performed during the placement of this mix. Table 5, contains the volumetric test results, Table 6 the gradation results and Table 7 the density results for the pavement built with G30654. The test values that are not within the specification limits are shown in bold red type with an asterisk. The mix design had problems meeting the air void (Va) and voids in mineral aggregate (VMA) targets, therefore an adjustment was made to the #4 and #8 sieves to produce a new mix design, G30654R.

A total of 2,336 tons was placed with a pay factor of 1.01 for the mix using G30654. The Contractor was paid a bonus of $472. 47.

Table 5. Volumetric test results for mix design G30654.								
	Test# & QA#	**Pb**	**Va**	**VMA**	**VFA**	**D/A**	**Gmb**	**Gmm**
Spec		**5.6**	**3.5**	**14.0 min**	**65-75**	**0.6-1.6**		
Limits		**5.1-6.1**	**2.0-5.0**	**13.0 min**				
G30654		**5.6**	**3.5**	**13.3**	**74.0**	**1.3**	**2.394**	**2.480**
6/30	1	5.5	**1.5**	**11.8**	**87.3**	1.6	2.433	2.471
7/1	2	5.6	**5.5**	15.5	64.5	1.3	2.342	2.478
7/2	3	5.6	4.4	14.6	69.9	1.3	2.362	2.470
7/7	TS-1	5.7	2.8	13.4	**79.1**	1.5	2.398	2.466
7/7	TS-2	5.6	3.6	14.0	74.3	1.2	2.379	2.467
7/7	TS-3	5.6	3.7	14.2	73.9	1.3	2.371	2.461
7/7	TS-4	505	3.5	13.9	74.8	1.3	2.376	2.463
Prod. Ave.		**5.6**	**3.6**	**13.9**	**74.8**	**1.4**	**2.380**	**2.468**
Std. Dev.		**0.07**	**1.2**	**1.1**	**7.1**	**0.1**	**0.029**	**0.006**
Bold red numbers indicate values that are out of specification.								

Table 6. Aggregate gradation results for mix design G30654.										
		¾"	1/2"	3/8"	#4	#8	#16	#30	#50	#200
Spec.	**Test # & QA#**	**100**	**90-100**	**90 Max.**		**28-58**				**2-7**
Limits		**94-100**	**93-100**	**79-90**	**39-49**	**28-33**				**3.7-7.0**
G30654		**100**	**99**	**85**	**44**	**29**	**20**	**15**	**10**	**5.7**
6/30	1	100	99	86	**53**	**34**	23	17	12	7.2
7/1	2	100	99	85	48	29	19	13	10	5.7
7/2	3	100	99	84	49	32	21	15	10	5.6
7/7	TS-1	100	99	84	**52**	32	22	16	11	6.8
7/7	TS-2	100	98	80	**50**	32	21	15	10	5.6
7/7	TS-3	100	98	83	**50**	31	21	15	11	6.2
7/7	TS-4	100	98	82	49	31	21	15	10	5.9
Prod. Ave.		**100**	**98.6**	**83.4**	**50.1**	**31.5**	**21.3**	**15.3**	**10.5**	**6.1**
Std. Dev.		**0.00**	**0.53**	**1.99**	**1.77**	**0.6**	**0.5**	**0.5**	**0.6**	**0.4**
Bold red numbers indicate values that are out of specification.										

Table 7. Density test results for mix design G39654.						
Test #	**1**	**2**	**3**	**4**	**5**	**Ave.**
1	91.3	92.2	91.7	92.7	93.1	**92.2**
2	92.4	91.8	92.5	93.4	93.6	**92.7**

Mix design G30654R was used for the remainder of the project. As shown below in Table 9, the targets for the No. 4 and No. 8 sieve were increased from 44 and 29 to 46 and 31, respectively. The limits (tolerances) were also changed to reflect this adjustment. The volumetric, gradation and density test results for the pavement built with this mix design are shown in Tables 8 and 9, respectively. The density test results are shown in Tables 10 and 11. The production paving had considerable problems meeting the voids in the fine aggregate (VFA) target with 77% of the samples not within the specification band. There were also some problems with the Va and VMA values, but not to the extent noted with the VFA. For the gradation test results there were a few samples that did not fall within the tolerance limits for the 3/8 inch and #8 sieves. The density values were excellent with an average of 94.9% for the pavement built with G30654R.

A total of 26,499 tons was placed with a pay factor of 1.05 earned. The Contractor was paid a bonus of $13,038.62.

Table 8. Volumetric test results for mix design G30654R.								
	Test # & QA#	Pb	Va	VMA	VFA	D/A	Gmb	Gmm
Spec		**5.6**	**3.5**	**14.0 min**	**65-75**	**0.6-1.6**		
Limits		**5.1-6.1**	**2.0-5.0**	**13.0 min**				
G30654R		**5.6**	**3.5**	**13.3**	**74.0**	**1.3**	**2.394**	**2.480**
7/9	1	5.7	2.6	13.4	**80.6**	1.3	2.397	2.461
7/9	2	5.6	3.3	13.5	**75.6**	1.4	2.389	2.471
7/9	3	5.6	4.1	14.6	71.9	1.3	2.362	2.462
7/10	4	5.8	2.8	13.5	**79.3**	1.3	2.395	2.464
7/14	5	5.7	3.1	13.7	**77.4**	1.4	2.388	2.465
7/14	6	5.8	3.7	14.2	73.9	1.3	2.377	2.469
7/15	7	5.9	2.8	13.8	**79.7**	1.2	2.390	2.459
7/15	8	5.7	4.0	14.0	71.4	1.3	2.380	2.479
7/15	9	5.8	2.7	13.6	**80.1**	1.2	2.391	2.458
7/16	10	5.9	2.8	13.9	**79.9**	1.2	2.389	2.457
7/16	11	5.6	2.8	13.6	**79.4**	1.2	2.387	2.457
7/16	12	5.9	2.3	13.4	**82.8**	1.2	2.402	2.458
7/17	13	5.7	3.2	13.5	**76.3**	1.3	2.395	2.473
7/17	14	5.6	2.9	13.4	**78.4**	1.3	2.393	2.464
7/18	15	5.4	3.2	13.0	**75.4**	1.2	2.399	2.478
7/18	16	5.6	3.7	14.0	73.6	1.3	2.375	2.467
7/18	17	5.7	3.0	13.4	**77.6**	1.3	2.396	2.470
7/18	18	5.6	3.6	13.6	73.5	1.3	2.388	2.476
7/19	19	5.7	3.3	13.4	**75.4**	1.3	2.396	2.478
7/19	20	5.7	2.8	13.3	**78.9**	1.3	2.399	2.468
7/19	21	5.6	2.8	13.1	**78.6**	1.4	2.402	2.470
7/19	22	5.9	2.3	13.3	**82.7**	1.3	2.403	2.460
7/19	23	5.7	**1.9**	**12.9**	**85.3**	1.3	2.409	2.456
7/19	24	5.7	**1.3**	**12.5**	**89.6**	1.4	2.422	2.454
7/19	25	5.6	3.8	14.0	72.9	1.3	2.377	2.472
7/21	26	5.6	2.8	13.4	**79.1**	1.2	2.394	2.462
7/21	27	5.7	2.6	13.5	**80.7**	1.2	2.393	2.456
7/22	28	5.7	3.1	13.9	**77.7**	1.2	2.384	2.459
7/22	29	5.3	3.7	13.5	72.6	1.2	2.382	2.474
7/22	30	5.8	3.9	14.8	73.6	1.0	2.360	2.456
7/23	31	5.7	2.5	13.1	**80.9**	1.3	2.405	2.467
7/23	32	5.6	2.6	**12.7**	**79.5**	1.4	2.412	2.476
7/24	33	5.6	2.6	**12.9**	**79.8**	1.5	2.408	2.472
7/25	34	5.7	2.6	**12.8**	**79.7**	1.5	2.413	2.477
7/25	35	5.7	3.1	13.9	**77.7**	1.1	2.383	2.458
Prod. Ave.		**5.7**	**3.0**	**13.5**	**78.0**	**1.3**	**2.393**	**2.466**
Std. Dev.		**0.13**	**0.60**	**0.49**	**33.89**	**0.1**	**0.013**	**0.008**

Bold red numbers indicate sample is out of the specification limits.

Table 9. Aggregate gradation results for mix design G30654R.										
		¾"	½"	3/8"	#4	#8	#16	#30	#50	#200
Spec.	**Test # & QA#**	**100**	**90-100**	**90 Max.**		**28-58**				**2-7**
Limits		**94-100**	**93-100**	**79-90**	**41-51**	**28-35**				**3.7-7.0**
G30654		**100**	**99**	**85**	**46**	**31**	**20**	**15**	**10**	**5.7**
7/9	1	100	98	79	46	**29**	20	15	11	6.0
7/9	2	100	100	82	46	**29**	20	15	11	6.1
7/9	3	100	99	85	44	29	20	15	10	5.7
7/10	4	100	99	85	46	31	20	15	10	5.7
7/14	5	100	98	83	47	29	20	15	11	6.2
7/14	6	100	98	82	46	29	20	14	10	6.0
7/15	7	100	98	82	46	29	20	14	10	5.6
7/15	8	100	99	85	46	31	20	15	10	5.7
7/15	9	100	99	82	46	30	20	14	10	5.6
7/16	10	100	97	83	46	29	20	14	10	5.8
7/16	11	100	98	**76**	41	28	19	14	10	5.6
7/16	12	100	99	82	50	32	21	15	11	5.8
7/17	13	100	99	81	43	28	20	14	10	5.9
7/17	14	100	99	**78**	42	28	19	14	10	5.8
7/18	15	100	96	**76**	42	**27**	19	14	10	5.1
7/18	16	100	99	81	44	**27**	19	14	10	5.8
7/18	17	100	100	81	46	30	20	15	11	5.9
7/18	18	100	99	80	45	29	20	14	10	5.7
7/19	19	100	99	84	47	31	21	15	11	5.8
7/19	20	100	99	82	49	32	21	15	11	6.0
7/19	21	100	98	83	49	32	22	16	11	6.1
7/19	22	100	99	83	47	31	21	15	11	6.0
7/19	23	100	99	86	51	33	22	16	11	6.2
7/19	24	100	99	85	50	33	22	16	11	6.4
7/19	25	100	99	85	49	31	21	15	11	5.7
7/21	26	100	99	79	44	28	19	14	10	5.5
7/21	27	100	99	83	46	30	21	15	11	5.7
7/22	28	100	99	85	46	31	20	15	10	5.7
7/22	29	100	98	79	43	28	20	14	10	5.1
7/22	30	100	99	85	47	29	19	13	9	4.9
7/23	31	100	98	79	45	29	20	15	11	5.9
7/23	32	100	98	**77**	45	30	21	15	11	5.9
7/24	33	100	99	**78**	44	29	20	15	11	6.4
7/25	34	100	99	79	45	29	20	15	11	6.4
7/25	35	100	99	83	47	29	20	14	16	5.2
Prod. Ave.		**100**	**98.7**	**81.7**	**45.9**	**29.7**	**20.2**	**14.7**	**10.6**	**5.8**
Std. Dev.		**0.0**	**0.76**	**2.80**	**2.32**	**1.57**	**0.83**	**0.68**	**1.9**	**0.35**
Bold red numbers indicate sample is out of the specification limits.										

Table 10. Density test results for Superpave Class ½ inch mix design G30654R.							
Test #	**1**	**2**	**3**	**4**	**5**	**Ave.**	**Tonnage**
1	97.2	95.8	95.3	94.8	94.7	95.6	400
2	95.8	95.4	94.1	94.5	95.7	95.1	400
3	94.2	96.6	95.7	97.9	94.3	95.7	400
4	93.4	95.6	96.3	96.2	95.7	95.4	350
5	94.5	97.3	98.2	96.2	95.8	96.4	400
6	97.8	95.5	96.4	94.5	97.7	96.4	420
7	93.0	91.8	92.6	92.8	93.1	92.7	700
8	96.2	91.5	97.4	93.0	93.3	94.3	400
9	94.3	93.2	93.2	95.9	93.2	94.0	400
10	93.8	92.8	97.1	96.2	92.8	94.5	400
11	96.9	94.7	94.4	95.6	95.2	95.4	223
12	97.7	94.8	93.8	96.2	97.0	95.9	400
13	95.4	94.7	94.4	96.3	96.5	95.5	400
14	94.4	95.2	93.3	94.2	93.6	94.1	400
15	95.5	94.0	93.2	95.6	95.4	94.7	400
16	91.1	94.8	95.4	94.0	**90.4**	93.1	400
17	93.8	94.9	95.8	95.2	94.7	94.9	261
18	93.0	96.5	93.0	94.5	97.5	94.9	400
19	96.8	95.6	93.0	95.1	97.0	95.5	400
20	92.0	94.9	95.6	91.8	93.4	93.6	400
21	95.9	65.4	94.2	95.8	96.4	95.5	400
22	97.6	93.4	92.0	93.5	94.0	94.1	400
23	94.1	93.2	94.7	95.5	92.9	94.1	338
24	94.9	97.1	97.7	97.7	95.7	96.6	400
25	94.8	94.8	92.5	93.2	95.8	94.2	400
26	93.3	96.0	96.9	91.9	95.9	94.8	400
27	93.1	98.0	96.7	94.6	96.5	95.8	280
28	94.3	91.8	94.7	95.0	94.3	94.0	290
29	95.0	95.8	95.7	92.7	95.6	95.6	400
30	95.1	94.2	94.1	93.1	95.5	94.5	400
31	96.0	93.8	94.1	93.1	95.5	95.5	400
32	94.7	92.5	92.6	93.5	95.5	93.8	400
33	94.7	96.1	94.5	93.9	93.9	94.6	400
34	93.9	95.2	95.2	93.3	95.0	94.5	400
35	96.9	97.6	96.9	96.6	96.7	96.9	400
36	96.7	96.2	92.9	93.7	95.3	95.0	400
37	95.0	95.0	97.3	97.8	95.8	96.2	400
38	96.1	92.8	96.5	95.3	94.0	94.9	400
39	95.0	93.2	96.3	96.1	96.1	95.3	400
40	95.6	93.5	98.0	95.6	95.9	95.7	400
41	96.3	95.2	94.0	95.4	96.2	95.4	181
42	94.6	95.1	94.6	92.4	93.9	94.1	181
43	93.0	93.0	95.0	94.9	94.3	94.0	418
44	97.3	95.8	95.7	96.4	98.6	96.8	418
45	95.0	95.9	97.3	95.0	94.0	95.4	400
46	96.6	93.7	94.7	93.5	96.1	94.9	400
47	96.0	95.7	98.5	95.0	92.9	95.6	400

Table 11. Continued density test results for mix design G30654R.							
Test #	**1**	**2**	**3**	**4**	**5**	**Ave.**	**Tonnage**
48	95.6	94.8	92.9	95.5	97.3	95.2	370
49	93.2	94.5	94.5	94.6	95.1	94.4	400
50	97.0	94.3	93.6	96.6	94.3	95.2	400
51	94.3	94.6	95.6	93.2	95.7	94.7	400
52	95.0	95.3	95.4	92.2	95.9	94.8	400
53	93.9	95.3	93.6	91.3	91.8	93.2	430
54	96.0	94.3	94.7	97.0	94.9	95.4	400
55	94.3	93.9	93.2	93.0	91.4	93.2	400
56	95.4	95.3	95.5	96.8	93.2	95.2	400
57	92.7	94.3	94.5	94.3	94.6	94.1	400
58	93.5	93.1	96.2	95.6	94.5	94.6	355
59	96.0	92.9	96.8	95.0	92.9	94.7	355
60	97.4	94.0	97.0	97.3	95.8	96.3	400
61	96.2	97.3	65.4	95.8	95.3	96.0	400
62	93.7	94.1	64.9	95.9	94.3	94.6	378
63	95.8	97.2	97.9	94.5	97.5	96.6	378
					Project Average	**94.9**	
					Range	**92.7 - 96.9**	
Bold red numbers indicate sample is out of the specification limits.							

POST-CONSTRUCTION EVALUATION

All of the test sections were opened to traffic in August of 2003. Initial wear measurements were made with the Pathway Van in the fall of 2004 and these were repeated in the spring and fall of 2005. The whitetopping sections were cored in August of 2004 to investigate the nature of the cracking that had occurred in the 3 and 4 inch thick sections. The micro/macro surfacing sections have been evaluated yearly as a part of the warranty process for the macro surfacing.

Wear/Rutting

Figure 11 shows the transverse profile results from the Pathway van for the four test sections. As noted earlier measurements were taken in the fall of 2004, following construction, and again in the spring and fall of 2005. The transverse profiles show the amount of rutting or wear in the wheel paths. It is recognized that on PCC pavements the profile is showing pavement wear, whereas for the asphalt sections it may be either pavement wear or rutting or a combination of both. The wear measurement for the micro/macro-surfacing is an average for both lanes.

The rutting or wear has increased each year in all of the test sections. The micro/macro surfacing is showing the most wear or rutting at 5.1 mm and the whitetopping and Superpave at 3.6 mm with the least wear or rutting. The Modified Class D at 4.5 mm ranks at the next highest wear/rutting below the micro/macro surfacing. The most costly pavement, the whitetopping is showing the most resistance to studded tire wear and the least expensive treatment, the micro/macro surfacing, is showing the least resistance. If the rate of wear noted in the first two years is projected into the future the micro/macro-surfacing will reach 10 mm of rutting in another 1.9 years for a total life of 4 years. It is WSDOT's policy that pavements are scheduled for rehabilitation when they reach 10 mm of rutting. The whitetopping and Superpave would reach this target value in another 3.6 years for a total life of 5.6 years. The Modified Class D is expected to reach 10 mm of rutting in another 2.4 years for a total life of 4.4 years. There is no guarantee that the rate of wear is a constant value over time, therefore, these are only estimates.

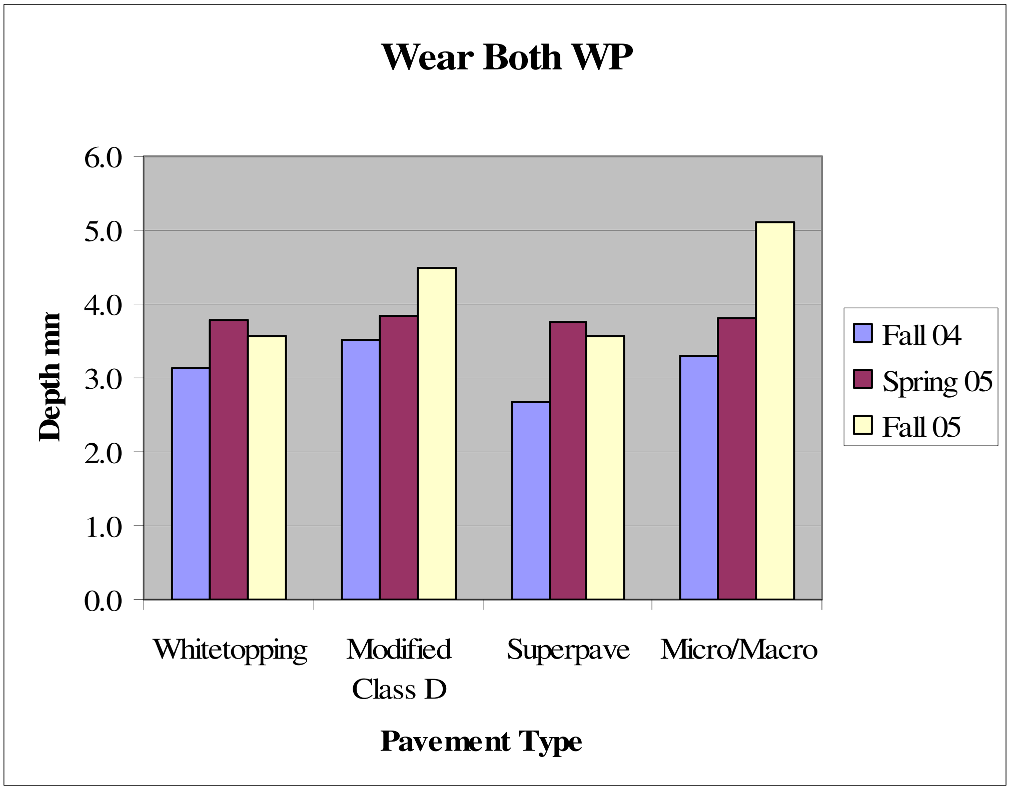


Figure 11. Average rutting or wear depths for each pavement type.

The increase in flexural strength from 650 psi to 800 psi does not appear to have had the same effect on the wear on the whitetopping as it did with the wear on the higher strength sections on SR-395. As was noted previously, the higher strength section on SR-395 had a greater initial resistance to wear from studded tires then the other sections with the lower strength mix. This initial resistance to wear has continued to be manifested in a decrease in total wear since they were constructed as compared to the lower strength sections.

The higher strength whitetopping and SPS section cannot be compared without a correction for traffic volumes and studded tire usage. The average directional daily traffic on SR-395 is 3,430 with as compared to I-90 with a 31,000 directional ADT. The SR-395 SPS sections would receive approximately the same traffic in 10 years as the I-90 section would receive in 1 year. The wear on the I-90 section was 3.1 mm in the Fall of 2004, one year from opening to traffic and this matches fairly closely with the 2.4 mm average measured on the SR-395 sections. There is no way to estimate the amount of studded tire use on either I-90 or SR-

395, but if the past survey results done by Maintenance are anywhere near accurate, it would suggest that the SR-395 section would have a lower percentage of vehicles using studded tires than the I-90 section. Therefore, the average wear rate of 2.4 mm on SR-395 would probably be equivalent to the wear rate on I-90 if a correction could be made for the lower percentage of vehicles using studded tires on SR-395.

Cracking

The 3 inch ultra-thin whitetopping section began displaying corner cracks (breaks) on both the centerline and shoulder transverse joint/lane edge intersections within two months of opening to traffic (see Figure 12). The 3 inch section has continued to show more cracking than the 4 inch or 5 inch section. The cracking of the 3 inch section was not unexpected. The literature warns against placing whitetopping on high traffic volume roadways in thicknesses less than 4 inches.

A survey of the Pathway images from the 2004 survey show the following statistics:

- 87% of the panels are cracked in the 3 inch section.
- 4% of the panels are cracked in the 4 inch section.
- 4% of the panels are cracked in the 5 inch section.

(A panel is considered to be a 5 foot by 6 foot area formed by the joint pattern.)

Figure 12. Typical corner crack within the 3-inch ultra thin whitetopping test section.

The cracking in the 3 inch section is characterized as corner cracks at almost all of the transverse/shoulder lane edge joints and many corner cracks at the transverse centerline joints. Corner cracks are also beginning to be noticed on both sides of the joint between the 5 x 6 panels. Longitudinal cracks are also noted in the shoulder side wheel path. These intersect with the corner cracks in many cases. Many of the shoulder side corner cracks are beginning to show some spalling. Photos of the cracking in the 3 inch section are shown in Figures 13, 14 and 15. The cracking in the 4 inch section is confined to a few corner cracks at the shoulder side transverse/lane edge joints. The cracking in the 5 inch section consists of only 2 corner cracks at the shoulder side transverse/lane edge joint and 5 mid-panel transverse cracks. These mid-panel transverse cracks do not show up in either the 3 or 4 inch sections (see Figure 16 for example of mid-panel crack). There is no continuation of the transverse cracks into the adjacent ACP shoulder.

Figure 13. Intersecting corner cracking in the 3 inch ultra-thin whitetopping section. August 2004.

Figure 14. Intersecting corner cracking in the 3 inch ultra- thin whitetopping section. August 2004.

Figure 15. Longitudinal view of intersecting cracking in the 3 inch ultra-thin section. August 2004.

Figure 16. Mid-panel transverse crack in 5 inch test section.

The white precipitate noticeable in the cracks (Figure 13, 14 and 15) was also noted in the MnROAD whitetopping sections (Burnham, 2005). There investigation revealed that the precipitate was calcium carbonate and that it was formed as a result of the carbonation of the concrete. Carbonation occurs in concrete because the calcium in the concrete is attacked by carbon dioxide and converts the calcium to calcium carbonate. The carbon dioxide enters the concrete through the water and air that enters the cracks. Normal carbonation results in a decrease of the porosity making the carbonated paste stronger which is an advantage in non-reinforced concrete.

An additional distress noted in the 3 inch ultra-thin whitetopping section is the presence of curling in the panels as noted in Figure 17. The series of waves or ripples is caused by the curling of the edges of each of the 5 foot panels. This is most noticeable in the 3 inch test section. Measurements made in August of 2004 by the Project Engineer on the original construction showed that the curling was greater than 3/16" in the 3 inch section and less than 1/16" in the 5 inch section. The measurements were made with a straightedge placed across each transverse joint. The cause of the curling is believed to be a moisture gradient where the top of the slab dries more rapidly then the middle and bottom of the slab. The loss of surface moisture causes the top of the slab to shrink creating a tension that curls the edges of the slab upward (Mark Snyder, personal correspondence).

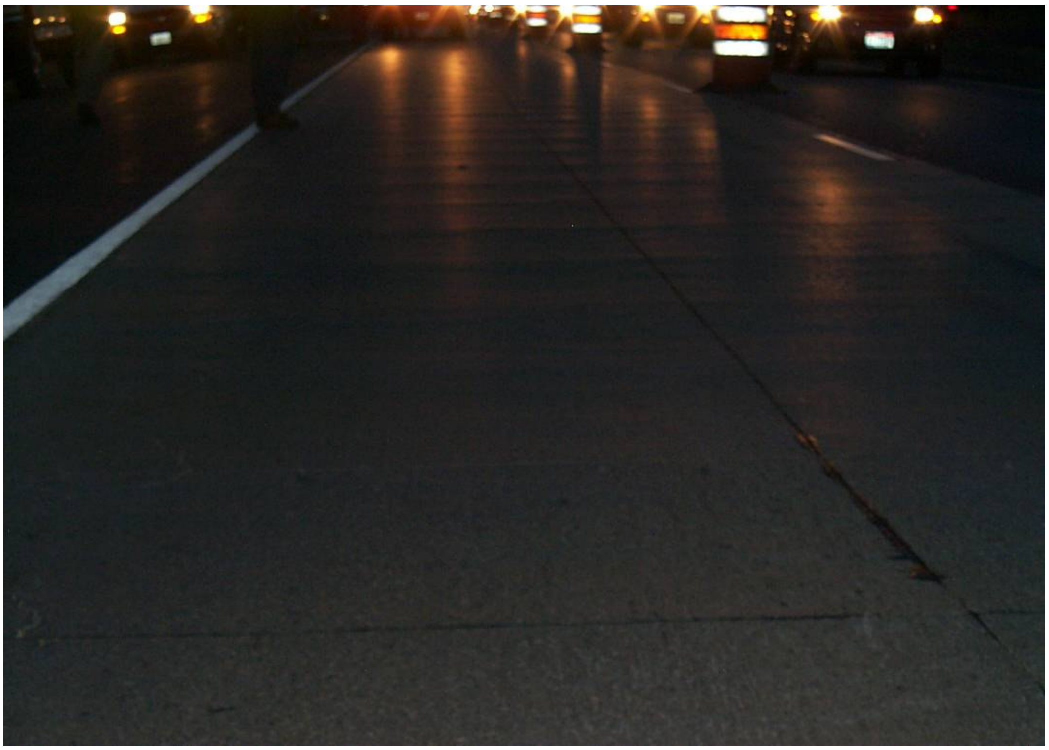


Figure 17. Night time photo of 3 inch ultra-thin whitetopping section showing curing of the panels.

Ride

Ride measurements were made with the Pathway Van on all of the sections at the same time that the wear measurements were taken. The results are shown in Table 12. The units of measure are the International Roughness Index (IRI) which is a widely used profile index that simulates the response of a passenger car to a roadway. A graph of the IRI values over time is shown in Figure 18. It is interesting to note the considerable difference between the ride values for Modified Class D, the Superpave ½ inch and the macro-surfacing sections as compared to the whitetopping section. It appears that the curling of the panels may be affecting the ride on this section. Note that the value for the micro/macro-surfacing section is a combination of the readings from both lanes.

Table 12. IRI values for the test section over time.

Test Section	Fall 2004	Spring 2005	Fall 2005
Whitetopping	89	88	110
Micro/Macro-Surfacing	63	59	66
Superpave Class ½" HMA	46	53	43
Modified Class D HMA	41	49	54

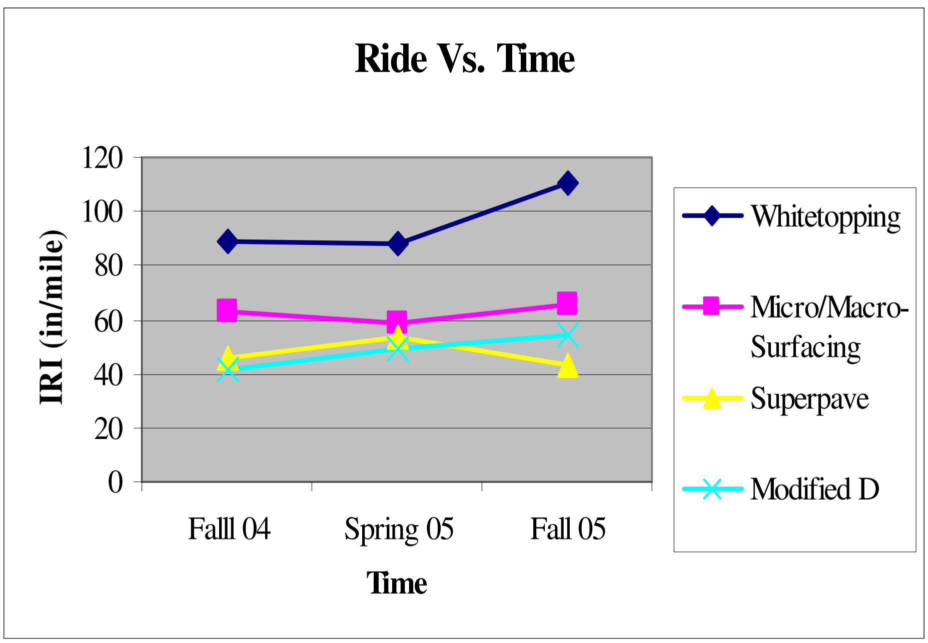


Figure 18. IRI versus time for the four pavement types.

Coring

The whitetopping was cored in August of 2004 to determine the condition of the pavement in both the cracked and crack free areas. Photos of the cores and their locations are shown in Appendix D. Eight cores were taken, five in the 3 inch section, and 1 each in the 4 and 5 inch sections. Four of the 5 cores from the 3 inch section were taken directly on crack locations (cores 1, 2, 4, and 5). Two of the cores were delaminated from the underlying asphalt pavement (cores 2 and 4) and two were solidly attached (cores 1 and 5). The one core from an area that was not cracked (core 3) was also solidly attached to the underlying pavement. Cores 2, 4, and 5 show multiple cracks in the body of the core that do not show up in the surface of the core, indicating greater internal deterioration of the PCC than one would assume from just looking at the surface of the pavement.

Cores were taken at crack locations in both the 4 and 5 inch sections. Both cores were delaminated from the underlying asphalt pavement. The core from the 4 inch section showed an additional crack below the surface.

Warranty Reviews

The construction contract included performance warranties for the micro-surfacing and macro-surfacing lasted 3 year and 1 year, respectively, from the date of physical completion (see Appendix C). A committee comprised of representatives from the Headquarters Pavement Management Section, the Headquarters Materials Laboratory, and the Regional Construction Office completed the required performance reviews. A copy of the one year review is included as Appendix E.

DISCUSSION

There are three areas of concern at this point in time. The first concern is with the rutting in the micro/macro-surfacing section. With the rut depth at 5.1 mm the rutting or wear is over half way to the 10 mm limit before resurfacing should be scheduled. Recent photos of the section show pop outs and delamination of the macro-surfacing adjacent to the wheel paths (see Figures 19 and 20). The life expectance of the section may be short based on these two issues.

Figure 19. Delamination of the macro-surfacing. Photo taken in January 2005.

Figure 20. Pop out in the macro-surfacing. Photo taken in January 2005.

The second concern is the cracking in the 3 inch section of the whitetopping. The large amount of corner and longitudinal cracks that are now spalling may indicate a short life for this section of whitetopping. Minnesota DOT placed sections of 3 inch whitetopping on their MnROAD test track (Burnham, 2005). Two of the three sections had 4’ by 4’ joint patterns and the third had a 5’ by 6’ spacing. The performance of the sections with the 4’ by 4’ spacing was much worse than the section with the 5’ by 6’ spacing and this difference was primarily due to the location of the joints in the wheel paths. Figure 19 shows the driving lane of MnROAD Test Cell 94 which was one of the 3 inch sections with 4’ by 4’ joint spacing. Note the corner cracking at every joint intersection. With time these locations developed potholes. In contrast, the section with the larger joint spacing performed much better, due primarily because the intersections of the longitudinal and transverse joints were not located in the wheel paths. Figure 20 shows the driving lane of Test Cell 95 that was built with a 5’ by 6’ joint spacing. The distress is concentrated in the area near the shoulder which is similar to what we are seeing on I-90. If our section progresses in a similar manner to the MnROAD section we should expect that some of the shoulder side corner cracked areas will continue to deteriorate and eventually require patching. Figures 21 and 22 are from the forensic report by Burnham, 2005.

Figure 21. Corner cracking in MnROAD Test Cell 94, 3 inch whitetopping with a 4 ft by 4 ft joint spacing. Photo courtesy of Mn/DOT.

Figure 22. Cracking in MnROAD Test Cell 95, 3 inch whitetopping with a 5 ft by 6 ft joint spacing. Photo courtesy of Mn/DOT.

The final concern is the delamination of the whitetopping from the underlying asphalt pavement. This was noted in the cores taken one year from opening to traffic and was present in all three thicknesses of whitetopping. Ultra-thin and thin whitetopping is designed as a composite section, therefore the loss of bonding to the underlying surface may lead to early failure. As noted in the WSDOT Pavement Guide Section 3.2.2.3:

> *PCC - flexible pavement bonding is critical to performance*. If the bond is inadequate, the PCC overlay will, in essence, function alone. This will substantially increase maximum slab tensile stresses, increasing the potential for cracking.

At this time it is impossible to determine the cause of the debonding. What we know from the coring is that it is occurring in portions of all three sections and that is was present within a year of opening to traffic. Although the surface of the underlying asphalt pavement was pressure washed and appeared clean it was noted that there could be a problem with in the 3 inch section because of the presence of the Superpave mix left in the rotomilled ruts.

PRELIMINARY PERFORMANCE CONCLUSIONS

Definitive conclusions cannot be drawn at this time due to the short length of time since construction of the sections. Evidence collected to date, however, does give some indication of the possible long term performance of some of the sections.

- The rate of rutting of 2.6 mm per year and the wear and delaminations noted in recent observations indicates that the performance life of the micro/macro-surfacing may be very short.
- The rate of rutting the Modified Class D at approximately 2.3 mm per year would provide a life expectancy of 4.4 to the 10 mm threshold if the rate remains constant.
- The rate of wear in the whitetopping section and wear/rutting in the Superpave control section at approximately 1.8 mm per year would provide a life expectancy of 5.6 years to the 10 mm threshold if the rate remains constant.
- The increase in cement content for the ultra-thin and thin whitetopping sections has not reduced the amount of studded tire wear as compared to the Superpave control section.

LONG TERM EVALUATION PLAN

The test sections are scheduled to be monitored for a period of 5 years as noted in the work plan found in Appendix D. The primary performance measure of interest is rutting, but friction, smoothness, and overall pavement performance will also be tracked and reported. Of particular interest is the debonding in all of the whitetopping sections and the beginning of spalling of the cracks in the 3 inch section. Both of these conditions warrant close monitoring.

REFERENCES

Burnham, Thomas R., 2005. "Forensic Investigation Report for Mn/ROAD Ultrathin Whitetopping Test Cells 93, 94, and 95," Maplewood, MN, Minnesota Department of Transportation, Office of Materials, Final Report, MN/RC - 2005-45.

Snyder, Mark, Consulting Engineer, Personal Communication, Pittsburg, PA.

WSDOT Interactive Pavement Guide, Washington State Department of Transportation, Materials Laboratory. http://wwwi.wsdot.wa.gov/maintops/mats/Apps/Pavement%20Guide%20Interactive/WSDOT_intro.htm

WSDOT Standard Specifications for Road, Bridge and Municipal Construction, 2000, English Version, M 41-10, Washington State Department of Transportation, Engineering Publications.

APPENDIX A

SR 395 SHRP SPS Test Section Update Report

Preface

The SPS test sections have been monitored since their construction in 1997. A report has been issued periodically that provides the current status of each of the test sections. The report was undated with wear measurements taken with the WSDOT Pathway Van in 2005. A brief summary of the results and how they relate to the I-90 whitetopping sections is included below. The updated report has also been included following the summary.

Summary

The SPS site consists of six sections built with 550 psi flexural strength mix and 6 with 900 psi flexural strength mix. One additional section was built with standard WSDOT 650 psi flexural strength mix to serve as a control section. The sections that were constructed with the higher flexural strength mix were initially more resistant to studded tire wear then the sections constructed with the lower strength mix. The initial wear measurements taken in 1998, 3 years after construction, showed an average of 0.5 mm of wear on the 900 psi sections and an average of 1.8 mm on the 550 psi sections. The WSDOT 650 psi control section had 1.4 mm of wear. The tined finish was still visible in the wheel paths of the 900 psi sections, but was completely worn away in the wheel paths of the 550 psi sections and the 650 psi control section. All wear measurements were made with the state owned Pathway van.

Another series of wear measurements were taken in 2005. They showed that the wear pattern established 3 years after construction is being maintained with each section experiencing about 2.0 mm of additional wear in the seven years elapsed between the two measurements. Following is the updated report on the SPS test sections.

Report Update

Reexamination of PCC Surface Wear and Tining

SR 395 – Adams County, Washington
LTPP Specific Pavement Studies
January 27, 2006

Introduction

The SPS PCC test sections were initially examined on August 20, 1998, by Jeff Uhlmeyer and Joe Mahoney. The purpose was to evaluate the surface wear in the wheelpaths and specifically on the tining grooves due to studded tires for all 13 sections (this includes the one WSDOT standard section). A representative from the paving contractor (Acme Materials and Construction of Spokane) noted during the Summer of 1998 that wear differences are apparent and appear to be associated with the different PCC mix designs (hence strength).

All 13 sections were paved during September 1995. The then applicable 1994 WSDOT Standard Specifications in Section 5-05.3(11) Finishing notes "The comb shall produce striations approximately 0.015 foot in depth at approximately ½-inch spacings in the fresh concrete." Thus, the Standard Specifications call for tine grooves about 4.6 mm in depth. The as-constructed depths were about 3.2 mm.

Three PCC mix designs were used to construct these SPS sections. From the report entitled "Construction Report on Site 530200—Strategic Study of Structural Factors for Rigid Pavements—SR 395—Adams County, Washington—Washington State Department of Transportation" prepared by Nichols Consulting Engineers, March 1997, the water cement ratios for the three PCC mixes used for the 13 sections are (based on actual field paving):

- 550 psi flexural strength: 0.46 W/C
- 650 psi flexural strength: 0.36 W/C
- 900 psi flexural strength: 0.29 W/C

All mixes have air entrainment and used a water reducer. The specific additives are Master Builders Pave Air 90 for air entrainment, Master Pave (a Type A water reducer), and Class F fly ash (fly ash was used in the "550 psi" and "650 psi" mixes but not the "900 psi" mix). The cement is a Type II supplied by Holnam from their Three Fork Montana, plant. The coarse aggregate is crushed basalt (obtained on the job site) and the fine aggregate a combination of natural field sand and crushed fines. Curing was achieved via a uniform coating of white pigmented curing compound placed on the PCC surface. The tining during construction occurred, on average, about 70 minutes after PCC placement for the 550 psi mix and after 20 minutes for the 900 psi mix (this excludes Section 530208 due to a partial water cure which resulted in a longer time period between PCC placement and tining). The average flexural strengths for the three mixes follows and are listed for 14 and 28 day cure beams:

"550 psi mix"

14 day beams:	485 psi
28 day beams:	709 psi

"650 psi mix"

14 day beams:	612 psi
28 day beams:	663 psi

"900 psi mix"

14 day beams:	831 psi
28 day beams:	945 psi

Data and Discussion

Table 1 was used in the August 1998 (three years following construction) letter report to summarize the average wear depth and observations about the tine grooves. (Flexural strength was used as in "indicator" variable to delineate between the three PCC mixes.) That data revealed that there were differences between the various PCC mixes. The 900 psi 14-day flexural strength showed little wheel path wear following three winters. The 550 and 650 psi had most of the tining in the wheel paths worn away.

On November 24, 2002, Joe Mahoney performed a quick review of studded tire wear in the SPS sections—about seven years following construction. Photographs for three of the sections, contained in Table 2, show that the 900 psi sections continue to perform better than the 550 or 650 psi ones with respect to studded tire wear. In fact, little additional wear is apparent for the 900 psi sections. The 550 and 650 psi sections have changed only modestly, as well, but all tining in the wheel paths is worn away.

On November 20, 2004, Joe Mahoney again performed a quick review of the studded tire wear in the SPS sections—about nine years following construction. Photographs for three of the sections, contained in Table 3, show that the 900 psi sections continue to perform better than the 550 and 650 psi one with respect to studded tire wear. Note that for the 900 psi sections, Section 530210 was substituted for 530202 (compare Tables 2 and 3).

On January 27, 2006, Keith Anderson updated the wear measurement information by adding data from the 2005 Pathway Van. The Pathway Van measures the wear in each wheel path using lasers and is therefore much more accurate than the 1998 wear measurement made with a straightedge. The 2005 data is added as an additional column in the original table of 1998 wear measurements. In addition, a chart showing the wear for each section for both surveys is included as Figure 1.

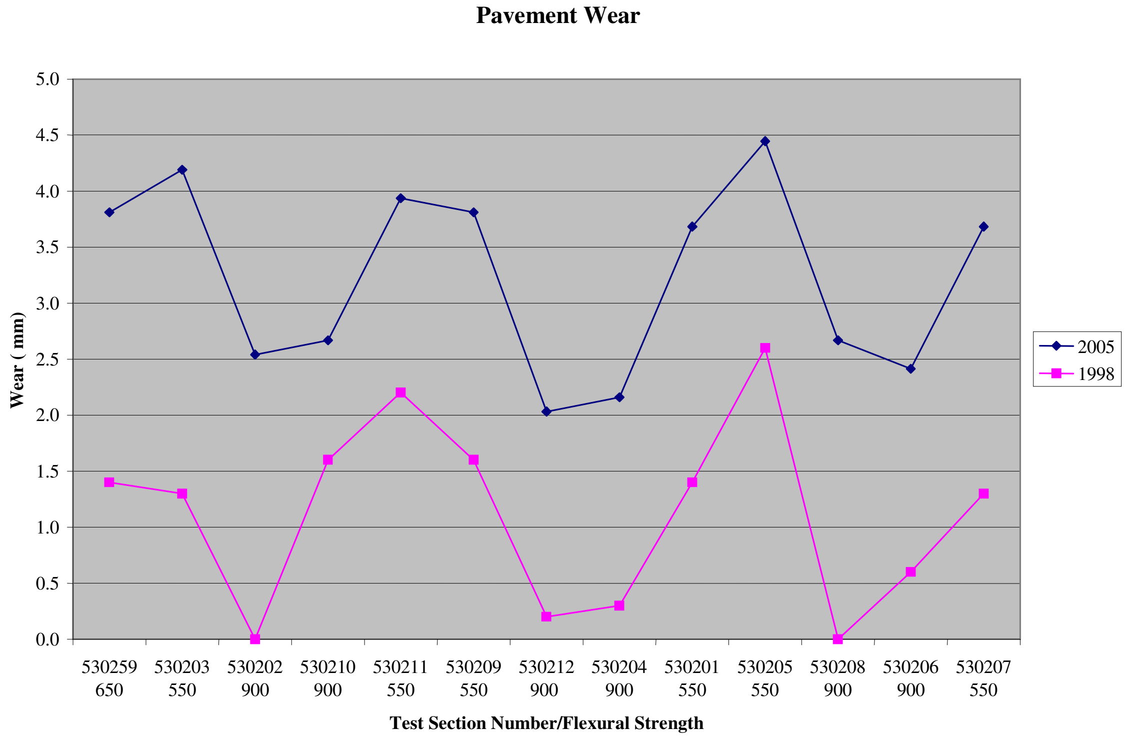


Figure 1. Pavement wear for each test section from 1998 and 2005 surveys.

Bottom Line

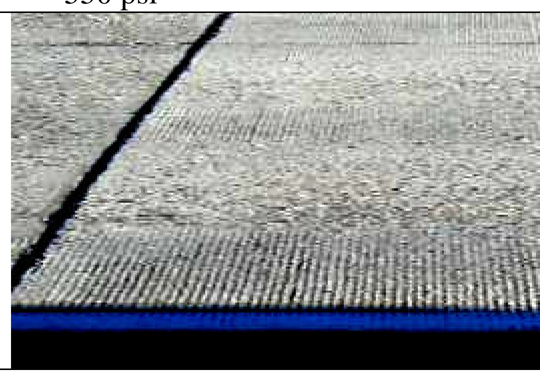
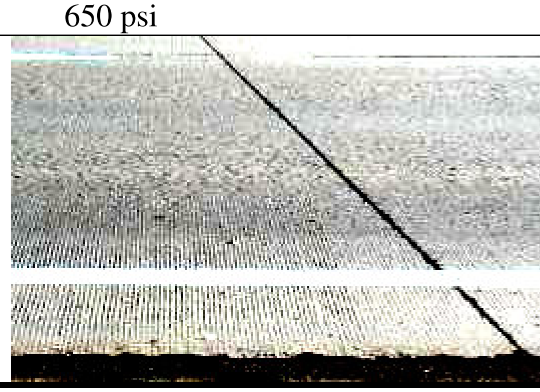
To date there is definitely less wear due to studded tires in the high strength sections (900 psi) as compared to the lower strength sections (550 and 650 psi). Further, the tine grooves are still apparent in the high strength sections and are, in essence, gone from the lower strength ones. The 2005 wear measurements mirror the 1998 measurements and show only about an average of 2.1 mm increase in wear in the seven years between surveys. The equal wear rate in the past seven years for all of the sections might indicate that the higher flexural strengths only reduced the initial wear of those sections. It will be interesting to monitor the wear rates for the next 5-10 years to see if this trend continues.

Table 1. Summary of SPS PCC Sections Wheelpath Wear in 1998 and 2005

SPS Identification No.	Section PCC Slab and Mix Design Features	1998 Average Wear Depth (mm)	2005 Average Wear Depth (mm)	Comments
530201	8” PCC 550 psi	1.4	3.7	Grooves barely visible in the WP
530202	8” PCC 900 psi	0.0	2.5	Tine depths range from 0 to 1.6 mm in the mainlane to 1.6 to 3.2 mm on the outside edge of the pavement.
530203	11” PCC 550 psi	1.3	4.2	Grooves generally not visible in the WP but 1.6 to 3.2 mm depth on the outside edge.
530204	11” PCC 900 psi	0.3	2.2	Grooves in WP worn but apparent.
530205	8” PCC 550 psi	2.6	4.4	Grooves are completely gone in the WP.
530206	8” PCC 900 psi	0.6	2.4	Grooves in WP worn but apparent.
530207	11” PCC 550 psi	1.3	3.7	Grooves in WP almost completely gone.
530208	11” PCC 900 psi	0.0	2.7	Grooves in WP in good condition.
530209	8” PCC 550 psi	1.6	3.8	Grooves in WP almost completely gone.
530210	8” PCC 900 psi	1.6	2.7	Grooves in WP worn but apparent.
530211	11” PCC 550 psi	2.2	3.9	Grooves barely visible in the WP.
530212	11” PCC 900 psi	0.2	2.0	Grooves in WP barely worn.
530259 (WSDOT Standard Section)	10” PCC 650 psi	1.4	3.8	Grooves barely visible in the WP.

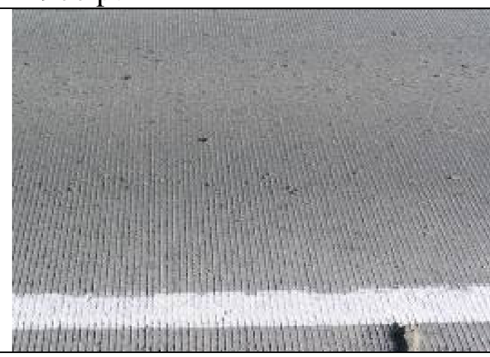
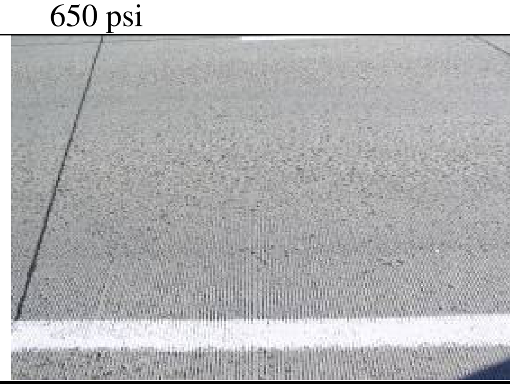
- PCC strengths are design 14 day flexural – based on beams.
- Wear depths in 1998 were measured in the outside lane and the outside wheelpath (WP) approximately three feet from the fog stripe. The Pathway Van was used in 2005 to measure the wear depth and it is an average of both wheelpaths.

Table 2. Summary of SPS PCC Sections Wheel Path Wear—November 24, 2002

<table>
<tr><th>SPS Identification No.</th><th colspan="2">Section PCC Slab and Mix Design Features
(Photographs taken November 24, 2002)</th></tr>
<tr><td rowspan="2">530202</td><td colspan="2">8” PCC
900 psi</td></tr>
<tr><td>
</td><td></td></tr>
<tr><td rowspan="2">530203</td><td colspan="2">11” PCC
550 psi</td></tr>
<tr><td>
</td><td></td></tr>
<tr><td rowspan="2">530259
(WSDOT Standard Section)</td><td colspan="2">10” PCC
650 psi</td></tr>
<tr><td>
</td><td></td></tr>
</table>

- PCC strengths are design 14 day flexural – based on beams.

Table 3. Summary of SPS PCC Sections Wheel Path Wear—November 20, 2004

SPS Identification No.	Section PCC Slab and Mix Design Features (Photographs taken November 20, 2004)
530202	8” PCC 900 psi  
530203	11” PCC 550 psi  
530259 (WSDOT Standard Section)	10” PCC 650 psi  

- PCC strengths are <u>design</u> 14 day flexural – based on beams.

APPENDIX B

Mix Designs

Whitetopping

Date Submitted:	6/13/2003
Contractor:	Acme Concrete Paving Prime Contractor
Subcontractor:	Central Pre-Mix Concrete Co. Subcontractor
Cement:	Lafarge Type I-II
Fly Ash:	ISG Resources, Inc. Class F
Water Reducer:	W.R. Grace & Company, WRDA-64, Type A, 28-36 oz/cy
Air Entrainment:	W.R. Grace & Company, Davarair, 6-10 oz/cy
Fibers:	W.R. Grace & Company, STRUX 90/40, 3.0 lbs/cy
Pit Number:	PSC-173 for 5/8”, 3/8”, coarse sand, and PSC-297 for fine sand
Aggregate:	Combined Gradation, 4 components, 5/8”, 3/8”, C/S, F/S, 30%, 25%, 25%, 20%, respectively
Cement Quantities:	650 lbs Type I-II, 160 lbs Class F
W/C Ratio:	0.33
Strength:	800 psi flexural at 14 days

Modified Class D HMA

Date Submitted: 5/29/2003
Pit Sources: Crushed Surfacing Base Course – PSC-173
Mineral Aggregate – PSC-173
Blend Sand – PSC-120
JMF: Modified Class D
Sand Equivalent: 67
Asphalt Content: 5.2%
Anti-Strip Additive: 0.50% Polarbond
Grade of Asphalt: 70-28
Mix ID Number: G30651

Material	1" – 3/8"	¾" – 3/8"	3/8" – 0		
Source	**C-173**	**C-173**	**C-173**	**Combined**	**Specification**
Ratio	**32.0%**	**33.0%**	**35.0%**	**100%**	
---	100.0	100.0	100.0	100.0	
---	100.0	100.0	100.0	100.0	
1	99.2	100.0	100.0	100.0	99-100
¾	73.5	100.0	100.0	92	85-96
½	12.0	81.7	100.0	66	60-71
4	1.5	1.2	60.1	22	14-27
8	1.2	1.1	39.0	14	8-20
200	0.5	0.9	7.5	3.1	1.0-6.0

Fracture Requirements: ¾ " 98%
½ " 92%
#4 100%

Coarse Aggregate: Bulk Specific Gravity (SSD) 2.680
Bulk Specific Gravity 2.663
Apparent Specific Gravity 2.709
Absorption (%) 0.64

Washington State Department of Transportation – Materials Laboratory
PO Box 47365 Olympia / 1655 S 2nd Ave. Tumwater / WA 98504
BITUMINOUS SECTION TEST REPORT

TEST OF: A.C.P MIX DESIGN CLASS D MOD	WORK ORDER NO: 006582
DATE SAMPLED: 05/29/2003	LAB ID NO: 0000292058
DATE RECVD HQS: 06/02/2003	TRANSMITTAL NO: 435117
SR NO: 90	MIX ID NO: G30651

Section: SULLIVAN RD. TO IDAHO STATE LINE – PHASE 1

---CONTRACTOR'S PROPOSAL---

Mat'l:	1" – 3/8"	3/4" – 3/8"	3/8" – 0	COMBINED	SPECIFICATIONS
Source:	C-173	C-173	C-173		
Ratio:	32%	33%	35%	100%	
-----	100.0	100	100.0	100	
1"	99.2	100	100.0	100	99-100
3/4"	73.5	100	100.0	92	85-96
1/2"	12.0	81.7	100.0	66	60-71
No. 4	1.5	1.2	60.1	22	14-27
No. 8	1.2	1.1	39.0	14	8-20
No. 200	0.5	0.9	7.50	3.1	1.0 – 6.0

---LABORATORY ANALYSIS------------------------SPECIFICATIONS--

ASPH% BY TOTAL WT OF MIX:%:	4.3	4.8	5.2	5.7	6.1	6.5
Stabilometer "S" Value:						
Coheisometer "C" Value:						
Density (lbs/cf):						
% Voids – Volume in Mix:						
% Voids in Mineral Agg:						
Max Density from Rice:						

---LOTTMAN STRIPPING EVALUATION---

% ANTI-STRIP	0%	1/4%	1/2%	3/4%	1%
Visual Appearance:	SLIGHT	SLIGHT	NONE	NONE	NONE
% Retained Strength:					

---RECOMMENDATIONS---

SUPPLIER	KOCH	
GRADE	PG70-28	
% ASPHALT (BY TOTAL MIX)	5.2%	
% ANTI-STRIP (BY WT.)	0.50	
TYPE OF ANTI-STRIP	POLARBOND	
Max Density lbs/cf		
MIX ID NUMBER	30651	
MIXING TEMPERATURE	268 TO 278 F	
Ignition Furnace Correction Factor:	0.07	INFORMATIONAL ONLY

Remarks:

Headquarters: T160- 1
Materials File--------------------------X T166- 2
Bituminous Section------------------ X T172 -
Region: Eastern T178 -
Construction Office- 46 ----------X
Materials Eng------- 46 ----------X
P.E.: D. McCALLUM--------- --X(2)

THOMAS E. BAKER, P.E.
Materials Engineer
By: Dennis M. Duffy P.E. ____________________
(360)709-5420
Date: 06 / 24 / 2003

Micro/Macro Surfacing

Date Submitted: 6/3/2003
Contractor: Intermountain Slurry Seal
Aggregate Source: PSC-173
Asphalt Source: Koch/Exxon
Aggregate: 100% *
Emulsion: 11.0 – 13.0%
Water: 1.0%
Additive (4% in sol.): 0 – 1% **
Mix Design Number: 2003.0458

*** Gradation has 11.6% passing the 200 sieve if gradation varies and the passing 200 is 15% then mix time and the quality of the system will decrease.**
**** Additive levels about this range may slow down the cure and set times considerably.**

Aggregate	Test	Result	Minimum	Maximum
Gradation, Type III		**Pass**	**-**	
Sand Equivalent	D2419	65	60	
Mix Report	ISSA A143			
Cohesion@ 30 min.	TB139*	15	12 @ 30 min.	
Cohesion@ 60 min.	TB138*	NS	20(NS) @ 60 min.	
Wet Track Abrasion Loss (g/ft^2)	TB100	40.4 @ 11% 26.9 @ 11%	-	50 @ 1-Hour 75 @ 6-Day
Classification Compatibility	TB144	11	11	-
Mix Time @ 25^0C, sec	TB113	250	120	-
Lateral Displacement, %	TB147	1.68 @ 13%	-	5
Excess Asphalt, (g/ft^2)	TB109	33.0 @ 13%	-	50
***ISSA TB139 "Mode of Rupture" Value**				

Gradation			
Sieve	**% Passing**	**Specification**	
1"	100.0	100	100
¾"	100.0	100	100
½"	100.0	100	100
3/8"	100.0	100	100
#4	83.6	70	90
#8	56.1	45	70
#16	38.5	28	50
#30	27.5	19	34
#50	20.3	12	25
#100	15.2	7	18
#200	11.9	5	15
Pan			

Wet Track Abrasion						
Sample	**A**	**B**	**C**	**D**	**E**	**F**
% Emulsion	11.0	13.0	15.0	11.0	13.0	15.0
% Total Moisture	7.5	6.5	5.5	7.5	6.5	5.5
% Cement	1.0	1.0	1.0	1.0	1.0	1.0
%Additive(4% sol)	0.0	0.0	0.0	0.0	0.0	0.0
Avg. Loss (g/ft^2)	40.4	23.9	19.9	26.9	23.9	30.3
Specification	50	50	50	75	75	75
Conditioning	1-Hour	1-Hour	1-Hour	6-Day	6-Day	6-Day

The mix design for the micro surfacing was developed by Koch Pavement Solutions for the contractor, Intermountain Slurry Seal. It specified the following for the Type III Microsurfacing, International Slurry Seal Association (ISSA):

Summary: A micro surfacing mix report was performed using Ralumac from Koch Performance Asphalt Company in North Salt Lake, UT and Type III aggregate Sullivan Pit:

Application: Surfacing----yes
Rut Fill------yes
Aggregate: 100%*
Emulsion: 11.0 to 13.0% (Ralumac)
Water: 5.0 to 11.0%
Cement: 1.0%
Additive (4% in sol.): 0 to 1%**

Slight modification of the mix design may be necessary in the field due to weather and surface conditions. This must be evaluated by the user at the job site. See note at end.

*Gradation has 11.6% passing the 200 sieve if gradation varies and the passing 200 is 15% then mix time and quality of the system will decrease.
**Additive levels about this range may slow down the cure and set times considerably.

The recommended gradation was:

Sieve	% Passing	Specification	
1”	100.0	100	100
¾”	100.0	100	100
1/2”	100.0	100	100
3/8”	100.0	100	100
#4	83.6	70	90
#8	56.1	45	70
#16	38.5	28	50
#30	27.5	19	34
#50	20.3	12	25
#100	15.2	7	18
#200	11.9	5	15
Pan			

Sand Equivalent: 65%

Class Superpave ½ inch

Date Submitted: 5/29/2003
Pit Sources: PSC-173
JMF: A.C.P. Class Superpave ½"
Sand Equivalent: 67
Asphalt Supplier: Koch Asphalt
Grade of Asphalt: 70-28
Asphalt Content: 5.6%
Anti-Strip Additive: 0.0
Mix ID Number: G30654

Material	1/2" – 1/4"	3/8 – 0		
Source	**C-173**	**C-173**	**Combined**	**Specification**
Ratio	**30.0%**	**70.0%**		
¾"	100.0	100.0	100.0	100
½"	95.2	100.0	99	90-100
3/8"	56.8	97.4	85	<90
4	7.0	60.5	44	
8	4.0	40.0	29	28-58
16	2.3	28.2	20	1.0-6.0
30	2.2	20.3	15	
50	2.1	13.8	10	
100	2.0	9.5	7	
200	1.8	7.3	5.7	2.0-7.0

Fracture: **100%**

Coarse Aggregate:

Bulk Specific Gravity (SSD)	2.671
Bulk Specific Gravity	2.643
Apparent Specific Gravity	2.719
Absorption (%)	1.05

Washington State Department of Transportation – Materials Laboratory
PO Box 47365 Olympia / 1655 S 2nd Ave. Tumwater / WA 98504
BITUMINOUS SECTION TEST REPORT

TEST OF: A.C.P MIX DESIGN CLASS SUPERPAVE 1/2”		WORK ORDER NO:	006582
DATE SAMPLED:	05/29/2003	LAB ID NO:	0000292061
DATE RECVD HQS:	06/02/2003	TRANSMITTAL NO:	292061
SR NO:	90	MIX ID NO:	G30654
Section:	SULLIVAN RD. TO IDAHO STATE LINE – PHASE 1		

---CONTRACTOR’S PROPOSAL---

Mat’l:	1/2" – 1/4"	3/8” – 0	COMBINED	SPECIFICATIONS
Source:	C-173	C-173		
Ratio:	30%	70%		
1 1/2"	100	100		
1”	100	100		
3/4”	100	100	100	100
1/2"	95.2	100	99	90 - 100
3/8”	56.8	97.4	85	< 90
No. 4	7.0	60.5	44	
No. 8	4.0	40.0	29	28 - 58
No. 16	2.3	28.2	20	
No. 30	2.2	20.3	15	
No. 50	2.1	13.8	10	
No. 100	2.0	9.5	7	
No. 200	1.8	7.3	5.7	2.0 – 7.0

--LABORATORY ANALYSIS------------------------SPECIFICATIONS--

ASPH% BY TOTAL WT OF MIX:	5.1	5.6	6.0	
%Gmm @ Ninit: 8	85.1	86.2	86.7	≤ 89.0
% VOIDS @ Ndes: 100	5.1	3.5	2.7	Approximate 3.5
% VMA @ Ndes: 100	13.9	13.3*	13.5	≥ 14.0*
% VFA @ Ndes: 100	63	74	80	64 – 75
%Gmm@ Nmax: 160		97.1		≤ 98.0%
DUST/ASPHALT RATIO	1.5	1.3	1.2	0.6 - 1.6
Pbe – Percent Binder Effective	3.9	4.3	4.7	
Gmm – MAX S. G. FROM RICE	2.493	2.480	2.467	
Gmb – BULK S. G. OF MIX	2.367	2.394	2.400	
Gsb – OF AGGREGATE BLEND		2.609		
Gsb – OF FINE AGGREGATE		2.567		
Gb – SPECIFIC GRAVITY OF BINDER		1.041		

--LOTTMAN STRIPPING EVALUATION--

% ANTI-STRIP	0%	1/4%	1/2%	3/4%	1%
Visual Appearance:	NONE	NONE	NONE	NONE	NONE
% Retained Strength:	92	95	95	100	101

--RECOMMENDATIONS---

SUPPLIER	KOCH ASPHALT	
GRADE	PG70-28	
% ASPHALT (BY TOTAL MIX)	5.6%	
% ANTI-STRIP (BY WT.)	0.0	
TYPE OF ANTI-STRIP		
IGNITION CALIBRATION FACTOR	0.29	(INFORMATIONAL ONLY)
MIX ID NUMBER	G30654	
MIXING TEMPERATURE	329	
COMPACTION TEMPERATURE	298	

Headquarters: T152 - 3 REMARKS: VERIFY MIXING AND COMPACTION
Construction Engineer----------------X T153 - TEMPERATURE PRIOR TO PRODUCTION
Materials File--------------------------X T166 - 2 RICE VALUE 2.480 = 154.4 lb/cf
General File----------------------------X T172 - *VMA OUT OF SPECIFICATION
Bituminous Section------------------ X T175 -
Region: Eastern T178 - 1
Construction Office- 46 ----------X
Materials Eng------- 46 ----------X
P.E.: D. McCALLUM--------- --X(2)

THOMAS E. BAKER, P.E.
Materials Engineer
By: Dennis M. Duffy P.E. ____________________
(360)709-5420
Date: 06 / 24 / 2003

APPENDIX C

Contract Special Provisions

DIVISION 5
SURFACE TREATMENTS AND PAVEMENTS

ASPHALT CONCRETE PAVEMENT

Description
The first sentence of the third paragraph of Section 5-04.1 is revised to read as follows:

(February 5, 2001)
Asphalt concrete Class A, Class B, Class D, Class F, Class G, and asphalt concrete Class Superpave are designated as leveling or wearing courses.

Section 5-04.1 is supplemented with the following:

(******)
Asphalt concrete pavement class modified D shall meet the requirements for asphalt concrete pavement class D except as modified herein.

(******)
Micro-surfacing for rut fill work shall consist of a mixture of polymerized asphalt emulsion, mineral aggregate, mineral filler, water and other additives properly proportioned, mixed and applied on a paved surface.

Macro-surfacing wearing course work shall consist of an application of polymer modified asphalt emulsion followed by a single layer of aggregate.

Materials

Section 5-04.2 is supplemented with the following:

Test Requirements
Section 9-03.8 (2) is supplemented with the following:

Asphalt Concrete Pavement Class Superpave
Aggregate for asphalt concrete pavement Class Superpave shall meet the following test requirements:

The aggregate shall meet the Flat and Elongated shape requirements, measured as percent by weight of flat-elongated in accordance with ASTM Test Method D4791, the percent shall not exceed 10 percent. The ratio shall be 5:1.

The fracture requirements for the combined coarse aggregate are at least *** 2 *** fractured face(s) on 90% of the material retained on each specification sieve U.S. No. 4 and above, if that sieve retains more that 5% of the total sample, when tested in accordance with WAQTC TM-1.

The fine aggregate angularity for the combined fine aggregate is tested in accordance with AASHTO T304, Method A. The minimum voids shall be 45%.

The minimum sand equivalent for the aggregate shall be 37.

The properties of the aggregate in the mix design for asphalt concrete pavement Class Superpave shall be such that, when it is combined within the limits set forth in Section 9-03.8(6) and mixed in the laboratory with the designated grade of asphalt cement, using the Superpave gyratory compactor in accordance with AASHTO 312, at *** 8 *** gyrations for N initial, *** 100 *** gyrations for N design, and *** 160 *** gyrations for N maximum, shall produce mixtures with the following test values:

	Class 3/8 In.		Class 1/2 In.		Class 3/4 In.		Class 1 In.	
Mix Criteria	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
Voids in Mineral Aggregate (VMA)	15.0%		14.0%		13.0%		12.0%	
% Voids Filled with Asphalt (VFA)	N/A	N/A	65	75	N/A	N/A	N/A	N/A
% Gmm at N int		N/A		89.00		N/A		N/A
% Gmm at N max		98.0		98.0		98.0		98.0
Dust / Asphalt Ratio	0.6	1.6	0.6	1.6	0.6	1.6	0.6	1.6
Modified Lottman Stripping Test	Pass		Pass		Pass		Pass	
% Air Voids (Va) (target value)	3.5%		3.5%		3.5%		3.5%	

The second paragraph of Section 9-03.8(2) is revised to read as follows:

When material is being produced and stockpiled for use on a specific contract or for a future contract, the fine aggregate angularity, flat and elongated particles, fracture and sand equivalent requirements shall apply at the time of stockpiling. When material is used from a stockpile that has not been tested as provided above, the fine aggregate angularity, flat and elongated particles, fracture and sand equivalents shall apply at the time of its introduction to the cold feed of the mixing plant.

Proportions of Materials

Section 9-03.8(6) is supplemented with the following:

Asphalt Concrete Pavement Class Superpave

The asphalt concrete shall be within the requirements listed in the following table, and meet the volumetric requirements listed in Section 9-03.8(2). When the mixture is tested in the field using the gyratory compactor, the mixture will have air voids within 2% to 5% at N design gyration level. Voids in mineral aggregate (VMA) so determined shall be greater than a value of 1.0% below the specified VMA value for the class of mix used. (i.e. for a design value of not less than 13.0%, the field acceptance value shall not be less than 12.0%)

The Contractors mix design proposal shall be between the control points, and shall not cross the maximum density line within the limits of the restricted zone as indicated in the following table.

The aggregate percentage refers to completed dry mix, and includes mineral filler when used.

Aggregate Gradation Control Points

Sieve Sizes	Grading Requirements Class Superpave			
	3/8 In.	**1/2 In.**	**3/4 In.**	**1 In.**
1 1/2" square				100
1" square			100	90 - 100
3/4" square		100	90 - 100	90 Maximum
1/2" square *	100	90 - 100	90 Maximum	*
3/8" square *	90 - 100	90 Maximum	*	*
U.S. No. 4 *	90 Maximum	*	*	*
U.S. No. 8 *	32 - 67	28 - 58	23 - 49	19 - 45
U.S. No. 200 *	2.0 - 7.0	2.0 - 7.0	2.0 - 7.0	1.0 - 7.0

* The noted screens have associated weighting factors listed in Section 5-04.5(1)A, Price Adjustment for Quality of AC Mix.

Boundaries of Aggregate Restricted Zone

	Class Superpave							
Sieve Sizes	**3/8 In.**		**1/2 In.**		**3/4 In.**		**1 In.**	
	Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
U.S. No. 4							39.5	39.5
U.S. No. 8	47.2	47.2	39.1	39.1	34.6	34.6	26.8	30.8
U.S. No. 16	31.6	37.6	25.6	31.6	22.3	28.3	18.1	24.1
U.S. No. 30	23.5	27.5	19.1	23.1	16.7	20.7	13.6	17.6
U.S. No. 50	18.7	18.7	15.5	15.5	13.7	13.7	11.4	11.4

Basis of Acceptance

Section 9-03.8(6)A, Item 3, subsection a, is supplemented with the following:

Class Superpave

Constituent of Mixture	**Tolerance Limits** The tolerance limit for each mix constituent shall not exceed the limits of the control points, except the tolerance limits for sieves designated as 100% passing will be 99-100.
Aggregate passing , 1", 3/4", 1/2" and 3/8" sieves	± 6%
Aggregate passing U.S. No. 4 sieve	± 5%
Aggregate passing U.S. No. 8 sieve	± 4%
Aggregate passing U.S. No. 200 sieve	± 2.0%
Asphalt cement	± 0.5%

These tolerance limits constitute the allowable limits as described in Section 1-06.2.

Section 9-03.8(6)A, Item 3, subsection c. 1, is supplemented with the following:

Asphalt Concrete Pavement Class Superpave

Aggregates. Upon written request from the Contractor, the Project Engineer may approve field adjustments to the JMF a maximum of 2 percent for the aggregate retained on the U.S. No. 8 sieve and above, 1 percent for aggregate passing the U.S. No. 8 sieve, and 0.5 percent for the aggregate passing the U.S. No. 200 sieve. These field adjustments to the JMF may be made by the Project Engineer provided the changes will produce material of equal or better quality.

Section 9-03.8(2) is supplemented with the following:

(******)
The fracture requirements for the aggregate for asphalt concrete pavement class modified D are at least two fractured faces on 90% of the material retained on each specification sieve U.S. No. 4 and above and at least one fractured face on 75% of the material retained on sieve U.S. No. 8. These fracture specifications apply to those sieves which retain more that 5% of the total sample, when tested in accordance with WAQTC TM-1.

Section 9-03.8(6) is supplemented with the following:

(******)
The grading and asphalt requirements for asphalt concrete pavement class modified D are as follows:

1" square	99-100%
¾" square	85-96%
½" square	60-71%
US No 4	14-27%
US No 8	8-20%
US No 200	1.0-6.0%
Asphalt % of total mixture	4-8%

(******)
Aggregate

Quality Tests
The aggregate for Micro-surfacing material shall meet the following criteria:

Test	Quality	Specification
AASHTO T176 (ASTM D2419)	Sand Equivalent	65 minimum
AASHTO T104 (ASTM C88)	Soundness	15% max w/ NA_2SO_4 or 25% w/ $MgSO_4$
AASHTO T96 (ASTM C131)	Abrasion Resistance	30% maximum

The aggregate for Macro-surfacing material shall meet the following criteria:

Test	Quality	Specification
FLH T508	Flakiness Index	17% maximum
AASHTO TP58	Micro-Deval	18 maximum
TM102	Deleterious materials	0.5% maximum
ASTM C127	Absorption	2% maximum
ASTM D5821	Fracture	98% One Fractured Face 95% Two Fractured Faces

Grading
The mix design aggregate gradation for Micro-surfacing material, including mineral filler, shall be tested in accordance with AASHTO T27 (ASTM C136) and AASHTO T11 (ASTM C117), and shall be within the following band:

Sieve Size	% Passing	Stockpile Tol.
3/8	100	
#4	70-90	+ 5%
#8	45-70	+ 5%
#16	28-50	+ 5%
#30	19-34	+ 4%
#50	12-25	+ 4%
#100	7-18	+ 3%
#200	5-15	+ 2%

The mix design aggregate gradation for Macro-surfacing shall be tested in accordance with AASHTO T27 (ASTM C136) and AASHTO T11 (ASTM C117), and shall be within the following band:

Sieve Size	% Passing
1/2	100
3/8	97
#4	12 maximum
#200	1.0 maximum

After the job mix gradation has been submitted, the percent passing each sieve should not vary by more than the stockpile tolerance if given and still remain within the gradation band. The percent passing shall not go from the high end to the low end of the range for any two consecutive screens.

Certified test reports for all tests shall be signed, dated, and submitted to the Engineer prior to the submission of the final mix design. All aggregate used on the project must be representative of the aggregate tested. The Contractor is responsible for maintaining quality control during the process of producing, hauling, and stockpiling the aggregate.

A sample of aggregate may be taken from the job location stockpile by the Engineer. The Engineer will evaluate the sample based on five gradation tests according to AASTO T2 and ASTM D75. The average of the five mix tests should be within gradation tolerances. The Contractor shall take corrective action if necessary to bring the aggregate into specifications.

Mineral Filler
Mineral filler, if required, shall be non-air entrained Portland Cement Type meeting the requirements of Standard Specification 9-01. The type and amount of mineral filler needed shall be determined by a laboratory mix design and shall be considered as part of the mineral gradation requirement.

Water
Water shall be clean, potable, and free of harmful salts or contaminates.

Asphalt Emulsion for Micro-Surfacing Material
Asphalt emulsion for Micro-surfacing shall be a polymer modified quick-setting, quick-traffic cationic asphalt emulsion. The polymer materials shall be co-milled with the emulsifier solution. The emulsion manufacturer shall certify that the emulsion contains a minimum of 3% polymer solids based on the mass of asphalt (residual asphalt) within the emulsion.

The polymer modified asphalt emulsion shall conform to the following requirements when tested in accordance with the specified test method.

Test on Emulsion	Test Method	Min.	Max.
Viscosity, Saybolt Furol at 77°F	AASHTO T59	15	100
Particle Charge Test	AASHTO T59	Positive	
Sieve Test, %	AASHTO T59		0.3
Storage Stability Test 24 Hour %	AASHTO T59		1.0
Settlement, % 5 Day	AASHTO T59		5.0
Residue by Distillation, %	AASHTO T59	62*	
Test on Residue From Distillation*			
Penetration, 77°F, 100 g, 5s	AASHTO T49	40	90
Ductility, 77°F, 5cm/min.cm	NEV T746	100	
Softening Point, R&B, Degree F.	AASHTO T53	135	
Viscosity, Vacuum, absolute 140°F, poise	AASHTO T202	8000	
Ash in Bituminous Materials, %	ASTM D3723		2.5
Kinematic Viscy @275°F, cSt/sec	ASTM D2170	650	

*Residue by distillation (Aluminum Alloy still per AASHTO T59), 350°F, temperature 20 minutes, commonly referred to as “Texas Modified Distillation.”

Each load of emulsified asphalt shall be accompanied by certification, in accordance with Section 9.02.2(1), from the asphalt emulsion manufacturer to ensure that it is the same formulation used in the job mix formula. Any asphalt emulsion formula changes must be approved by the Engineer.

Asphalt Emulsion for Macro-Surfacing Material

The base asphalt for the Macro-surfacing emulsion shall be modified with the polymer prior to emulsification

The polymer modified asphalt emulsion shall conform to the following requirements when tested in accordance with the specified test method.

Test on Emulsion	Test Method	Min.	Max.
Sieve Test, %	AASHTO T59		0.5
Viscosity, Saybolt Furol @ 122°F	AASHTO T59	50	600
Residue by Distillation @ 400°F, %	AASHTO T59	65	
Oil Distillate by vol emulsion, %	AASHTO T59		2
Test on Residue From Distillation*			
Penetration @ 77°F, 100 g, 5s	ASTM D 5-97	typ 60	150
Elastic Recovery @ 50°F, %	AASHTO T301	55	

The emulsion shall be transferred directly to the support vehicles or application equipment from the transport tankers; no other storage tanks shall be used. Emulsion shall be used within 48 hours of initial delivery from the producing facility. The temperature of the emulsion will be maintained at 140°F in the transport tankers. No emulsion shall be stored in the application vehicle overnight.

Additives

Additives may be added to the emulsion mix or any of the component materials to provide the control of the quick-set properties and increase adhesion. They must be included as part of the mix design and certified as to their compatibility with the other components of the mix.

Macro-Surfacing Mix Design

At least fourteen (14) days before the Micro-Surfacing commences, the Contractor shall submit to the Engineer a complete mix design prepared and certified by a laboratory capable of performing the required ISSA tests. Compatibility of the aggregate, polymer modified emulsion, mineral filler, and other additives shall be verified by the mix design. The mix design shall be made using the same aggregate gradation that the Contractor will provide on the project. After the mix design has been submitted, no substitution will be permitted, without notifying the Engineer. Required tests and values are as follows:

Test	Description	Specification
ISSA TB-139	Wet Cohesion @	
	30 minutes (set)	0.87 ft-lb, min.
	60 minutes (traffic)	1.45 ft-lb, min.
ISSA TB-109	Asphalt Content,	50 gal/ft2, max.
	Loaded Wheel Test	
	Sand Adhesion	
ISSA TB-100	Asphalt Content, Wet	
	Track Abrasion Loss	
	1-hour soak	50 gal/ft2, max.
	6-day soak	75 gal/ft2, max.
ISSA TB-114	Wet Stripping	Pass (90%, min.)
ISSA TB-147A	Lateral Displacement	5%, max.
	Specific Gravity	2.10, max.
		after 1000 cycles of
		125 Lb.
ISSA TB-144	Classification	(AAA, BAA)
	Compatibility	11 grade points, min.
ISSA TB-113	Mix Time @ 77°F	Controllable to
		120 sec., min.

The mixing test and set time test should be checked at the highest temperatures expected during construction (approx. 100°F)

The laboratory shall report the quantitative effects of moisture content on the unit weight of the aggregate (bulking effect). The report must clearly show the proportions of aggregate, mineral filler (min. and max.), water (optimum), additive(s) (usage), and polymer modified asphalt emulsion based on the dry weight of the aggregate.

All the component materials used in the mix design shall be representative of materials proposed by the Contractor to be used.

The percentages of each individual material required shall be shown in the laboratory report. Adjustments may be required during construction, based on field conditions. The Engineer must be notified of all adjustments.

The component materials should be within the following limits:

Residual Asphalt	5.5% to 9.5% by dry weight of aggregate
Mineral Filler	0% to 3% by dry weight of aggregate
Additive	As required to provide specified mix consistency
Water	As required to produce proper mix consistency

Construction Requirements

(ER January 28, 2003)
Hauling Equipment
Section 5-04.3(2) is supplemented with the following:

Direct transfer of the asphalt concrete mixture from the hauling equipment to the paving machine will not be allowed. A material transfer device or vehicle will be required to deliver the asphalt concrete mixture from the hauling equipment to the paving machine when placing any course of asphalt concrete pavement except prelevel less than 0.08 feet in thickness. A material transfer device or vehicle is optional for shoulders when they are paved separate from the driving lanes. If a windrow elevator is used, the length of the windrow may be limited by the Engineer.

The material transfer device or vehicle shall mix the asphalt concrete after delivery by the hauling equipment but prior to laydown by the paving machine. Mixing of the asphalt concrete material shall be sufficient to obtain a consistent temperature throughout the mixture.

Rollers
Section 5-04.3(4) is supplemented with the following:

(******)
The rollers for compaction of the Macro-surfacing shall be self-propelled and equipped with smooth pneumatic tires

Conditioning of Existing Surface

Preparation of Existing Surface
Section 5-04.3(5)A is supplemented with the following:

(******)
Prior to Micro-surfacing, all pavement repair work shall be allowed to adequately cure, all loose materials shall be removed, and crack sealant shall be below or flush with surface.

A Micro-surfacing tack coat is required on all surfaces. The Micro-surfacing tack coat shall use CSS-1h and shall be applied at a rate of between 0.05 to 0.10 gal/sy or as determined by the Engineer. The tack coat shall be allowed to cure prior to micro-surfacing application to avoid clumping and accumulation on the machine.

Prior to Macro-surfacing, all pavement shall be cleaned of dirt and dust by sweeping or other methods approved by the Engineer. The Macro-surfacing shall not be placed until the Micro-surfacing has cured for a minimum of seven calendar days.

(ER January 28, 2003)
Pavement Repair
The last paragraph of Section 5-04.3(5)E is revised to read:

Asphalt Conc. Pavement for approaches & Pavement Repair shall be asphalt concrete pavement class A, B, D, F, G, or any class used on the project and approved by the Engineer. The Engineer will be responsible for the mix design approval.

Preparation of Aggregates

Mix Design
Section 5-04.3(7)A is supplemented with the following:

(December 2, 2002)
Prior to the production of asphalt concrete pavement Class Superpave, the Contractor shall perform a minimum of three different aggregate trial blends for the purpose of determining the design aggregate structure in accordance with AASHTO PP-28. Once the design aggregate structure has been established, the Contractor shall provide data that demonstrates the design aggregate structure meets the requirements of Sections 9-03.8(2) and 9-03.8(6). All costs associated with this portion of the mix design shall be incidental to the cost per ton of asphalt concrete pavement Class Superpave.

Upon request and subject to availability, the Contractor may use a WSDOT superpave gyratory compactor to develop the design aggregate structure.

The Contractor shall obtain representative samples from mineral aggregate stockpiles and blend sand sources to be used in asphalt concrete Class Superpave production, and submit them for development of a mix design. Sample submittal shall include liquid asphalt source, three different aggregate trial blend data, design aggregate structure data, combining ratios of mineral aggregate stockpiles and blend sand that will be used. This will be the basis for the mix design and job mix formula (JMF). Adjustments to the JMF may be made per Section 9-03.8(6)A. The Contractor shall allow 20 working days for approval and design once the material has been received in the Olympia Service Center's Materials Laboratory in Tumwater.

Mixing

Section 5-04.3(8) is supplemented with the following:

(******)
Mixing Machine
The Micro-surfacing mixture shall be mixed using continuous twin-shaft pugmill mixers of adequate size and power for the type of Micro-surfacing being placed. All indicators shall be in working order prior to commencing mixing and spreading operations.

Mixer-spreader trucks shall be equipped to proportion emulsion, water, aggregate, and set control additives by volume. All rotating and reciprocating equipment on mixer-spreader trucks shall be covered with metal guards.

The mixer spreader truck shall not be operated unless all metal guards are in place and all low-flow and non-flow devices and revolution counters are in good working condition and functioning properly.

The aggregate feeder shall be connected directly to the drive on the emulsion pump. The drive shaft of the aggregate feeder shall be equipped with a revolution counter reading to the nearest one-tenth of a revolution.

Calibration
Each mixing unit to be used on the project shall be calibrated in the presence of the Engineer prior to construction. The Contractor shall generate documentation for the Engineer. The documentation shall include individual calibration of each material at various settings, which relate to the machines metering devices. No machine will be allowed to work on the project until the calibration has been completed and/or accepted. Any change in aggregate or emulsion source shall require re-calibration. At the conclusion of the calibration of each machine to be used on the job, the Contractor shall demonstrate the machine’s ability to mix all components together so as to simulate an end product.

Acceptance Sampling and Testing

(December 2, 2002)
Section 5-04.3(8)A, Item 1 is supplemented with the following:

Asphalt concrete pavement Class Superpave will be evaluated for quality of volumetric properties (VMA, Va), gradation and asphalt content.

Section 5-04.3(8)A, Item 3. A. (2), is supplemented with the following:

Asphalt concrete pavement Class Superpave samples for compliance of volumetric properties (VMA, Va), gradation and asphalt content will be obtained on a random basis from the hauling vehicle.

Section 5-04.3(8)A, Item 3. C., is revised to read as follows:

Test Results. The Engineer will furnish the Contractor with a copy of the results of all acceptance testing performed in the field by ***11:00 a.m.*** the morning of the next workday after sampling, or for nighttime work within four hours after the beginning of the next paving shift. The Engineer will also provide, by ***1:00 p.m.*** of the next workday after sampling, the Composite Pay Factor (CPF) of the completed sublots after three sublots have been produced.

Individual acceptance sample test results (VMA, Va, gradation, and asphalt content) may be challenged by the Contractor. A written challenge of the test results by the Contractor shall be received by the Project Engineer within five working days after receipt of the specific test results. A split of the original acceptance sample shall be sent, for testing, to the Regional Materials Lab or to State Materials Lab as determined by the Engineer. The challenged sample will not be tested with the same equipment or by the same tester that ran the original acceptance sample. The challenge sample will be tested for a complete VMA, Va, gradation analysis and asphalt content.

The results of the challenge sample will be compared to the original results of the acceptance sample test and evaluated according to the following criteria:

	Deviation
VMA	±1.5 percent
Va	±0.7 percent
No. 4 sieve and larger	±4 percent
No. 6 sieve to No. 80 sieve	±2 percent
No. 100 and No. 200 sieve	±0.4 percent
Asphalt %	±0.3 percent

If the deviation of the challenge sample is within each parameter established, the acceptance sample will be used to determine the composite pay factor and the cost of testing will be deducted from any monies due or that may come due the Contractor under the contract, at the rate of $200 per test.

If the deviation of the challenge sample is outside of any one parameter established, the challenge sample will be used to determine the composite pay factor and the cost of testing will be the Contracting Agency's responsibility.

Section 5-04.3(8)A, Item 3. D., is supplemented with the following:

Acceptance testing of asphalt concrete pavement Class Superpave for compliance of volumetric properties (VMA, Va) will be AASHTO T312 Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the SHRP Gyratory Compactor. WSDOT Method of Test for AASHTO T166 FOP for Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens. WSDOT FOP for AASHTO T209 FOP for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures “Rice Density.”

Section 5-04.3(8)A, Item 3. E. (5), is supplemented with the following:

“For Asphalt Concrete Class Superpave the Contractor shall shut down operations and shall not resume asphalt concrete placement until such time as the engineer is satisfied that specification material can be produced:

a. Whenever the Composite Pay Factor (CPF) of a lot in progress drops below 1.00 and the Contractor is taking no corrective action:

b. Whenever the Item Pay Factor (PFi) for any individual item of a lot in progress drops below 0.95 and the Contractor is taking no corrective action:

c. Whenever either the Composite Pay Factor (CPF) or the Item Pay Factor (PFi) for any individual item of a lot in progress is less than 0.75.

Spreading And Finishing

Section 5-04.3(9) is supplemented with the following:

(April 1, 2002)
Unless otherwise directed by the Engineer or specified in the Plans or in the Special Provisions, the nominal compacted depth of any layer of any course shall not exceed the following depths:

Asphalt Concrete Superpave Class 1"	0.35 foot
Asphalt Concrete Superpave Class 3/4" and 1/2" when used for Base Course	0.35 foot
Asphalt Concrete Superpave Class 3/4" and 1/2"	0.25 foot
Asphalt Concrete Superpave Class 3/8"	0.10 foot

(******)
Spreading Equipment for Micro-Surfacing
The Micro-surfacing paving mixture shall be spread uniformly by means of a mechanical type spreader box, attached to the mixer and equipped with paddles mounted with adjustable shafts to continually agitate and distribute the materials. The equipment shall provide sufficient agitation to prevent mix from segregating, breaking in the box or causing excessive side build-up or lumps. To prevent loss of mixture from the box, the Contractor shall attach flexible seals, front and rear, in contact with the road. On single courses and finished courses a secondary strike off shall be attached to the spreader box to provide a finished surface texture. The spreader box shall be adjustable to lane and shoulder widths.

Ruts of one-half inch or greater in depth shall be filled independently with a rut-filling spreader box, either five or six feet in width. For shallow rutting of less than one-half inch in depth, a full-width scratch-coat pass may be used.

Sufficient amount of material shall be carried at all times in all parts of the spreader box to ensure complete coverage. No lumps or unmixed aggregate will be permitted in finished surface.

A smooth, neat seam shall be provided where two passes meet. Excess material shall be immediately removed from the ends of the runs.

Spreading Equipment for Macro-Surfacing
The Macro-surfacing spread hopper shall consist of a variable width hopper system including driven augers and spread rollers. There shall be continuous conveyor feed to the hopper system. A suitable full-width screen with two-inch mesh shall cover the spread hopper to catch all oversized and foreign objects. The aggregate spreader will be calibrated in accordance with ASTM D5624-95.

Application Vehicle
The application vehicle shall be capable of applying a uniform application of emulsion and cover aggregate without the vehicle driving on the newly applied surface. It shall have an integrated dual spray bar and aggregate spread hopper whose width can be varied independently during continuous operation. No more than a length of 48 inches of emulsion shall be laid without aggregate cover. All systems for the application of materials shall be computer controlled.

Control System
The application rate computer shall be able to vary either aggregate or emulsion application rates continuously during vehicle operation. The aggregate computer shall monitor the speed of the vehicle and vary the gate opening in order to maintain the set application rate at forward operating speeds. The emulsion computer shall indicate gallons of binder sprayed, length of roadway surfaced, and the area of roadway surfaced. The equipment shall be calibrated at the start of the project.

Emulsion Application System
An insulated emulsion tank shall be provided on the application vehicle. The tank shall have a functional capacity gage. The operator's station shall have an indicator of the tank level and be capable of transferring additional emulsion into the tank during continuous operation. A removable strainer shall be applied to remove unwanted material prior to entering the tank.

The spray bars shall allow for positive circulation from one end of the bar to the other. Nozzles shall be spaced no greater that four inches apart on center on the spray bars and have an individual valve for each spray nozzle, so the spray width can be adjusted synchronized with the aggregate hopper width during operation.

Support Vehicles
There shall be support vehicles to allow for the continuous feeding and operation of the application vehicle. The support vehicles shall be capable of simultaneously feeding both aggregate and emulsion to the application vehicle.

Aggregate Removal Equipment
The finished surface shall be sweep with rotary brooms to remove excess aggregate before traffic is allowed on the roadway. Tractor tires will not be permitted. All rotary brooms shall be in good repair and able to apply controlled uniform sweeping pressure across the width of the broom. The equipment shall have variable down pressure, variable angle of approach, and independently controlled variable rotational speed. The broom bristles shall be straight, a minimum of five inches in length, and uniform length across the width of the broom. The axis of the broom shall be parallel to the roadway at all times.

The roadway shall not be released to traffic until the excess aggregate has been removed from the road surface to the satisfaction of the Engineer.

Compaction

General
The second sentence of the first paragraph of Section 5-04.3(10)A is revised to read as follows:

(******)
The completed course shall be free from ridges, ruts, humps, depressions, objectionable marks, or irregularities (including, but not limited to, cyclic density defects) and in conformance with the line, grade, and cross-section shown in the Plans or as established by the Engineer.

Joints
Section 5-04.3(11) is supplemented with the following:

(******)
The Contractor shall construct a step wedge longitudinal joint along all Asphalt Concrete Pavement Cl. Modified D longitudinal joints as detailed in the Plans.

(December 2, 2002)
Control
The first sentence of the first and fourth paragraphs of Section 5-04.3(10)B are revised to include the following:

Asphalt concrete pavement Class Superpave.

The following is inserted after the third paragraph of Section 5-04.3(10)B:

For asphalt concrete pavement Class Superpave a test sections shall be constructed for each mix design used for the purpose of determining if the mix is compactable, establish a nuclear density gauge correlation factor, and meets the requirements of Sections 9-03.8(2) and 9-03.8(6).

The test section shall be constructed at the beginning of production paving and will be at least 600 tons and a maximum of 800 tons. No further wearing or leveling will be paved the day of and the day following the test section.

Construction of the test section shall be done using the equipment and rolling patterns that the Contractor expects to use in the paving operation. A test section will be considered to have established compactibility, when the average of the three tests exceeds 92 percent of the maximum density, or when all three tests individually exceed 91 percent of the maximum density determined by AASHTO T209. This will require consideration of the presence of the correlation factor for the nuclear density gauge and may require resolution after the correlation factor is known. When results have demonstrated that the mix is not compactable, or not capable of meeting the requirements in Sections 9-03.8(2) and 9-03.8(6), the Contractor shall make appropriate adjustments to the mix, or placement and compaction operation, based on information obtained from the construction of the test section. After Engineer approved adjustments are made, production paving may proceed, or the Contractor may request that another test section be constructed according to the above procedure.

The asphalt concrete pavement used for the test section shall be measured by the ton and paid for at the unit bid price for asphalt concrete pavement Class Superpave. All costs associated with constructing the test section or sections will be incidental to the cost of the asphalt concrete pavement Class Superpave. A pay factor of 1.00 for compaction, gradation, and asphalt content will be used for the quantity of mix used in construction of the test section or sections.

Section 5-04.3(10)B is supplemented with the following:

(******)
Cyclic Density
In addition to the random acceptance density testing, the Engineer may also evaluate the mixture for low cyclic density of the pavement using density profiles. Low cyclic density areas are defined as spots or streaks in the pavement that have a density differential that exceeds a density range of 5 lb/ft^3 and/or a density drop of 2.5 lb/ft^3. If four or more low cyclic density area areas identified in a lot, a cyclic density price adjustment will be assessed for that lot. The price adjustment will be calculated as 15% of the unit bid price for the quantity of ACP represented by that lot. Only one area per delivered truckload of hot-mix will be counted toward the number of infractions. The outside 1.5 feet of pavement will be excluded from this analysis, as will any area not tested for density under the Quality Assurance specification.

(******)
Surface Smoothness
Section 5-04.3(13) is deleted in its entirety and replaced with the following:

This project will utilize a targeted International Roughness Index (IRI) as the basis for the bid item, “Smoothness Compliance Adjustment”.

The completed surface of all superpave courses shall be of uniform texture, smooth, uniform as to crown and grade and free from defects of all kinds.

The entire length of each through lane shall be profiled from the beginning to the end of the project. Ramps, shoulders and tapers shall not be profiled and will not be subject to incentive/disincentive adjustments.

The finished profile of the entire length of a lane shall be taken at one time. Profiles may be taken with or against stationing.

All longitudinal pavement surfaces not requiring IRI measurements will be measured by the Contractor using a 10 foot straightedge. Areas showing high spots of more than 1/8 inch in 10 feet shall be marked and diamond ground until the high spot does not exceed 1/8 inch in 10 feet.

The profile of the approach slab and bridge decks shall be deleted from the profile before the IRI is determined. Incentive/disincentive payments will not be made for these areas. If the Engineer determines that corrective work is required in this area, the Contractor shall complete this to meet the 1/8 inch in 10 feet requirement at no cost to the Contracting Agency.

The Micro-surfacing for rut fill surface will be excluded from the IRI penalty/bonus calculations. The finished micro-surfacing IRI shall not be higher than the existing IRI value.

Testing Equipment
WSDOT will furnish the following profilometer for use on this project:

AMES Engineering Lightweight Inertial Surface Analyzer
LISA
Box 310
Ames, Iowa 50010
(800)205-6355

The profilometer will be delivered to the project by Contractor. The profilometer, trailer, and accessories will be available after the progress schedule has been approved by the Engineer at the Department of Transportation, Eastern Region, at 2714 N Mayfair Street, Spokane WA. The profilometer will include all manuals and accessories necessary to document the smoothness of the pavement as per these specifications. A road legal trailer designed to haul the profilometer will also be provided to transport the profilometer. The profilometer, trailer, and accessories shall remain the property of WSDOT after completion of the profile work on the project, and shall be delivered to the Department of Transportation, Eastern Region, at 2714 N Mayfair Street, Spokane WA 99207 within 2 working days after the Final IRI is determined for the project. The Contractor shall be responsible for the profilometer and accessories from the time it is picked up for transport to the project until it is delivered back to WSDOT.

The lightweight profiler shall be operated by the Contractor per the manufacturer's recommendations. The Contractor shall be responsible for the required training and if needed the assistance of a manufacturer's representative. This training shall cover, but not be limited to, the proper use and calibration of the lightweight profiler, marking of must-grinds, use of the on board computer for determining IRI, storing, downloading and printing data.

Smoothness Testing Procedure
The Contractor shall profile the surface of the final lift of pavement placed on the first day of paving as soon as possible after the initial section has cooled enough to allow the profilometer to complete the work without damaging the new asphalt. This work shall be accomplished prior to any further placement of wearing course.

The profilometer shall develop an IRI for each lane. The IRI shall consist of two values averaged together which are taken parallel to the lane edge and in each wheel track of the lane. The data shall be provided in 0.1 mile or portion of intervals. This data shall be provided both on a computer disk (provided by the Contracting Agency) and on a paper print out (provided by the Contractor).

This information shall be given to WSDOT immediately upon completion of the testing. If the Contractor fails to provide the data as required it will be considered an unacceptable IRI rating and work will be suspended.

After the first day of paving, the Contractor shall determine the frequency of IRI measurement, however, the Engineer may require an IRI determination at any time if it is suspected that the IRI is not acceptable.

Production shall be suspended if:

1. The Contractor fails to provide the information as stated above; or
2. The IRI exceeds 60 in/mile; or
3. The IRI exceeds the existing IRI on the pavement that is being overlayed.

Production shall remain suspended until the Engineer is satisfied that the Contractor has taken appropriate measures to correct the process that caused the suspension.

When production is resumed, the Contractor shall profile the pavement placed as specified for the initial placement.

During the last review, conducted in 2001 by the Contracting Agency the following average IRI (inches/mile) values were obtained:

Eastbound I-90

MP to	MP	IRI (in/mi)
291.77	294.47	62
294.47	295.10	50
295.10	295.50	57
295.50	298.13	54
298.13	299.10	48
299.10	299.15	51
299.15	299.50	56
299.50	299.52	70
299.52	299.82	65

Westbound I-90

MP to	MP	IRI (in/mi)
291.72	294.47	52
294.47	295.10	53
295.10	295.50	54
295.50	298.13	51
298.13	299.10	45
299.10	299.15	58
299.15	299.50	60
299.50	299.52	110
299.52	299.81	82
299.81	299.82	207

IRI values for 0.10 mile segments of the project are available for review at the office of the Project Engineer.

Bumps or Other Corrective Action
At the completion of the paving operation the Contractor shall utilize the lightweight profilometer to profile all driving surfaces and identify all bumps which exceed 1/8 inch in 10 feet.

All bumps that exceed 1/8 inch in 10 feet shall be diamond ground until the bump does not exceed 1/8 inch in 10 feet.

The exact location of each bump shall be determined by the Contractor and the location marked on the pavement before diamond grinding commences. The area that is diamond ground shall also be checked by the Contractor after grinding is complete to ensure that the area meets specifications.

Diamond grinding shall not reduce planned pavement thickness by more than 1/4 inch.

All diamond grinding of bumps or other corrective work, all necessary traffic control devices and flaggers, shall be completed at the Contractor's expense. In the event that other bid item work requiring traffic control is being performed concurrently and it is within the traffic control limits, the appropriate traffic control expenses shall be shared equally between the Contracting Agency and the Contractor.

If deviations are found which exceed the allowable, described above, and, in the opinion of the Engineer, correction by means of any of the methods specified above will not produce satisfactory results as to smoothness and serviceability, the Engineer may accept the completed pavement and shall deduct from monies due or that may become due to the Contractor the sum of $500.00 for each and every section of single traffic lane 100 feet in length in which any deviations as described above are found. Under the circumstances described above, the decision whether to accept the completed pavement or to require corrections as described above shall be vested entirely in the Engineer.

(******)
Surface Quality of Micro-Surfacing
The finished surface of the Micro-surfacing shall be free from excessive scratch marks, tears, rippling, and other surface irregularities. The surface shall not contain ripples greater than 1/8 inch in depth measured by a ten-foot straight edge. The surface shall not exhibit more than four tear marks greater than 1/2 inch wide and four inches long, or greater than one inch wide and three inches long in any 27 square yards.

The longitudinal joints shall coincide with the proposed painted lane lines. Longitudinal joints shall be constructed with less than a three-inch overlap on adjacent passes and no more than one-fourth inch elevation difference as measured with a ten-foot straight edge. If applicable, place overlapping passes on the uphill side to prevent any ponding of water. Edges shall be neat and uniform with no more than two inches of horizontal variance in any 100 feet.

Planing Bituminous Pavement
Section 5-04.3(14) is supplemented with the following:

(March 13, 1995)
Vertical Edge Planing
During planing of bituminous pavement in the travelled lanes, the Contractor shall coordinate the planing and paving operations such that the planed roadway surface shall not remain unpaved at the end of the work day. The Contractor shall have a contingency plan to ensure that no planed areas remain unpaved due to equipment breakdown or other emergency.

Weather Limitations
Section 5-04.3(16) is supplemented with the following:

(******)
The Micro-surfacing mixture can be placed only when both the air and pavement surface temperature is 45°F or above and rising. Placement is not permitted if it is raining or threatening to rain or temperatures are forecasted to be below 32°F within 24 hours.

The Macro-surfacing mixture may be placed when the air temperature is above 60°F and stable. Application will be stopped four hours prior to expected rain and 24 hours prior to freezing conditions.

Section 5-04.3 is supplemented with the following:

(******)
Qualification of Micro-surfacing Contractor
Placement of the Micro-surfacing shall be supervised by skilled personnel having at least two years experience as a supervisor in the use of micro-surfacing equipment. The Contractor shall provide the Engineer documentation verifying the experience of supervisory personnel. This documentation shall include where the experience of each staff member was gained, the names, current addresses, and current phone numbers for each of the clients. Work cannot begin until the supervisory experience level has been proven satisfactory to the Project Engineer.

Performance Criteria

Performance criteria, as defined in the Washington State Department of Transportation Distress Manual (March 1992), shall include, but not limited to, the following:

Bleeding and Flushing for Micro-Surfacing
Limit high severity bleeding and flushing in any 1000 square foot area to not more than a total of 20 square feet during the warranty period. The minimum unit of measurement shall be one square foot. No bleeding at joints is allowed.

Bleeding and Flushing for Macro-Surfacing
All bleeding surfaces shall be covered with approved cover material such that the asphaltic material will not adhere to or be picked up by the wheels of vehicles.

Surface Loss (Debonding/Delamination) for Micro-Surfacing
Limit loss or surface interlock by traffic wear, debonding, or replacement in any 1000 square feet area to no more than a total of 20 square feet during the warranty period. The minimum unit of measurement shall be one-tenth (0.10) square foot. The normal effects of snow plows and deicing operations on the roadway shall not be considered part of “traffic wear”.

Surface Loss (Debonding/Delamination for Macro-Surfacing)
Damage or loss of aggregate in the surface under normal traffic wear exceeding 2% of the surface area in any 500 ft lineal section shall be repaired by the Contractor. The normal effects of snow plows and deicing operations on the roadway shall not be considered part of “traffic wear”.

Weathering and Raveling
Limit high severity weathering and raveling in any 1000 square feet area to no more that a total of 20 square feet during the warranty period. The minimum unit or measurement shall be one-tenth (0.10) square foot.

Performance Determination

Determination of performance criteria will be made by a committee from the State. The decision of the committee shall be binding. The committee shall consist of the following:

A representative from the State’s Pavement Management Section.
A representative from the State’s Materials Testing Laboratory.
A representative from the Regional Construction Office.

Measurement

Section 5-04.4 is supplemented with the following:

(******)
Micro-surfacing for rut fill will be measured by the ton of pavement placed.

Macro-surfacing wearing course shall be measured by the square yards of pavement surfaced.

Payment

Section 5-04.5 is supplemented with the following:

(February 5, 2001)
"Asphalt Conc. Pavement Cl. Superpave ___ PG ___", per ton.

(******)

"Micro-Surfacing For Rut Fill", per ton.
"Macro-Surfacing Wearing Course", per square yard.

(******)
"Cyclic Density Price Adjustment", by calculation
"Cyclic Density Price Adjustment" will be calculated and paid for as described in Section 5-04.3(10)B

"Smoothness Compliance Adjustment", by calculation.
"Smoothness Compliance Adjustment" will be calculated and paid for as described in Section 5-04.5(1)C

Quality Assurance Price Adjustment

(ER January 29, 2003)
All costs to incorporate the material transfer device or vehicle into the paving train shall be included in the unit contract prices for the associated bid items involved.

(December 2, 2002)
Price Adjustment for Quality of AC Mix
Section 5-04.5(1)A is supplemented with the following:

Factors for Asphalt Concrete Class Superpave

Constituent	Factor "f"
VMA (Voids in mineral aggregate)	30
Va (Air Voids)	30
All aggregate passing 1/2"	2
All aggregate passing 3/8"	2
All aggregate passing U.S. No. 4	2
All aggregate passing U.S. No. 8	15
All aggregate passing U.S. No. 200	15
Asphalt Content	30

(******)
Table of Price Adjustment Factors for asphalt concrete pavement Class Modified D:

Constituent	Factor "f"
All aggregate passing 1/2"	10
All aggregate passing 3/8"	20
All aggregate passing U.S. No. 4	25
All aggregate passing U.S. No. 8	15
All aggregate passing U.S. No. 200	20

Note: Modified D mix shall be evaluated for gradation only. The quality incentive multiplier shall be 40 percent rather than 60.

Section 5-04.5(1) is supplemented with the following:

(******)
5-04.5(1)C Price Adjustment for Pavement Smoothness
The final IRI will be made after all bump removal and other corrective actions have been completed.

Final acceptance and incentive/disincentive payments for pavement smoothness will be made based on the final IRI value, and applied to each 0.1 mile section in accordance with the following:

Target IRI Value: *** 45.0***

When AS < XX
Incentive Value = ((XX - AS) / (TV)) * 250.00
When AS > YY
Disincentive Value = ((AS - YY) / (TV)) * 100.00

Where: AS = Actual Smoothness value determined
TV = Target IRI Value
XX = Target IRI Value minus 2.0
YY = Target IRI Value plus 9.0

When the AS value falls between or equals the XX and YY values the Contractor shall be paid at the unit contract price, with no incentive or disincentive adjustment taken.

The Incentive Base for this contract is $250.00 for each 0.1 lane mile increment or fraction thereof, the Disincentive base for this contract is $100.00 for each 0.1 lane mile increment or fraction thereof.

NOTE:
For this contract the Incentive / Disincentive portion of the specification shall be enforced as follows:

1. The complete incentive and disincentive shall be calculated as defined in this Special Provision.
2. The incentive and disincentive shall be implemented fully so long as the net result of the accumulated values does not go below zero.

All portions of the “Bump or other Corrective Action” section shall be enforced.

(******)
Warranty Requirements

Bond and Liability Insurance
Furnish a warranty performance bond, equal to 50% of the total contract amount for the Micro-surfacing, at the time of the bid. Bond is to be effective for a warranty period of three years from the date of physical completion, Section 1-08.5 of the Standard Specifications.

Furnish a warranty performance bond, equal to 50% of the total contract amount for the Macro-surfacing, at the time of the bid. Bond is to be effective for a warranty period of one year from the date of physical completion, Section 1-08.5 of the Standard Specifications.

The Contractors shall furnish proof of, and maintain, property damage and public liability insurance for the warranty period.

To be released from the warranty responsibilities, all of the following criteria must be satisfied:

1. Meet the performance requirements for the repair or replacement during the warranty period.

2. Satisfy warranty requirements for repair or replacement, traffic control, and incidentals at no additional cost to the State.

Warranty Work
The State will:

1. Monitor warranted pavement to determine Micro-surfacing and Macro-surfacing performance.

2. Perform all tests and/or observations.

3. Provide access to all tests results.

4. Notify the Contractor in writing of any required warranty work.

5. Perform necessary emergency work, including but not limited to, sweeping or pothole repairs. The State will determine if the problem requires immediate attention. The Contractor will be notified of work performed by the State and the nature of the problem. Repairs performed by the State that are local to one small area and determined to be not related to the Micro-surfacing or Macro-surfacing will not affect the warranty as applied to the remaining section(s) of Micro-surfacing.

The Contractor shall:

1. Perform all warranty work at NO cost to the State. This includes, but is not limited to, supplying all material and labor for traffic control, removal of defective materials, and performing all warranty work. As long as written notification is provided within the warranty period, the Contractor is obligated to perform warranty work even if the work extends beyond the warranty period.

2. Provide certification that the materials and mixture, used in warranty work, meet or exceed the requirements of this Special Provision.

3. Complete all warranty work of repairs, permanent replacement, traffic control, and pavement markings in accordance with the original traffic control plans.

4. Repair areas that do not meet the performance criteria section within thirty calendar days of written notification by the State. Submit the proposed repair procedure, prior to performing any repairs, to the State for review and approval.

5. Bear the expense of all work, resulting from a defect in the Micro-surfacing or Macro-surfacing, that is, required to maintain the road in safe operable condition until Contractor arrives to perform the necessary repairs. Work performed by the State will not affect the Contractor's responsibility to perform the required permanent repairs under the warranty.

6. Perform all required repairs, including replacement, to meet the construction requirements in the Special Provision. Permanent repairs shall be accomplished by applying a full lane width pass over a minimum lineal length of 100 feet or as directed by the Engineer.

7. Replace temporary repairs with permanent repairs as soon as weather allows.

8. Replace entirely any 1000 square foot lane segment that has repairs or defects exceeding a total of 5% of the area. The minimum unit of measurement for repairs or defects shall be one square foot.

Surfacing Reviews
The Contracting Agency will complete a surfacing review at the physical completion of the project, then another at yearly intervals until the warranty time for each surfacing is expired.

CEMENT CONCRETE PAVEMENT

Materials

Section 5-05.2 is supplemented with the following:

(******)
Structural Fiber Reinforcement
The fibers shall be engineered, synthetic fibers which have been specifically manufactured to an optimum gradation for use as a secondary reinforcement in Portland Cement concrete. The fibers shall not contain any reprocessed olefin materials. The following requirements shall be met for the fibers:

Specific Gravity	0.90 to 0.95
Modulus of Elasticity	500 KSI, minimum
Tensile Strength	70 KSI, minimum
Length	1 inch to 2 1/2 inches
Absorption Rate	nil

The fiber supplier shall provide a representative to instruct the concrete supplier in proper batching and mixing of material for initial placement.

Fiber reinforcement will be accepted by the Engineer based on catalog cuts supplied by the Contractor.

Construction Requirements

Concrete Mix Design for Paving
The material bullet of Section 5-05.3(1) is revised to read as follows:

(******)
1. **Materials.** Materials shall conform to Section 5-05-2. Fine aggregate shall conform to Section 9-03.1(2), Class 1. Coarse aggregate shall conform to Section 9-03.1(4) AASHTO grading No. 67. An alternative combination gradation may be proposed, which has a minimum aggregate size equal to or greater than a 1-inch square sieve. The fracture requirements for the coarse aggregate is one fractured face on 75% of the material on each specification sieve U.S. No. 4 and above, if that sieve retains more than 5% of the total sample. The combined aggregate gradation shall conform to Section 9-03.1(5). Fly Ash, if used, shall conform to Section 9-23.9 and shall be limited to Class F with a maximum CaO content of 15 percent by weight. The fly ash shall be limited to 25 percent by weight, of the total cementitious material. As an alternative to the use of fly ash and cement as separate components, a blended hydraulic cement may be used. Blended hydraulic cement shall conform to ASTM C 595 Type IP. Fiber reinforcement shall be 3 pounds of synthetic fibers per cubic yard introduced at the batch plant per manufacturers recommendations

In making calculations relative to cement factor or allowable water/cement ratio, the total cementitious material shall be taken as the weight of Portland cement plus the weight of fly ash. The minimum cementitious material for any mix design shall be 800 pounds per cubic yard.

The second sentence of the Submittals bullet of Section 5-05.3(1) is revised to read as follows:

(******)
The mix shall be capable of providing a minimum flexural strength of 800 psi at 14 days.

Consistency
The first sentence of the second paragraph of Section 5-05.3(2) is revised to read as follows:

(******)
The water/cementitious material ratio, by weight, shall not exceed 0.33.

Equipment

Finishing Equipment
Section 5-05.3(3)C is supplemented with the following:

(******)
Approved slip-form paving equipment shall be used to place all concrete on I-90.

Subgrade
Section 5-05.3(6) is supplemented with the following:

(******)
Surface Preparation for White Topping
Following the completion of rotomilling operation the entire lane being overlaid shall be thoroughly cleaned. The roadway shall be cleaned by an approved method of water blasting with 3500 PSI minimum pressure. The final surface shall be free from dust, oil, grease and other foreign material that may reduce the bond of the new concrete to the existing ACP. After the water blast cleaning is completed the entire lane being overlaid shall be cleaned in final preparation for placing concrete using either oil-free compressed air or vaccum machines. The prepared surface shall be dry prior to concrete placement.

Placing, Spreading, and Compacting Concrete
(******)
The last sentence of the first paragraph of Section 5-05.3(7) is deleted.

The third paragraph of Section 5-05.3(7) is deleted.

Slip Form Construction
The second sentence of Section 5.05.3(7)A is revised to read as follows:

(******)
The alignment and elevation of the paver shall be regulated from a multi-footed ski at least 30 foot in length or outside reference lines established for this purpose.

Finishing
The third paragraph of Section 5-05.3(11) is revised to read as follows:

(******)
The pavement shall be given a final finish surface by drawing a carpet drag longitudinally along the pavement before the concrete has taken an initial set. The carpet drag shall be a single piece of carpet of sufficient length to span the full width of the pavement being placed and adjustable so as to have up to 4 feet longitudinal length in contact with the concrete being finished. The carpet shall be artificial grass type having a molded polyethylene pile face with a blade length of 5/8" to 1' and a minimum mass of 70 ounces per square yard. The backing shall be a strong durable material not subject to rot and shall be adequately bonded to the facing to withstand use as specified.

The fourth and fifth paragraphs of Section 5-05.3(11) are revised to read as follows:

(******)
At the beginning and end of each test section the Contractor shall, with an approved stamp, indent the concrete surface near the right hand edge of the panel to indicate the depth of the white topping and month, day and year of placement.

Curing

Curing Compound
The third sentence of the first paragraph of section 5-05.3(13)A is revised to read as follows:

(******)
It shall be applied uniformly at the rate of one gallon to not more than 75 square feet.

Measurement
Section 5-05.4 is revised to read as follows:

(******)
Cement concrete pavement will be measured by the square yard for the completed pavement. The area will be determined from measurements taken as listed below.

1. The width measurement will be the width of the pavement shown on the typical cross-section in the Plans, additional widening where called for, or as otherwise specified in writing by the Engineer.
2. The length will be measured horizontally along the center of each roadway or ramp.

Payment
Section 5-05.5 is revised to read as follows:

(******)
Payment will be made in accordance with Section 1-04.1, for each of the following bid items that are included in the proposal:

"Cement Conc. Pavement", per square yard.
The unit contract price per square yard for "Cement Conc. Pavement" shall include the surface preparation of the existing bituminous pavement and furnishing, placing, finishing, curing, sawing and sealing the PCCP white topping.

"Ride Smoothness Compliance Adjustment", by calculation.
Payment for "Ride Smoothness Compliance Adjustment" will be calculated by multiplying the unit contract price for cement concrete pavement, times the percent of adjustment determined from the schedule below.

1. Adjustment will be based on the initial profile index before corrective work.
2. "Ride Smoothness Compliance Adjustment" will be calculated for each 0.1 mile section represented by profilogram using the following schedule:

Ride Smoothness Profile Index (inches per mile)	Compliance Adjustment (Percent adjustment)
1.0 or less	+4
over 1.0 to 2.0	+3
over 2.0 to 3.0	+2
over 3.0 to 4.0	+1
over 4.0 to 7.0	0
over 7.0	-2*

Also requires correction to 7 inches per mile

"Portland Cement Conc. Compliance Adjustment", by calculation.
Payment for "Portland Cement Concrete Compliance Adjustment" will be calculated by multiplying the unit contract price for the cement concrete pavement, times the volume for adjustment times the percent of the adjustment determined from the calculated CPF and or the Deficiency Adjustment listed in Section 5-05.5(1)A.

Pavement Thickness
(******)
Section 5-05.5(1) is deleted in its entirety.

APPENDIX D

Whitetopping Core Results

Photos, location information and descriptions of each core are detailed below. A listing of the underlying pavement structure for each core location is included at the end.

CORE: 1

LOCATION: MP 293.24
On Longitudinal Crack In a Panel
2.3' From Edge of Lane
1.1 From Panel Joint

DESCRIPTION: 3" PCCP (Solidly Attached to HMA)
Existing HMA Ground 0.10'

Figure 1. Side view. August 2004

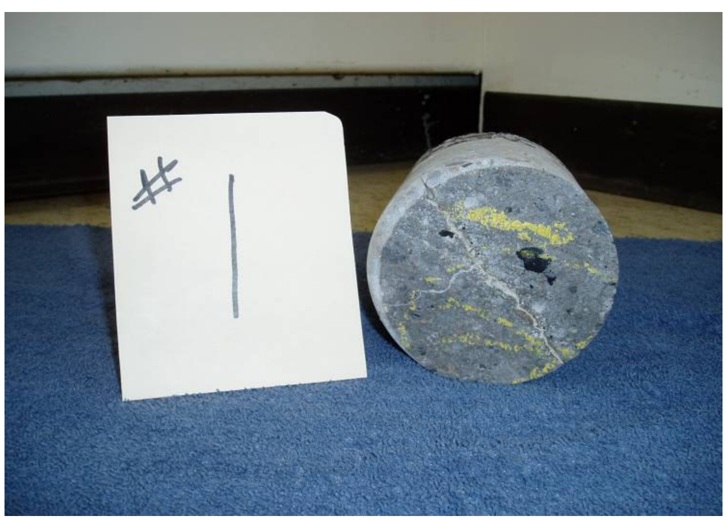


Figure 2. End view showing cracks. August 2004

CORE: 2

LOCATION: MP 293.24
On Transverse Joint/Crack Intersection
2.35’ From Edge of Lane

DESCRIPTION: 3” PCCP (Delaminated from HMA)
Existing HMA Ground 0.10’

Figure 3. Side view showing panel joint. August 2004.

Figure 4. End view showing joint and crack. August 2004

CORE: 3

LOCATION: MP 293.24
Mid-Panel, Not on a Crack or Joint
2.5' From Edge of Lane
2.5' From Panel Joint

DESCRIPTION: 3" PCCP (Solidly Attached to HMA)
Existing HMA Ground 0.10'

Figure 5. Side view showing whitetopping solidly attached to HMA. August 2004.

Figure 6. End view. August 2004

CORE: 4

LOCATION: MP 293.32
On Panel Joint/Crack Intersection
1.85’ From Edge of Lane

DESCRIPTION: 3” PCCP (Delaminated from HMA)
Existing HMA Ground 0.10’

Figure 7. Side view showing panel joint and horizontal cracks. August 2004.

Figure 8. End view showing panel joint and cracks. August 2004

CORE: 5

LOCATION: MP 293.32
On Longitudinal Cracks In a Panel
1.2' From Edge of Lane
1.5' From Panel Joint

DESCRIPTION: 3" PCCP (Solidly Attached to HMA)
Existing HMA Ground 0.10'

Figure 9. Side view showing cracks and solidly attached HMA. August 2004.

Figure 10. End view showing cracks. August 2004

CORE: 6

LOCATION: MP 293.36
On Corner Crack/Panel Joint Intersection
2.55' From Edge of Lane
On Joint

DESCRIPTION: 4" PCCP (Delaminated from HMA)
Existing HMA Ground 0.18'

NOTES: HMA below PCCP stripped like CSTC, old Class E Layer that had Class D on it at one time.

Figure 11. Side view showing panel joint and cracks. 8/04

Figure 12. End view showing joint and cracks. 8/04

CORE: 7

LOCATION: MP 293.48
On Corner Crack/Panel Joint Intersection
3.4' From Edge of Lane
On Joint

DESCRIPTION: 5" PCCP (Delaminated from HMA)
Existing HMA Ground 0.27'

NOTES: Class E below from 1978, flushed out.

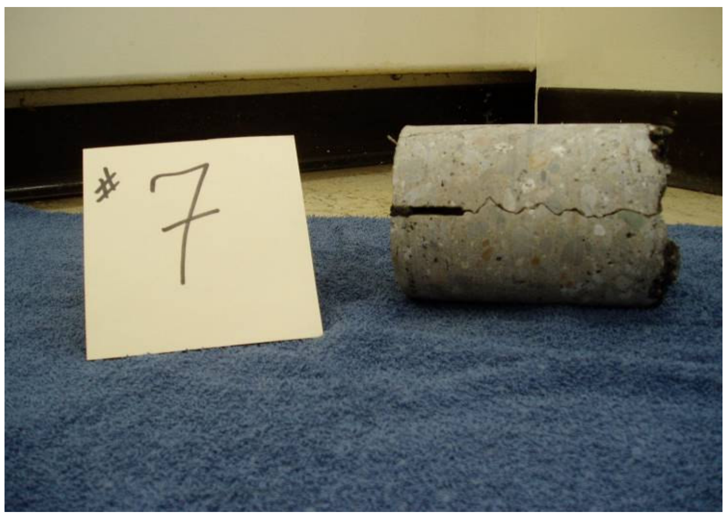


Figure 13. Side view showing panel joint. Aug. 2004.

Figure 14. End view showing joint and crack. Aug. 04.

Existing surfacing prior to whitetopping.			
EXISTING SECTION	CORES 1 – 5 Grind Depth 0.10’	CORE 6 Grind Depth 0.18’	CORE 7 Grind Depth 0.27’
0.15’ Class A HMA (1995)	0.05’	-	-
0.11’ Class E HMA (1992)	0.11’	0.08’	-
0.10’ Class B HMA (1978)			0.09’
0.25’ Class B HMA (1968)			0.25’
0.25’ Class B HMA (1958)	0.60’	0.60’	0.25’
0.50’ CTB (1958)	0.50’	0.50’	0.50’
0.17’ CSTC (1958)	0.17’	0.17’	0.17’

APPENDIX E

Micro/Macro Warranty Review

Performance Summary

I-90, Sullivan Rd. to Idaho State Line
Experimental Rut Resistant Sections
Milepost 293.15 to Milepost 293.55

Prepared by

Jeff S. Uhlmeyer, P.E.
Pavement Design Engineer
Washington State Department of Transportation

June 2004

Introduction

During July 2003, Experimental Rut Resistant Sections using asphalt and concrete products were placed on I-90 between MP 293.16 and 293.57 on Sullivan Road to Idaho State Line pavement rehabilitation project. This section of I-90 was chosen due to the high use of studded tires and the chronic rutting that occurs in Eastern Washington, particularly in the Spokane area. Washington State Department of Transportation (WSDOT) roadways in Eastern Washington typically average 12.7 years of performance before resurfacing is required. This particular section of I-90 had measurable rutting within six years, that in some locations were up to one inch deep (WSDOT criteria for requiring resurfacing occurs at rut depths exceeding ½ inch deep). This experimental section provides an excellent opportunity to evaluate two asphalt and one concrete section to help WSDOT engineers better understand and design future surfacing for state highways, particularly in areas of studded tire wear.

Description of Test Sections

The locations of the Experimental Rut Resistant Sections are illustrated in Figure 1 and discussed as follows:

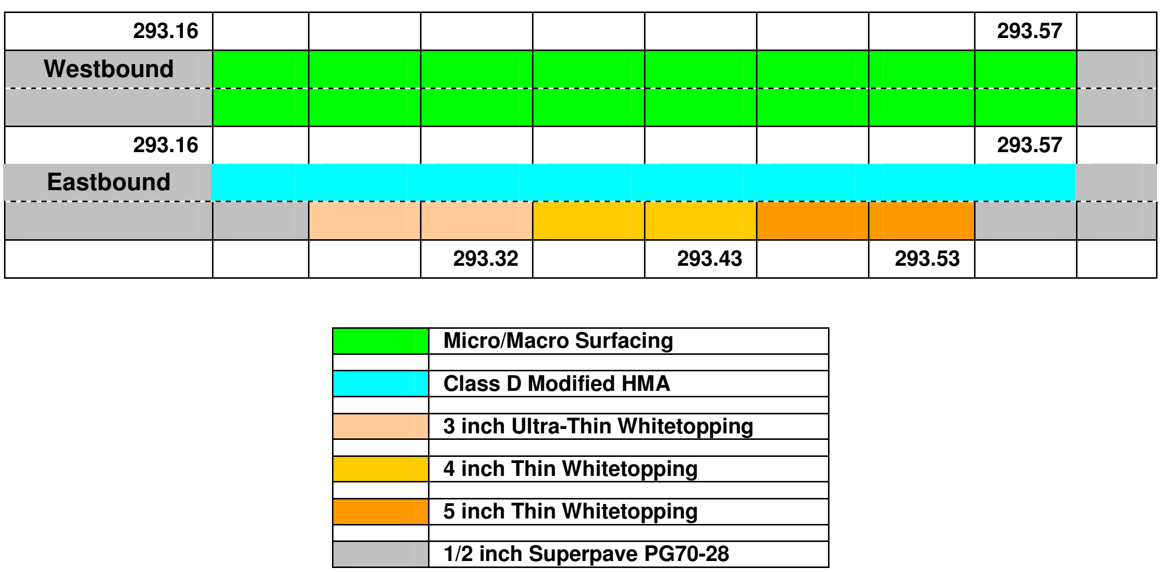


Figure 1. Location of test sections.

Rut Resistant Test Sections (MP 293.16 to MP 293.57)

Ultra Thin and Thin Whitetopping- This section contains three contiguous 500' sections of ultra thin whitetopping and thin whitetopping pavement placed in the outside eastbound lane. Whitetopping pavement sections are a composite pavement that consists of concrete placed over an existing asphalt pavement. The existing asphalt pavement is milled to increase the bond of the concrete to the underlying asphalt. The strength of the section is obtained from the composite nature of the asphalt and concrete materials.

Various thicknesses of concrete were placed to study their structural capacity and performance. The ultra thin whitetopping section is 3 inches thick. The thin whitetopping sections are 4 and 5 inches thick. The concrete mix design used for the section was modified to target a higher strength pavement than traditionally used by WSDOT. The higher strength PCCP mixes appear to be more resistant to the abrasive wear of studded tires. Additionally, polyester fibers were incorporated into the mix at the rate of three pounds per cubic yard. The purpose of the polyester fibers is to hold cracks tight should they develop. Image 1 shows the whitetopping test section.

Image 1. Ultra Thin and Thin Whitetopping Test Section placed in the outside lane of eastbound I-90 (MP 293.15 to MP 293.55).

Hot Mix Asphalt - Modified D – The Modified D asphalt section consists of a coarser aggregate than WSDOT's standard asphalt paving mixture. The coarser aggregate provides an aggregate skeleton that may resist load in addition to wear caused by studded tires. Modified D pavements have performed well in areas outside of Spokane, however, the Modified D asphalt has not been subjected to the high studded tire use as experienced on the experimental section. Modified D asphalt has an open surface texture and is typically placed two inches thick. The Modified D asphalt section is 1,500 feet long and is located in the inside eastbound lane. Image 2 shows placement of the Modified D asphalt.

Image 2. Placement of Modified D asphalt in the inside eastbound lane of I-90 (MP 293.15 to MP 293.55).

Micro Surfacing/Macro Surfacing – The Micro/Macro Surfacing test section first received a rut filling of the existing ruts and then a resurfacing of the roadway with a thin high quality surface treatment. Specifically, Micro-Surfacing is comprised of a mixture of finely graded high quality aggregated, asphalt, mineral filler and water. Micro-Surfacing is applied as a slurry by a specialty contractor using self-contained mixing and laying equipment. Following the rut filling (see Image 3), Macro-Surfacing is placed (see Image 4). Macro-Surfacing is a single pass surface treatment designed to place both the asphalt emulsion and the aggregate. The surface treatment is approximately ½ inch thick and consists of hard and durable aggregates bond together with a high strength asphalt emulsion binder. The Micro/Macro Surfacing test section is 1,500 feet long and is located in the both the inside and outside westbound lanes.

Image 3. Micro Surfacing placed as a rut fill prior to Macro-Surfacing within the two westbound lanes of I-90 (MP 293.15 to MP 293.55).

Image 4. Macro Surfacing Test Section placed on top of the Micro-Surfacing rut fill placed in the westbound lanes of I-90 (MP 293.15 to MP 293.55).

<u>Control Section</u>

Hot Mix Asphalt ½ inch – The Hot Mix Asphalt ½ inch control section consists of WSDOT' standard surface course paving mix. Hot Mix Asphalt ½ inch provides a dense asphalt surface that is placed 2 inches thick. Excluding the experimental rut resistant sections (MP 293.15 to MP 293.55), MP 292.10 to MP 299.82 was paved with Hot Mix Asphalt ½ inch and will be the standard to which the experimental sections are compared against.

Performance Results

Since the experimental sections were placed in July 2003, performance results are limited. As part of this experiment, yearly rut measurements will be taken to quantify performance of the individual sections and rut depths that result from the use of studded tires. The first rut measurements were taken April 2004 to correspond with the removal of studded tires.

After eight months of service average rut measurements for the individual sections are as follows:

Surfacing Type	Rut Depth (mm)
Ultra Thin and Thin Whitetopping	1.5
Modified D Asphalt	2.5
Micro-Surfacing/Macro-Surfacing	3.3
Hot Mix Asphalt ½ inch	2.4

Three to five years of performance will be necessary to draw any conclusions on the performance of individual sections. For pavements less than one year, the experimental sections are performing as expected. Specific performance comments for individual test sections follow.

The 3 inch Ultra Thin Whitetopping section began displaying corner cracks (breaks) at the edge of the lane within three months of installation (see Image 5). Currently, the cracking is remaining tight and does not pose a performance problem on I-90. The 4 and 5 inch Thin Whitetopping sections are performing well.

Image 5. Typical corner crack within the 3-inch ultra thin whitetopping test section.

The Micro/Macro-Surfacing sections has a different texture within the wheel paths, however, this is likely from traffic embedding the aggregate slightly into the surface. Any distress showing at this time is cosmetic and is not affecting the performance of the section. The surface texture is shown in Image 6.

Image 6. Surface texture of the Macro Surfacing.

Both the Modified D asphalt test section and Hot Mix Asphalt ½ inch control section are performing typical to other asphalt roadways placed in the Eastern Region. No performance problems have been noted.

A detailed annual report documenting the first year will be published by the WSDOT Materials Laboratory during Fall 2004.

APPENDIX F

Experimental Feature Work Plan

Washington State Department of Transportation

WORK PLAN

Ultra-Thin Whitetopping\ Thin Whitetopping

I-90, Sullivan Rd. to Idaho State Line
Milepost 292.10 to Milepost 299.82

Prepared by

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March 2003

Introduction

This section of Interstate 90 presently is constructed with an ACP wearing course. The ACP has been failing prematurely due to wear. There is no evident shoving or displacement of the ACP material. Premature wear of the pavement is a result of surface abrasion primarily caused by studded tires.

Plan of Study

Under this proposal the existing ACP structure will be overlaid/inlaid with Ultra-Thin Whitetopping (UTW) and Thin Whitetopping (TWT). The pavement will be monitored to determine its ability to resist surface abrasion, to structurally withstand the expected Equivalent Single Axle Loads (ESAL) and for ride quality.

Scope

This project contains three contiguous 500’ sections of UTW and TWT placed in the truck lane. One section will be 3 inches (0.25’) thick, one section will be 4 inches (0.33’) thick and one section will be 5 inches (0.42’) thick.

While a 3-inch (0.25’) thick UTW is considered thin for the truck lane of an interstate, the information obtained from the experiment will be beneficial in determining UTW thicknesses in the passing lane. Total ESAL’s in the truck lane are about 1.1 million ESAL’s per year. ESAL’s within the passing lane are 10 to 15 percent of those in the truck lane or 110,000 to 165,000. ESAL’s within this range may be applicable for the UTW sections.

Mix Design

The mix design requirements will be modified to target a higher strength pavement than traditional PCCP mixes to better resist the abrasive wear from studded tires. Polyester fibers at the rate of 3 pounds per cubic yard will be incorporated into the mix. The polyester fibers will help hold cracks tight should they develop.

Surface Preparation

The existing surface will be rotomilled. The milled surface will be prepared by pressure washing followed by cleaning with vactor truck or compressed air.

Construction

Concrete will be placed by a slip form paver. The final finish will be constructed by the carpet drag method. Curing compound will be applied at twice the normal rate. The completed pavement will be sawed at a 5' by 6' joint pattern. The joints will be sealed. The completed UTW and TWT surfaces will be placed 0.15' above the existing asphalt surface. The proposed 0.15' asphalt overlay depth for the adjacent asphalt lanes will be placed to match the UTW and TWT surfaces. The longitudinal joints between the PCCP and ACP will be sealed.

Risks

Information obtained from the MnROADS whitetopping experiments indicates that the 4 inch (0.33') and 5 inch (0.42') sections may perform well on SR 90. However, the 3-inch (0.25') section may fail within 3 to 5 years. The Eastern Region is aware of this potential and will repair or rehabilitate any of the sections that fail prematurely.

Layout

The UTW and TWT construction will be in the eastbound truck lane (12' wide) from MP 293.15 to MP 293.55.

Staffing

This research project will be constructed as part of a larger rehabilitation project. Therefore the Region Project office will coordinate and manage all construction aspects. Representatives from WSDOT Materials Laboratory (1 to 3 persons) will also be involved with the process.

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Testing

The completed PCCP will be skid tested to determine friction values.

Reporting

An "End of Construction" report will be written following completion of the test section. This report will include construction details of the test section, construction test results, and other details concerning the overall process. Annual summaries will also be conducted over the next 5 years. At the end of the 5-year period, a final report will be written which summarizes performance characteristics and future recommendations for use of this process.

Cost Estimate

Construction Costs

Description	Quantity	Unit Cost	Total Price
UTW/Whitetopping	2300 S.Y.	$40	
Total			$ 92,000

Testing Costs

Condition Survey – will be conducted as part of statewide annual survey

Rut Measurements – 6 surveys (2 hours each) requires traffic control = $2,000

Skid test = $1,500

Report Writing Costs

Initial Report – 20 hours = $1,500
Annual Report – 5 hours (1 hour each) = $500
Final Report – 10 hours = $1,000

TOTAL COST = $95,000

Schedule

Construction Date – June and July 2003

Date	Condition Survey (Annual)	End of Construction Report	Annual Report	Final Report
August 2003		X		
August 2004	X		X	
August 2005	X		X	
August 2006	X		X	
August 2007	X		X	
August 2008	X		X	X