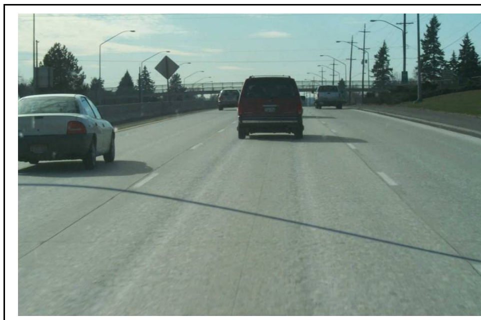
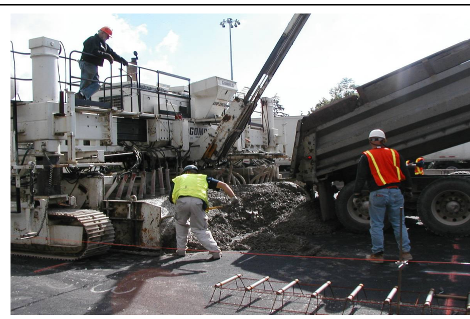
Experimental Feature Report

Post Construction & Performance Report
Experimental Features WA 05-02

Performance of a Portland Cement Concrete Pavement with Carpet Drag Finish

Contract 6757
I-5
Federal Way to S. 317th Street HOV Direct Access
MP 143.25 to 144.74





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

16. ABSTRACT

This report documents the construction of a section of Portland cement concrete pavement on I-5 in the vicinity of Federal Way, Washington. The project included the use of a carpet drag finish on the PCCP. Use of the carpet drag finish is a departure from the tined finish that is normally used by WSDOT.

Initial data was collect on pavement wear, ride, and friction resistance to develop a baseline for comparison over time and with other projects that use different finishing techniques such as tining. The project will be monitored for a period of five years to measure the performance of the carpet drag finish with respect to wear, ride, friction resistance, and potentially noise.

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DISCLAIMER

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OBJECTIVE

The primary objective of this experimental feature is to evaluate how a new portland cement concrete pavement with a carpet drag finishing will resist the wear from studded tires. The wear measured on portland cement concrete pavements in the state of Washington is primarily due to allowing studded tires to be used between November 1 and March 31. The damage from studded tires results in gradual dishing of the wheel paths to actual visible ruts in the wheel paths. In the case of our standard finishing method, transverse tining, this loss of material results in no visible trace of the tining after as little as three years of traffic. Figure 1 shows a concrete pavement that was constructed in 1995 on state route (SR) 395 just south of Interstate 90 (Ritzville vicinity). At the time of this photo, this pavement had been in service for seven years (photo taken in 2003). The average annual daily traffic on this route is approximately 6,800 vehicles. It can be seen that the tining in the wheel paths has been completely worn away due to studded tires (note that the tining is still visible at the pavement edges).

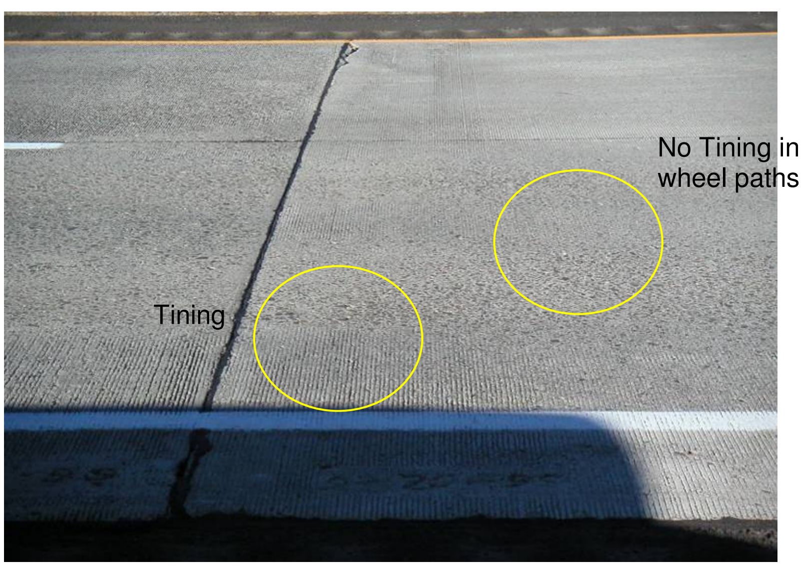


Figure 1. Concrete pavement on SR-395 south of Interstate 90 interchange.

In contrast, Figure 2 shows a 13 year old concrete pavement located on Interstate 45 in Houston, Texas. Note the clear pattern of the tine marks across the entire width of the pavement lane. The average daily traffic count on this section of interstate is 178,000 vehicles per day. Though the state of Texas allows studded tires, in reality the climate in Texas does not typically warrant the use of them. The damaging effects of studded tires is clearly observable in these two examples which is made even more dramatic when considering that the Texas pavement has received more than 26 times the daily traffic volume (6,800 versus 178,000) and has been in place for almost twice the number of years (seven years versus 13 years) as the pavement on state route (SR) 395.

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

An even more dramatic example of studded tire wear is shown in Figure 3. The wear, in this case, has formed ½ inch deep ruts in the portland cement concrete pavement. This type of rutting is especially prevalent in the Spokane area, which is reported to have the highest use of studded tires in the entire state.

Figure 3. Wear due to studded tires on a portland cement concrete pavement (I-90 vicinity of Spokane).

This project may also provide a site for monitoring tire/pavement noise as WSDOT investigates the feasibility of using different types of pavement as mitigation strategies to reduce roadway noise. The carpet drag finish has been shown to be "quieter" than transverse tining. We intend to monitor this section once measurement equipment has been purchased and test procedures have been finalized which is expected to occur before the summer of 2006.

One of the challenges facing WSDOT is to reduce the excessive wear pavements receive from studded tires. A series of experimental features are underway that address various strategies to mitigate this type of wear (Table 1). These include the use of combined aggregate gradation, higher strength mix designs, and additives that produce a harder cement paste. A companion project has been constructed in the Spokane area on I-90. On that particular project, Contract 6620, Argonne Road to Sullivan Road, MP 286.91 to 292.38, the entire project was built with the carpet drag finishing process and it included special test sections of higher flexural strength mixes and mixes with concrete hardener additives. The key to this experimental feature is that we now have a concrete pavement on a heavy trafficked roadway in Western Washington to compliment the project on I-90 in Spokane.

Table 1. Experimental features on mitigation of studded tire wear in PCCP.

Exp. Feature Number	Experimental Feature Title	Location
01-02	Combined Aggregate Gradation for PCCP	I-90, Sprague Ave I/C Phase III, C6947
03-02	Ultra-Thin Whitetopping/Thin Whitetopping	I-90, Sullivan Road to Idaho State Line, C6582
03-04	PCCP Features (Carpet Drag, Flexural Strength, and Surface Smoothness)	I-90, Argonne Road to Sullivan Road, C6620
04-01	Use of Hard-Cem in Concrete Pavements	I-90, Argonne Rd. to Sullivan Rd., C6620
05-02	PCCP Features (Carpet Drag and Noise Mitigation)	I-5, Federal Way to S. 317th Street HOV Direct Access, C6757
05-04	PCCP with Higher Slag and Cement Content	I-90, Argonne Road to Sullivan Road, C6620
05-05	PCCP Features, (Carpet Drag and Noise Mitigation)	I-5, Pierce Co. Line to Tukwila I/C - Stage 4, C6883

BACKGROUND

The Federal Highway Administration technical advisory T 5040.36, entitled "Surface Texture for Asphalt and Concrete Pavements," provides guidance to states regarding pavement types or mitigation strategies that have been successful in providing pavements with acceptable friction resistance characteristics. This advisory can be found at the following website:
http://www.fhwa.dot.gov/legsregs/directives/techadvs/t504036.htm

The advisory lists tining, exposed aggregate surface, broom or artificial turf drag, diamond grooving, and diamond grinding as treatments that can yield adequate wet weather friction characteristics for concrete pavements. The choice of artificial turf drag comes with the additional requirement that states must provide proof that the technique will provide adequate wet weather friction resistance over the long-term. The advisory does not define "long-term," but because it is a safety issue one might presume that it is an extended period of time such as 20-30 years. This experimental feature will collect information on the long-term performance of artificial turf drag with respect to friction resistance and also wear resistance.

Currently there is a national interest in the possibility that certain hot mix asphalt pavement types or certain concrete finishing techniques could be used as substitutes for noise walls or used in conjunction with walls as an overall acceptable noise reduction strategy. The use of aggressive tining has been cited as one of the causes of higher noise levels by some states. As a result, FHWA is allowing states to experiment with different finishing techniques as a means of providing sufficient supporting data to allow their use as a noise mitigation strategy. Again, long-term performance is an issue that must be resolved through documentation of noise and pavement performance. Until such time as a strategy or methodology has proved to provide a quieter pavement over time, FHWA will restrict the use of pavement type or finishing method as a noise abatement measure. FHWA has developed guidelines for qualification of pavement type as an acceptable

noise mitigation strategy under a program called "Quiet Pavement Pilot Program" (QPPP), see website for more details:
http://www.fhwa.dot.gov/environment/noise/qpppmem.htm

It is not currently WSDOT's plan to file a QPPP plan, but we are interested in collecting data on different pavement types and finishing methods that could result in a reduction of noise for communities in our state. The Arizona Department of Transportation (ADOT) is leading efforts to qualify asphalt-rubber friction courses as noise mitigation strategies and has filed a QPPP plan. It is WSDOT's intent to work closely with ADOT and the states involved in the State Pavement Technology Consortium (SPTC) to gain from their experience. The SPTC is comprised of four states, California, Minnesota, Texas, and Washington. We intend to closely follow California who has embarked on a multi-year, multi-million dollar study on mitigation of pavement noise.

PROJECT DESCRIPTION

The project is located on I-5 in the vicinity of Federal Way, Washington (Figure 4). The project involves reconstruction of the southbound lanes using 13 inches of PCCP over 4.2 inches of hot mix asphalt over 4.2 inches of crushed surfacing. The crushed surfacing was produced on the job site by recycling the existing portland cement concrete pavement. The total length of the project is 1.49 miles (5.96 lane miles). The total length of the new PCCP is 0.61 miles (2.44 lane miles). In addition, the plans call for the outside 2 lanes of the existing PCCP to be retrofitted with dowel bars and all of the existing pavement diamond ground to provide a smooth longitudinal profile for the remaining 0.88 miles (3.52 lane miles).

Figure 4. Project vicinity map for Contract 6757, Federal Way to S. 317th Street HOV Direct Access, I-5 MP 143.25 to 144.74.

The 50-year traffic loading for this location is approximately 200 million ESALs. Detailed information concerning the project is listed below in Table 2

Table 2. Contract 6757 information.	
Project Title	Federal Way to S. 317th Street HOV Direct Access
Contract Number	6757
Route	I-5
Milepost Limits	MP 143.25 to MP 144.74
Contractor	ICON Materials
Paving Subcontractor	Salinas Construction
Concrete Supplier	Miles Sand & Gravel
WSDOT Region	Northwest
Project Engineer	John Chi

CONSTRUCTION

Concrete Mix Design

Detailed information on the mix design used for the mainline paving is included in Table 3. Additional information on the compressive strength to flexural strength correlation and the combined aggregate gradation proportions are included in Appendix A.

Table 3. Details of mix design 15650AS used for the mainline paving.

Cement	Lafarge Type I-II, 611 lbs/cy
Air Entrainment	Master Builders MB-AE-90, 5-20 oz/cy
Water Reducer	Mater Builders Polyheen 997, 23 oz/cy
Water Quantity	233 lbs/cy
Water Cement Ratio (Maximum)	0.38
Aggregate	Combined gradation
Pit Source	B-345
Flexural Strength Requirement	650 psi

Paving

The mainline paving was conducted on May 24, May 27, June 2, June 6, June 7 and June 8, 2005. The contractor transported the wet concrete from the supplier to the job site using dump trucks. A Gomaco GHP-2800 paver was used to spread and consolidate the wet concrete on the prepared asphalt base (Figure 5). Dowel bar baskets were placed in the appropriate locations immediately in front of the mix as the paver moved down the grade.

Figure 5. Paving machine and dump trucks used to transport the wet concrete.

A carpet drag finish was applied to the wet concrete with a 24 foot wide section of artificial turf attached to the finishing machine as shown in Figure 6. The artificial turf was weighted down with gravel to keep it in contact with the concrete. Additional photos of the artificial turf are shown in Figures 7 and 8. The texture of the finished concrete after receiving the carpet drag is shown in Figures 9 and 10.

The no-cost change order for the use of the carpet drag texture is included in Appendix B (Portland Cement Concrete Finishing Information). It called for the surface to be textured with Astro Turf carpet to produce a minimum depth of texture of 1.0 mm as determined by ASTM E 965-87, "Test Method for Measuring Surface Macrotexture depth Using a Sand Volumetric Technique". A description of the WSDOT Standard Specification for finishing as well as the Texas and Minnesota DOT specifications for carpet drag finishing are also included in Appendix B. The Minnesota specification was chosen for this project because it provided a way to test if the contractor was achieving the desired texture. The Texas specification, which does not specify a required depth of texture, was used on two I-90 projects, Sullivan Road to Idaho State Line, and Argonne Road to Sullivan Road. These two projects went to contract prior to this project.

Figure 6. Close-up of carpet drag attached to the Gomaco finishing machine.

Figure 7. The artificial turf attached to the finishing machine.

Figure 8. Close-up of the artificial turf.

Figure 9. Final finish prior to the application of curing compound.

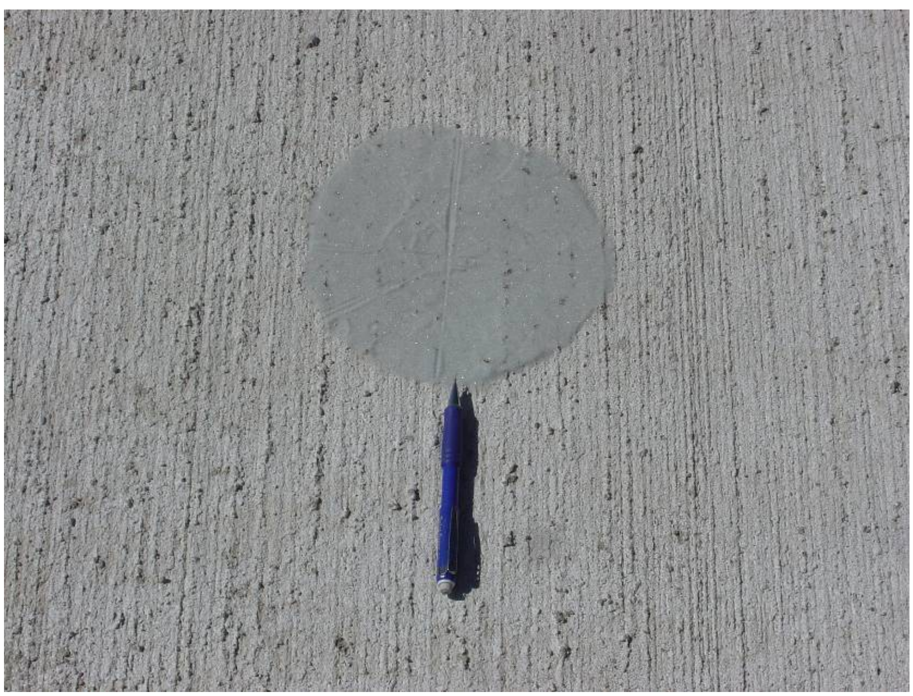


Figure 10. Close-up of final carpet drag texture. Circle is sand from a sand patch test.

A liquid curing compound (W.R. Meadows Sealtight 1600-White) was applied from the same finishing machine used to apply the carpet drag texture (Figure 11).

Figure 11. Curing compound being applied by the finishing machine.

The final operation was to saw cut the green concrete over the centers of the installed dowel bars to initiate the transverse joints at the prescribed 15 foot intervals and the longitudinal joints.

The median two lanes were paved first starting from the north end of the job and moving south as shown on the strip map (Figure 12). The outside two lanes were paved next, again moving from the north to the south to the vicinity of the S. 320th Street overcrossing, which did not have sufficient clearance for the paving machine to pass under it. Paving then resumed from the south end of the project toward the north to the overcrossing. The following day concrete was poured into the gap and finished by hand to complete the mainline paving. A total of 5,711.3 cubic yards of concrete were placed. Table 4 summarizes the paving information.

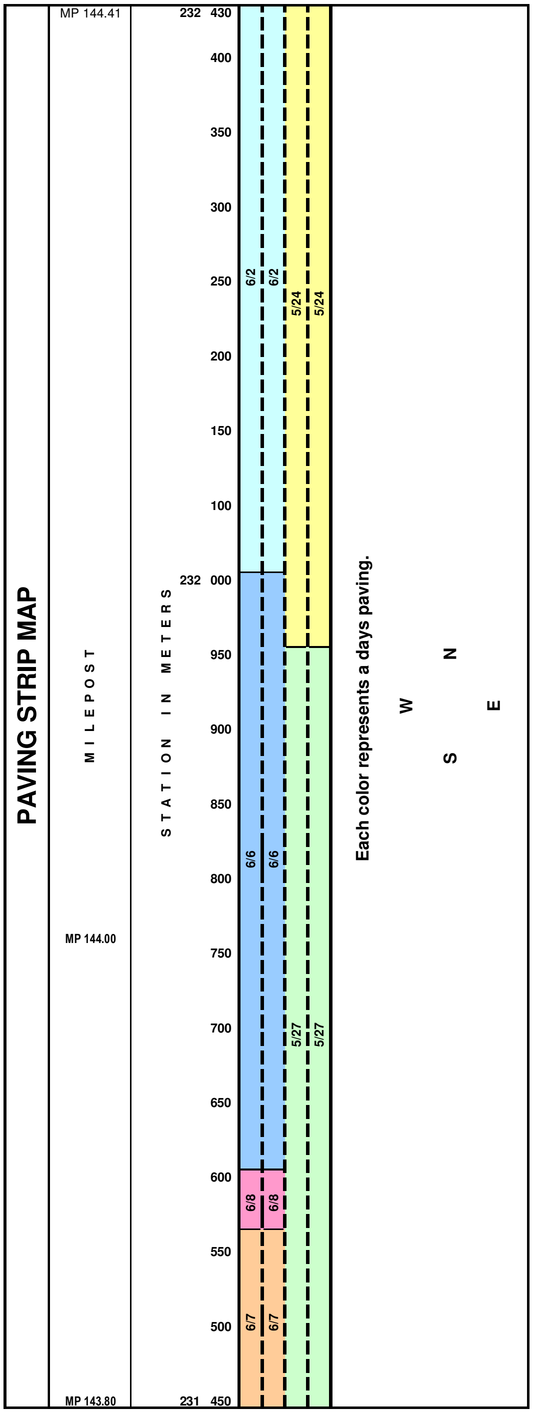


Figure 12. Strip map of project showing the location and limits of each days paving.

Table 4. Details of the paving operation.				
Date	**Stations**		**Concrete Quantity (yd)^3**	**Comments**
5/24/2005	144.11	144.41	1,192.8	Lanes 3 & 4, carpet drag finish, 24 ft width
5/27/2005	143.80	144.11	1,227.9	Lanes 3 & 4, carpet drag finish, 24 ft width
6/2/2005	144.14	144.41	1,392.1	Lanes 1 & 2, carpet drag finish, 24 ft width
6/6/2005	143.87	144.14	1,408.0	Lanes 1 & 2, carpet drag finish, 26 ft width
6/7/2005	143.79	143.87	355.5	Lanes 1 & 2, carpet drag finish, 26 ft width
6/8/2005	143.87	143.89	135.0	Lanes 1 & 2, paved by hand, carpet drag, 24 ft width
		Sum	**5,711.3**	Note: Lane 1 is outside, truck lane. Lane 4 median, passing lane.

CONSTRUCTION TESTING

Strength Measurements

Sixteen sets of paired cylinders were tested to measure the compressive strength of the pavement. The average compressive strength of each set of cylinders was converted to a flexural strength using the conversion factor developed from the mix design correlation (Table 5). The flexural strength to compressive strength conversion factor was 9.7 resulting in a required test cylinder compressive strength of 4,491 psi. There was only one set of cylinders that failed to meet the flexural strength requirement and it was for the last day of mainline paving. The average flexural strength for the 16 sets of cylinders was 702 psi.

Table 5. Cylinder break information for mainline paving.

Date	Location	Compressive Strength (psi)	Flexural Strength (psi)	Pass/Fail 650 (psi)
5/24/2005	144.11	5,436	715	Pass
5/24/2005	144.20	5,705	733	Pass
5/24/2005	144.30	5,534	722	Pass
5/24/2005	144.41	5,867	743	Pass
5/27/2005	144.11	5,302	706	Pass
5/27/2005	143.99	4,809	673	Pass
5/27/2005	143.91	5,203	700	Pass
5/27/2005	143.81	4,880	678	Pass
6/2/2005	144.39	5,174	698	Pass
6/2/2005	144.21	4,548	654	Pass
6/2/2005	144.28	4,835	674	Pass
6/6/2005	144.14	5,529	721	Pass
6/6/2005	144.05	5,908	745	Pass
6/6/2005	143.95	5,131	695	Pass
6/7/2005	143.86	5,715	733	Pass
6/8/2005	143.89	4,462	648	Fail
	Average	5,252	702	

Roughness Measurements

The Contractor used a California type profilograph to make the required smoothness measurements of the finished pavement. A 0.2 inch blanking band was used as per the Standard Specifications. The overall Project Ride Index (PRI) was 1.66 in/mile, which is well under the 7.0 in/mile required in the Standard Specifications. Individual lane measurements are shown in Table 6.

Table 6. Summary of data from contractor provided profilograph runs.

Lane and Wheel Path	Starting Milepost	Ending Milepost	Counts	Overall PRI (inches)	Comments
2 LWP	144.41	144.15	0.48	1.87	Start at north end to just north of 317th bridge.
1 LWP	144.41	144.15	0.49	1.90	Ending at the concrete lane on off ramp. Paved
1 RWP	144.15	144.41	0.57	2.20	two lanes wide (24') **No must grinds.**
1 and 2				**1.99**	
4 RWP	144.41	144.12	1.07	3.66	Start at north end to just north of 317th bridge.
4 LWP	144.12	144.41	0.65	2.22	Paved two lanes wide (26') **No must grinds.**
3 RWP	144.12	144.41	0.69	2.36	
3 and 4				**2.75**	
4 LWP	144.06	143.79	0.57	2.23	Starting just south of 317th St. falsework ending
4 RWP	143.79	144.06	0.35	1.35	@ full width reconstruction south of 320th bridge.
3 RWP	144.06	143.79	0.37	1.44	Paved two lanes wide (26') **No must grinds.**
3 and 4				**1.67**	
2 LWP	143.86	143.79	0.03	0.46	Started just south of 320th bridge ending @ full
2 RWP	143.79	143.86	0.04	0.63	Width reconstruction. Paved 2 lanes wide (24')
1 RWP	143.86	143.79	0.11	1.73	**No must grinds.**
1 and 2				**0.94**	
1 RWP	144.14	143.90	0.30	1.26	Starting just north of 317th street bridge to just north
2 LWP	144.14	143.90	0.07	0.30	of 320th street bridge. Paved 2 lanes wide (24')
2 RWP	143.90	144.14	0.31	1.32	**No must grinds.**
1 and 2				**0.96**	
		Project PRI		**1.66**	

POST-CONSTRUCTION TESTING

Texture Measurements

Sand patch tests were conducted on the finished concrete to measure the depth of texture using ASTM E-965, Measuring Pavement Microtexture Depth Using a Volumetric Technique. Sand patch tests were run by the HQ Pavements Section on a portion of the project to sample the degree of texture being produced by the contractor. The results from these tests are shown in Table 7. Four of the 18 tests fell below the minimum target depth of 1.0 mm but the average of 1.14 mm met the value recommended in the change order. Figure 13 is a collection of photos that show the sand patch test procedure. A copy of the data collection sheet and a sample calculation is included in Appendix C.

Table 7. Sand patch test results on carpet drag texture.

Date	Milepost	Lane (1 is HOV)	Panel Location	Average Diameter (mm)	Average Macro Texture (mm)
5/26/2005	144.39	2	Middle	194.75	1.14
5/26/2005	144.39	3	Middle	186.75	1.24
5/26/2005	144.36	2	Middle	181.50	1.32
5/26/2005	144.36	3	Middle	184.50	1.28
5/26/2005	144.30	2	Middle	209.00	0.99
5/26/2005	144.30	3	Middle	190.00	1.20
5/26/2005	144.20	2	Middle	194.50	1.15
5/26/2005	144.20	3	Middle	197.50	1.11
5/26/2005	144.14	2	Middle	239.75	0.76
5/26/2005	144.14	3	Middle	262.00	0.63
6/3/2005	144.39	4	Middle	171.50	1.48
6/3/2005	144.39	5	Middle	179.50	1.35
6/3/2005	144.36	4	Middle	168.25	1.53
6/3/2005	144.36	5	Middle	185.50	1.26
6/3/2005	144.30	4	Middle	196.00	1.13
6/3/2005	144.30	5	Middle	202.50	1.05
6/3/2005	144.20	4	Middle	236.75	0.77
6/3/2005	144.20	5	Middle	197.25	1.12
			Average	**198.75**	**1.14**

a. Measured amount of glass beads in film container.

b. Pouring beads onto pavement.

c. Beads poured onto pavement.

d. Spreading beads with hockey puck.

e. Beads being spread to fill surface voids.

f. Measuring diameter of bead circle.

Figure 13. Procedure for running a sand patch test to measure macrotexture depth using ASTM E-965.

Roughness and Ride Measurements

Ride and transverse profile measurements were taken on September 6, 2005 using the WSDOT Pavement Condition Collection Van. The transverse profile and International Roughness Index (IRI) measurements are summarized in Table 8. The current lane configuration, that accommodates the on-going construction in the median, did not allow the data collection van to follow the wheel paths for each lane. As a result of this, the van crossed over the longitudinal joints between lanes. The results thus produced by the van include the readings when the laser drops into and out of the longitudinal joints. It is possible to look at individual transverse profiles and pick some that did not cross over longitudinal joints. A survey of a number of these individual profiles reveals that the true wear of the pavement is more on the order of 0.3 to 1.3 mm. This coincides with the expectation that a new portland cement concrete pavement would have essentially a flat transverse profile, therefore, these values seem more realistic than the 3.0 mm average noted in Table 8. Values for individual transverse profiles for the existing pavement that was diamond ground ranged between 0.9 and 4.0 mm. It thus appears that the diamond grinding did not remove all of the studded tire wear from the original pavement. The lanes will be run again after the construction is completed and the lanes are returned to their normal configuration.

The ride values are also influenced by the current lane configuration. The values for both the new PCCP and the diamond ground old pavement are very good in spite of the issue with crossing the longitudinal joints. An IRI in the low to middle 80's is just slightly higher than some of the most recent PCC paving on I-90 in the Spokane area. For that particular project individual values of 60 were recorded. As a comparison, the average for all of the HMA overlay and new construction projects measured in the past three years is 74. Once again, these measurements will be rerun once the lanes are returned to their normal configuration and a slight improvement in the IRI's is predicted.

Table 8. Ride and wear measurements.

Old PCCP with DBR and Diamond Grinding							
Lane	**IRI Left (in/mile)**	**IRI Right (in/mile)**	**IRI Average (in/mile)**	**Wear Left (mm)**	**Wear Right (mm)**	**Wear Center (mm)**	**Left, Right & Center (mm)**
HOV	83.92	87.23	85.31	3	4	4	4
3	84.38	83.08	83.46	5	6	4	5
2	84.31	71.85	77.77	6	6	6	6
1	83.85	87.15	85.15	5	6	5	5
Average IRI for all lanes			**82.92**	**Average for all lanes**			**5**
New PCCP with Carpet Drag Finish							
Lane	**IRI Left (in/mile)**	**IRI Right (in/mile)**	**IRI Average (in/mile)**	**Wear Left (mm)**	**Wear Right (mm)**	**Wear Center (mm)**	**Left, Right & Center (mm)**
HOV	92.75	85.15	88.70	2	2	3	3
3	82.65	79.10	80.55	2	3	4	3
2	82.50	96.55	89.25	2	4	3	3
1	109.40	135.75	122.40	3	4	4	4
Average for all but lane 1			**86.17**	**Average for all but lane 1**			**3**
Note: Lane 1 in the carpet drag section is half PCCP and half ACP due to the current configuration of the lanes to accommodate construction in the median.							

Friction Testing

Friction resistance testing was performed on September 2, 2005 using the WSDOT Locked Wheel Friction Tester meeting ASTM E274 specifications. The average friction number (FN) for the carpet drag finished PCCP is 51.2 with a range of values from 39.7 to 58.0 (Table 9). The average FN for the existing PCCP which received the diamond grinding is 40.5 with a range of 33.0 to 46.0 (Table 10).

Table 9. Friction numbers for PCCP with carpet drag finish.

LANE	MP	FN	LANE	MP	FN
4	144.4	53.6	2	144.4	53.1
4	144.3	58.0	2	144.3	51.7
4	144.2	56.9	2	144.2	45.0
4	144.1	56.9	2	144.1	56.6
4	143.0	57.8	2	144.0	48.1
4	143.9	50.9	2	143.9	54.7
3	144.4	51.6	1	144.4	48.1
3	144.3	53.2	1	144.3	50.2
3	144.2	51.0	1	144.2	39.7
3	144.1	53.9	1	144.1	44.8
3	144.0	50.2	1	144.0	46.5
3	143.9	41.2	1	143.9	55.9
		Range	**39.7 – 58.0**	**Average**	**51.2**

Table 10. Friction numbers for existing PCCP with diamond grinding.

LANE	MP	FN	LANE	MP	FN
4	144.7	45.8	2	144.7	33.6
4	144.6	42.5	2	144.6	33.0
4	144.5	43.6	2	144.5	46.0
3	144.7	41.9	1	144.7	34.7
3	144.6	37.4	1	144.6	44.7
3	144.5	43.7	1	144.5	39.6
		Range	**33.0 – 46.0**	**Average**	**40.5**

The friction numbers for both the new pavement and the rehabilitated existing pavement are very good. The Materials Laboratory has been collecting post construction friction data on a number of projects completed within the last 10 years to track the performance of the various finishing methods (Figure 14). The average for the carpet drag portion of Contract 6757 falls between the other two projects with the same type of texture. The average for the dowel bar retrofit and diamond ground section was lowest on the chart; however, the average of 40.5 is still a very good friction number and well above anything that would be considered unacceptable (below 30).

The projects shown in Figure 14 are being retested on an annual basis to track the friction number change over time in the categories of pavements with tined texture, carpet drag texture, and diamond grinding texture. These charts are included in Appendix D.

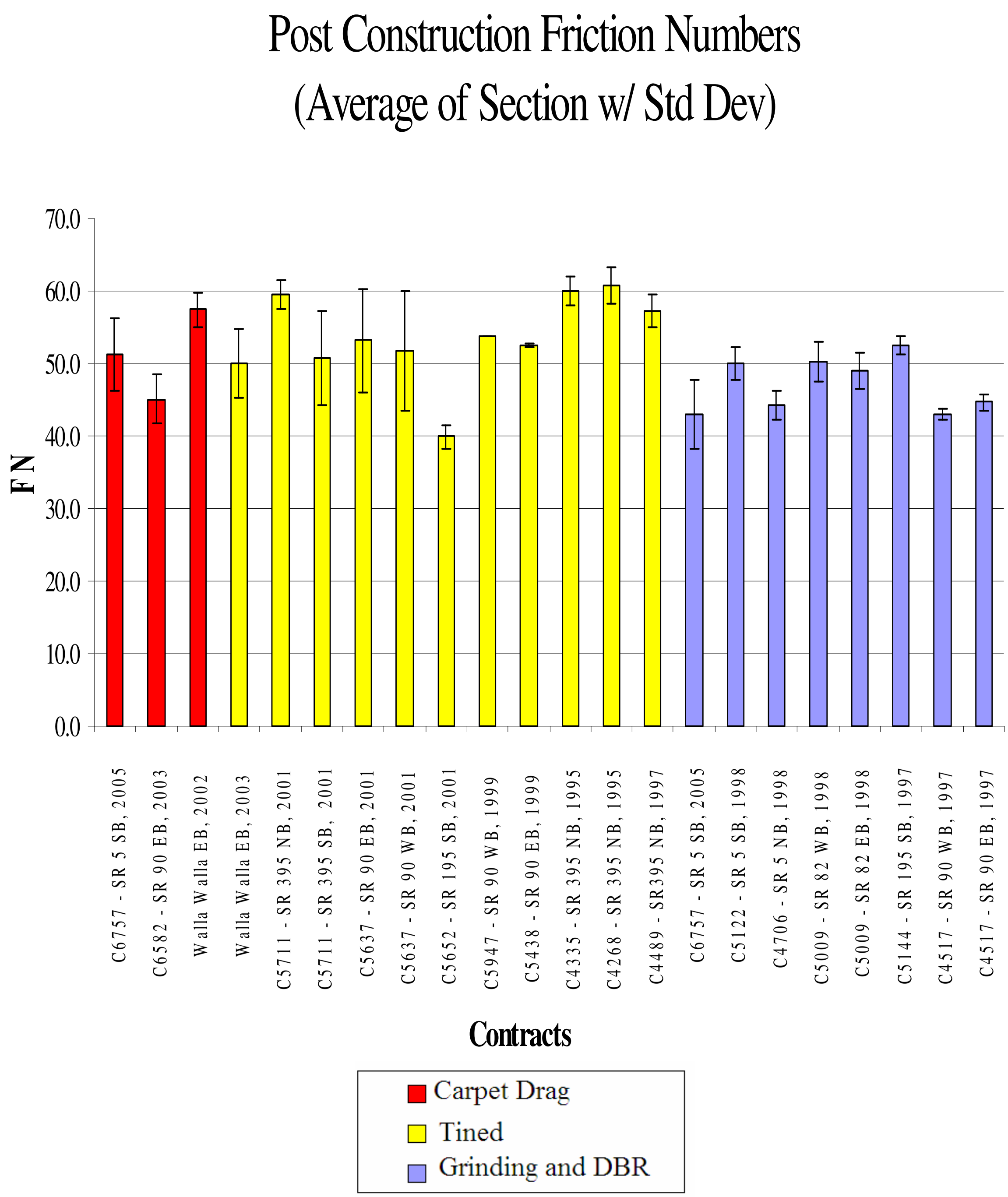


Figure 14. Post-construction friction numbers for projects with tined, carpet drag, and diamond ground surfaces.

SUMMARY

The construction of this project was accomplished without any problems that would adversely affect the outcome of its comparison with similar projects across the state that have or will use either a carpet drag or tined finish. Cylinder breaks converted to flexural strengths generally met the required 650 psi. The profilograph roughness values were well within the specification limits. The sand patch measurements met the recommended 1.0 mm of texture for the majority of the tests. The initial post-construction rutting and ride measurements are in the range of what is expected from new PCCP construction and a retest after all lanes are returned to a normal alignment might reveal more accurate results. The friction numbers are equivalent to other post construction values measured on other projects. In summary, the project is representative of new pavement with carpet drag texture and older pavement with diamond grinding.

FUTURE RESEARCH

The experimental feature work plan (see Appendix E) calls for this project to be monitored for a period of five years. Data from pavement condition surveys, transverse profile, ride, and friction measurements will be collected and compared to other sections of PCCP built with both carpet drag and tined finishes. The section will also be monitored for noise when the required equipment is purchased to make these measurements. Annual update reports will be generated as well as a final report at the end of the study period.

APPENDIX A

PCCP Mix Design

Feb 22 2005 2:39PM MILES SAND AND GRAVEL CO 2533516005 p.4

Washington State Department of Transportation

Concrete Mix Design

Contractor	Submitted By: Salinas	Date: 2-22-2005
Concrete Supplier: Miles Sand & Gravel	Plant Location: Auburn	
Contract Number: 6757	Contract Name: Federal Way s. 317th St HOV Direct Access	

This mix is to be used in the following Bid Item No(s): 68

Concrete Class: *(check one only)*

☐ 3000 ☐ 4000 ☐ 4000D ☐ 4000P[a] ☐ 4000W[a] ☐ Concrete Overlay ☒ Cement Concrete Pavement[d]

☐ Other

Remarks:

Mix Design No. 15650AS

Cementitious Materials	Source	Type or Class	Sp. Gr.	Lbs/cy
Cement	Lafarge	I-II	3.15	423
Fly Ash [a]				
Microsilica				
Latex				
Slag	Lafarge	I	2.83	141

Concrete Admixtures	Manufacturer	Product	Type	Est. Range (oz/cy)
Air Entrainment	Master Builders	MB-AE-90	Air Ent.	5-20
Water Reducer	Master Builders	Polyheed 997	A	23
High-Range Water Reducer				
Set Retarder				
Other				

Water (Maximum) 233 (lbs/cy) Reclaimed/Recycled Water[e] (Maximum) 0.38 (lbs/cy)

Water Cementitious Ratio (Maximum) 0.38

Design Performance	1	2	3	4	5	Average
28 Day Compressive Strength (cylinders) psi	5,510	5,590	5,680	5,620	5,460	5,572
14 Day Flexural[d] Strength (beams) psi	720	710	750	730	710	724

Reviewed By: TSM for John Chi, PE — PE Signature

14 March 2005 — Date

Distribution: Original - Contractor
Copies To - State Materials Lab-General Materials Eng.; Regional Materials Lab; Project Inspector

DOT Form 350-040 EF

APPROVED

Combined Gradation Chart

Concrete Aggregates	Component 1	Component 2	Component 3	Component 4	Component 5	Combined Gradation
WSDOT Pit No.	B-345	B-345	B-345	B-345		
ASR Mitigation Required? b	☐ Yes ☒ No	☐ Yes ☒ No	☐ Yes ☒ No	☐ Yes ☒ No	☐ Yes ☐ No	
Grading c	3/4 x 1/4 Chip	57	Class 2	1 1/2"		
Percent of Total Aggregate	18.1	32.9	33.4	15.6		100%
Specific Gravity	2.71	2.71	2.65	2.70		
Lbs/cy (ssd)	590	1075	1090	510		

Percent Passing

2 inch						
1-1/2 inch						
1 inch						
3/4 inch						
1/2 inch						
3/8 inch						
No. 4						
No. 8						
No. 16						
No. 30						
No. 50						
No. 100						
No. 200						

Aggregate Correction Factor: ____________ Fineness Modulus: 2.91 ____________ (Required for Class 2 Sand)

Notes:

a Required for Class 4000D and 4000P mixes

b If Alkali Silica Reactivity Mitigation is required per WSDOT ASA Database - Attach evidence that mitigating measure controls expansion in the form of ASTM C 1260 / AASHTO T303, ASTM C 1293, or ASTM C 295 test results

c AASHTO No. 467, 57, 67, 7, 8; WSDOT Class 1, Class 2; or combined gradation. See Standard Specification 9-03.1

d Required for Cement Concrete Pavements

e Attach test results indicating conformance to Standard Specification 9-25.1

DOT Form 350-040 EF

COMBINE GRADATIONS WORKSHEET

Date: 2/22/05

MIX I.D.: 15650AS

SOURCE: Pit # B-345

		%used		%used		%used		%used		Total	%	Wt.
Sieve	1 3/8"	15.6%	7/8"	32.9%	3/4"chip	18.1%	Sand	33.4%	sieve	Pass	Retain	Retain
% Total Coarse Agg		23.4%		49.4%		27.1%	CA/FA%	33.4%				
2"	100.0%	15.6%	100.0%	32.9%	100.0%	18.1%	100.0%	33.4%	2"	100.0%	0.0%	0.0
1 1/2"	100.0%	15.6%	100.0%	32.9%	100.0%	18.1%	100.0%	33.4%	1 1/2"	100.0%	0.0%	0.0
1 1/4"	97.6%	15.2%	100.0%	32.9%	100.0%	18.1%	100.0%	33.4%	1 1/4"	99.8%	0.4%	12.2
1"	16.0%	2.5%	100.0%	32.9%	100.0%	18.1%	100.0%	33.4%	1"	86.9%	12.7%	416.2
3/4"	0.1%	0.0%	82.3%	27.1%	100.0%	18.1%	100.0%	33.4%	3/4"	78.6%	8.3%	271.3
1/2"	0.1%	0.0%	30.9%	10.2%	98.7%	17.8%	100.0%	33.4%	1/2"	61.4%	17.2%	560.1
3/8"	0.1%	0.0%	9.3%	3.1%	76.7%	13.9%	100.0%	33.4%	3/8"	50.3%	11.1%	362.0
#4	0.0%	0.0%	1.2%	0.4%	3.6%	0.7%	97.4%	32.5%	#4	33.6%	16.8%	547.2
#8	0.0%	0.0%	0.6%	0.2%	0.5%	0.1%	83.6%	27.9%	#8	28.2%	5.4%	175.2
#16	0.0%	0.0%	0.0%	0.0%	0.3%	0.1%	64.8%	21.6%	#16	21.7%	6.5%	212.6
#30	0.0%	0.0%	0.0%	0.0%	0.3%	0.1%	41.8%	14.0%	#30	14.0%	7.7%	250.7
#50	0.0%	0.0%	0.0%	0.0%	0.3%	0.1%	17.5%	5.8%	#50	5.9%	8.1%	264.9
#100	0.0%	0.0%	0.0%	0.0%	0.3%	0.1%	4.5%	1.5%	#100	1.6%	4.3%	141.7
#200	0.0%	0.0%	0.0%	0.0%	0.3%	0.1%	1.5%	0.5%	#200	0.6%	1.0%	32.7
MIX WT.	510		1075		590		1090			3265	0.6%	18.1
												3265.0

Feb 22 2005

APPENDIX B

Portland Cement Concrete Finishing Information

Current WSDOT Specification

The current WSDOT Standard Specifications call for a tined finish to be applied to all PCC pavements as noted in the italicized portion of the section, 4-05.3(11) Finishing, shown below.

5-05.3(11) Finishing

After the concrete has been given a preliminary finish by means of finishing devices incorporated in the slip-form paving equipment, the surface of the fresh concrete shall be checked by the Contractor with a straightedge device not less than 10 feet in length. High areas indicated by the straightedge device shall be removed by the hand-float method. Each successive check with the straightedge device shall lap the previous check path by at least 1/2 of the length of the straightedge. The requirements of this paragraph may be waived if it is successfully demonstrated that other means will consistently produce a surface with a satisfactory profile index and meeting the 10-foot straightedge requirement specified in Section 5-05.3(12).

Any edge slump of the pavement, exclusive of specified edging, in excess of ¼ inch shall be erected before the concrete has hardened. If edge slump on any 1 foot or greater length of hardened concrete exceeds 1 inch, the concrete shall be repaired as provided in section 5-05.3(22).

The pavement shall be given a final finish surface by texturing with a comb perpendicular to the centerline of the pavement. The comb shall produce striations approximately 1/8 inch to 3/16 inch in depth. Randomly space the striations from 1/2 inch to 1-1/4 inch. The comb shall be operated mechanically either singly or in gangs with several placed end to end. Finishing shall take place with the elements of the comb as nearly perpendicular to the concrete surface as is practical, to eliminate dragging the mortar. If the striation equipment has not been previously approved, a test section shall be constructed prior to approval of the equipment. If the pavement has a raised curb without a formed concrete gutter, the texturing shall end 2 feet from the curb line.

At the beginning and end of paving each day, the Contractor shall, with an approved stamp, indent the concrete surface near the right hand edge of the panel to indicate the date, month, and year of placement.

At approximate 500-foot intervals where designated by the Engineer the Contractor shall, with an approved stamp, indent the concrete surface near the right hand edge of the pavement with the stationing of the roadway.

Change Order to Contract 6757

The carpet drag texturing on Contract 6757 was added to the project via a change order as shown below. It should be noted that the entire mainline paving received the carpet drag texturing not just the section delineated in the change order.

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION
CHANGE ORDER

DATE: 02/28/05
page 2 **of** 2

CONTRACT NO: 006757	**CHANGE ORDER NO:** 39

All work, materials, and measurements to be in accordance with the provisions of the Standard Specifications and Special Provisions for the type of construction involved.

This contract is revised as follows:

DESCRIPTION
This change order revises the final pavement finish for a portion of the new PCCP.

CONSTRUCTION REQUIREMENTS
The new PCCP between Station LW 231+850 and Station LW 232+430.63, shall be given a final textured finish by dragging the surface with Astro Turf carpet. The depth of texture produced by the Astro Turf shall be a minimum of 1.0 mm.

All other areas of new PCCP shall be finished as specified in Section 5-05.3(11).

MEASUREMENT AND PAYMENT
This is a no-cost change order.

TIME
Contract time is not affected by this change order.

Minnesota Department of Transportation Specification for Texturing

The WSDOT specification for carpet drag texturing was patterned after the Minnesota Department of Transportation's specification, S-106.1 Pavement Texture. A copy of that specification is included below. The change order for Contract 6757 did not include the sampling and testing plan required by the Minnesota specification because this was primarily a trial of the texturing method and not of the quality control features needed to enforce such a specification.

S-106.1 PAVEMENT TEXTURE

Remove the third through fourth paragraphs of Mn/DOT 2301.3L and any other references to tining in the concrete pavement and replace with the following:

The texture achieved by the carpet drag shall be tested by the Concrete Paving Contractor in accordance with ASTM E 965-87, *"Test Method for Measuring Surface Macrotexture Depth Using a Sand Volumetric Technique",* to ensure the texture is adequate for skid resistance. The test location will be determined by the Agency and at a point located transversely to fall in the outside wheelpath. The results of ASTM E 965-87 shall show an average texture depth of any lot, as defined below, shall have a minimum value of 1.00 mm [**1/25 inc**h]. Any lot showing an average of less than 1.00 mm [**1/25 inc**h] but equal to or greater than 0.80 mm [**1/32 inc**h] will be accepted as substantial compliance but the Contractor shall amend their operation to achieve the required 1.00 mm [**1/25 inc**h] minimum depth. (It is not the intention of this tolerance to allow the Contractor to continuously pave with an average texture depth of less than 1.00 mm [**1/25 inc**h]). Any lot showing an average texture depth of less than 0.80 mm [**1/32 inc**h] shall require diamond grinding of the pavement represented by this lot to attain the necessary texture. Any individual test showing a texture depth of less than 0.70 mm [**1/36 inc**h] shall require diamond grinding of the pavement represented by this test to attain the necessary texture of 1.00 mm [**1/25 inc**h]. Limits of any failing individual test shall be determined by running additional tests at 30 m [**100 foo**t] intervals before and after the failing test location. All testing of the surface texture shall be completed no later than the day following pavement placement. A lot shall represent one days paving per driving lane. Lots shall be broken down into sublots representing 300 m [**1000 linear fee**t] of pavement. Each lot shall have a minimum of 3 sublots. If production results in less than 3 sublots per day, the quantities shall be included in the next day of concrete production. All adjoining driving lanes shall be tested at the same location but shall be considered individual lots. The test locations will be randomly chosen by the Agency and given to the Contractor. The location of the test shall be determined using a random number chart (or other approved method) and multiplying the random number by the 300 m **[1000 linear foo**t] sublot size (Example: Random number (0.65) X 300 m **[1000 linear foo**t] results in taking a sample from the load representing the 195 m **[650 linear fee**t] from the previous sublot extents).

Texas Department of Transportation Specification for Texturing

The Texas Department of Transportation's specification for carpet drag texturing is provided below as a contract to the Minnesota Department of Transportation's specification used on this contract. The Texas specification was used on two previous contracts, Contract 6620, Argonne Road to Sullivan Road, and Contract 6582, Sullivan Road to Idaho State Line. The latter contract involved the paving of a short section of whitetopping as a studded tire mitigation trial. The first contract is the one mentioned previously as having low friction numbers due to a lack of texture. The Texas specification is followed by the Special Provisions used on the two WSDOT contracts.

<u>Texas DOT</u>

Article 360.4. Equipment, Subarticle (14) Texturing Equipment, Section (a) Carpet Drag is voided and replaced by the following:

APPENDIX C. Carpet Drag. Carpet drag shall be mounted on a work bridge or a moveable support system capable of varying the area of carpet in contact with the pavement. 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 a four (4) foot longitudinal length of carpet in contact with the concrete being placed. Where construction operations necessitate and with the approval of the Engineer, the length and width of the carpet may be varied to accommodate specific applications. The carpeting used shall be an artificial grass type having a molded polyethylene pile face with a blade length of 5/8 inches to one (1) inch and a minimum weight 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.

WSDOT Special Provision

Contract 6620, Argonne Road to Sullivan Road and Contract 6582, Sullivan Road to Idaho State Line

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 carpeting 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.

APPENDIX C

Data Collection Form and Sample Calculation for Sand Patch Test

Sand Patch Test Data Collection Form

ASTM E 965- SAND PATCH TEST

$MATX_d = 4V/\pi D_{avg.}^2$

Date: _____________
Location: _____________
Operator: _____________
Texture type: _________________________

Trial 1

Volume of glass spheres, V: ____________mm^3

Dia. 1: ________mm Dia. 2: ________mm Dia. 3: ________mm Dia. 4: ________mm

Average Diameter, $D_{avg.}$: [ ] mm

Avg. Macro Texture Depth, $MATX_d$: _____________mm

Trial 2

Volume of glass spheres, V: ____________mm^3

Dia. 1: ________mm Dia. 2: ________mm Dia. 3: ________mm Dia. 4: ________mm

Average Diameter, $D_{avg.}$: [ ] mm

Avg. Macro Texture Depth, $MATX_d$: _____________mm

Trial 3

Volume of glass spheres, V: ____________mm^3

Dia. 1: ________mm Dia. 2: ________mm Dia. 3: ________mm Dia. 4: ________mm

Average Diameter, $D_{avg.}$: [ ] mm

Avg. Macro Texture Depth, $MATX_d$: _____________mm

Trial 4

Volume of glass spheres, V: ____________mm^3

Dia. 1: ________mm Dia. 2: ________mm Dia. 3: ________mm Dia. 4: ________mm

Average Diameter, $D_{avg.}$: [ ] mm

Avg. Macro Texture Depth, $MATX_d$: _____________mm

Sample Calculation of Texture Depth

The volume of the canister was calculated to be:

V = 34.1 and when converted to mm^3 equals **34,100**.

$MATX_d = 4V/\pi D_{avg.}^2$

Example

Trial 1

Volume of glass spheres, V: **34,100** mm^3

Dia. 1: **201** mm Dia. 2: **198** mm Dia. 3: **210** mm Dia. 4: **195** mm

Average Diameter, $D_{avg.}$: **201** mm

$$MATX_d = 4V/\pi D_{avg.}^2$$

$$(4 \times 34{,}100) / (3.14159) \times (201 \times 201)$$

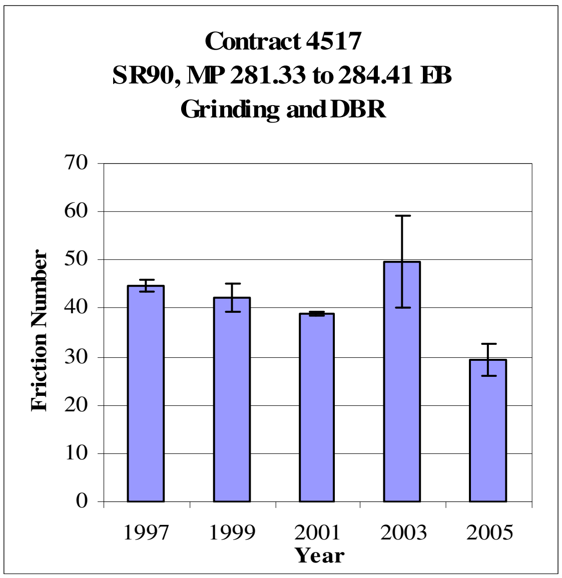
$$136{,}400 / (3.14159 \times 40{,}401)$$

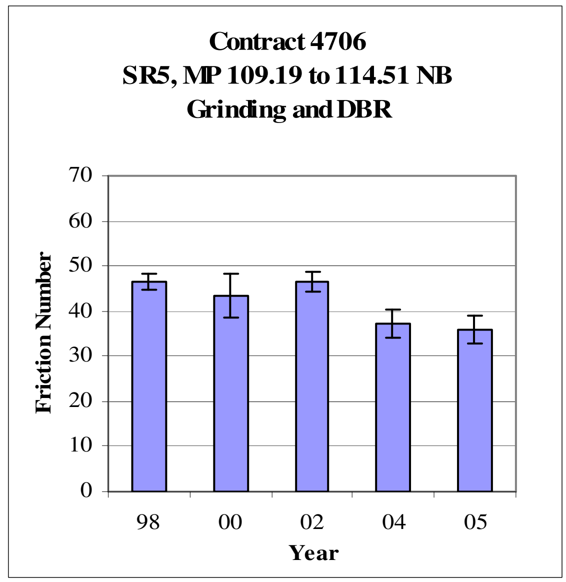
$$136{,}400 / 126{,}923.49 = 1.07$$

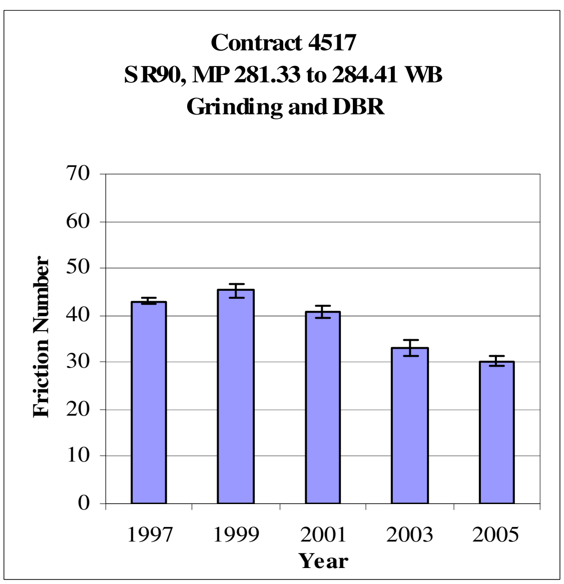
APPENDIX D

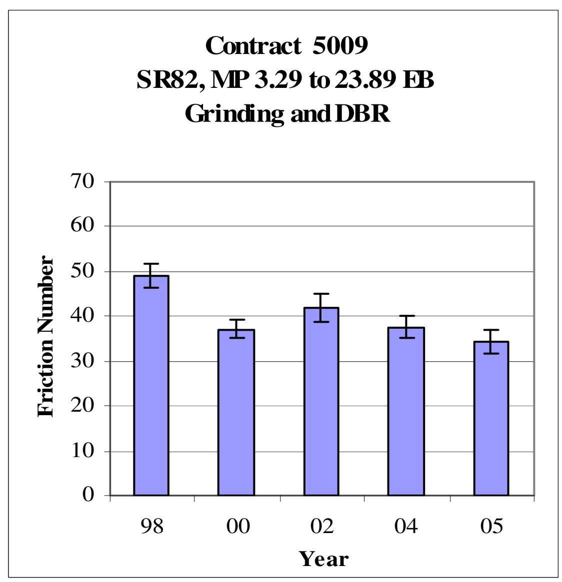
Friction Number History for Pavements with Various Finishing Methods

Charts showing the changes in friction number over time for sections of pavements with tined texture, carpet drag texture, and diamond grinding texture.

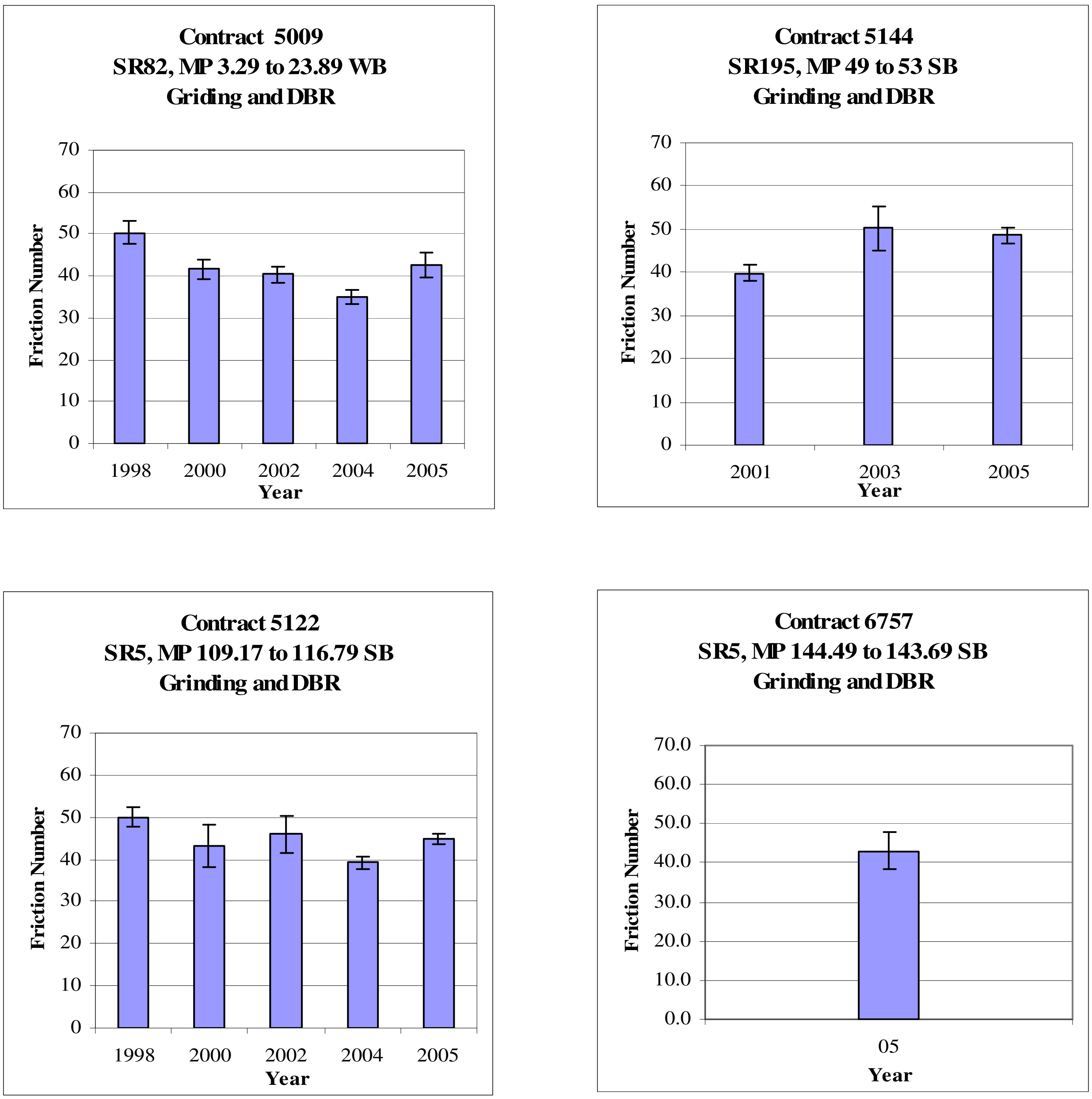




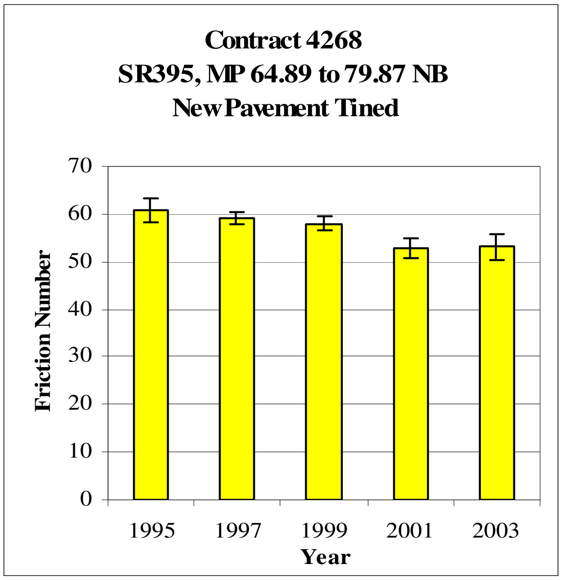


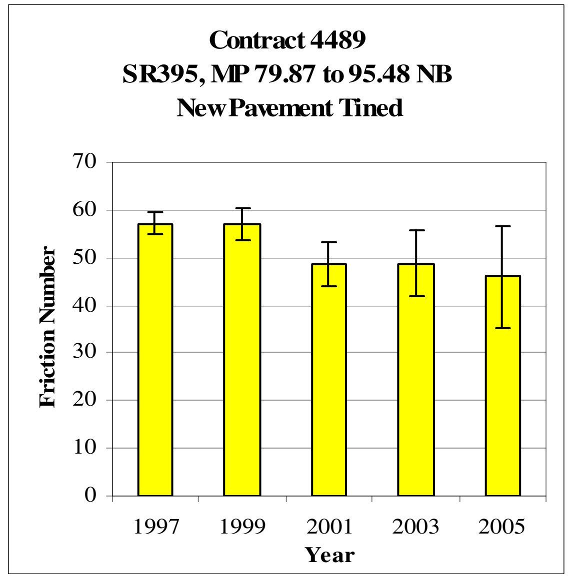


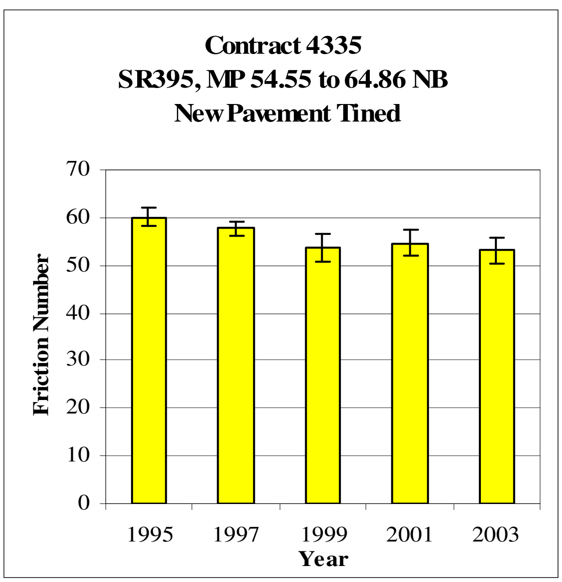
Average friction number versus year for PCC pavements with grinding and dowel bar retrofit.

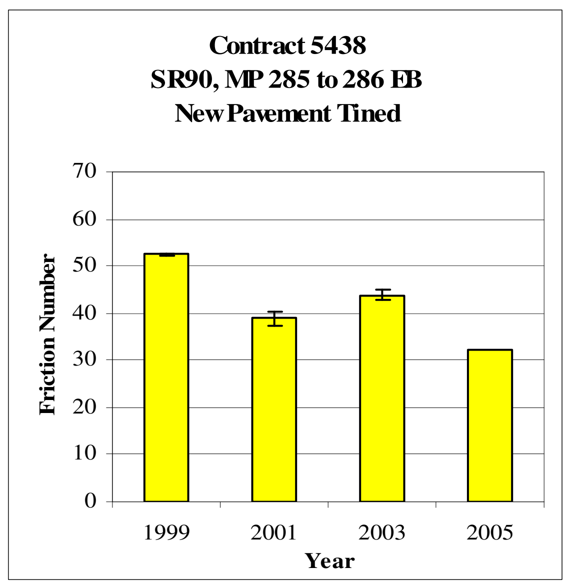


Average friction number versus year for PCC pavements with grinding and dowel bar retrofit.

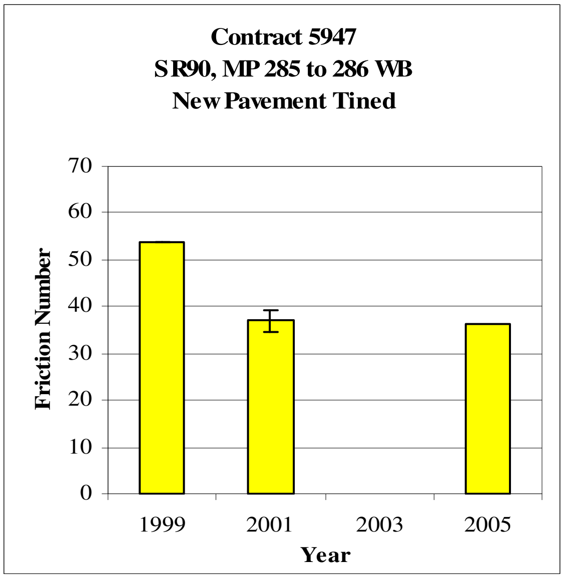


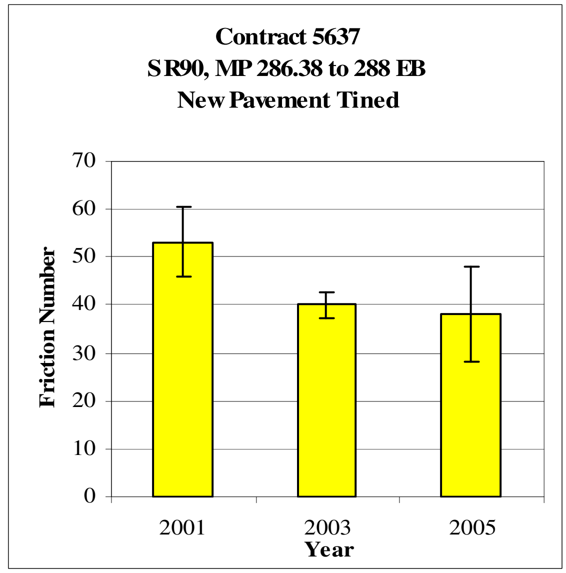


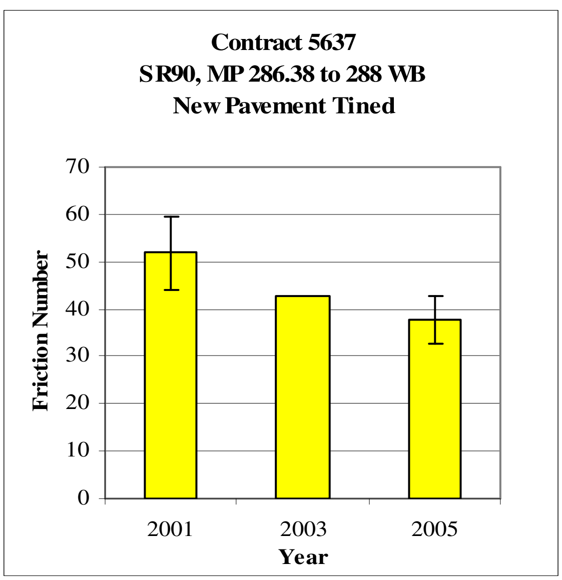


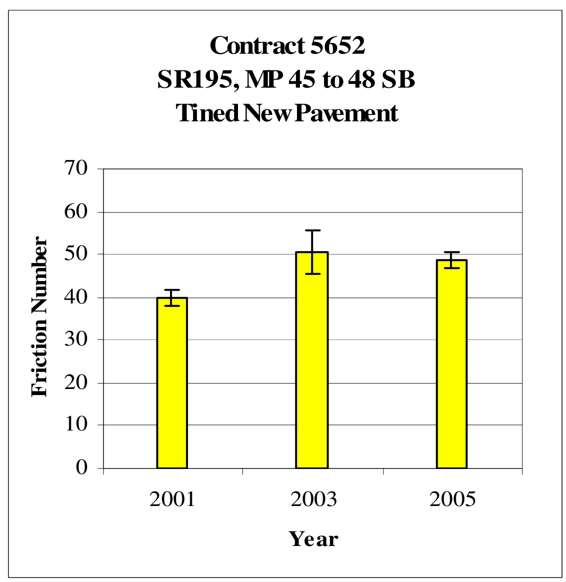


Average friction number versus year for PCC pavements with transverse tined finish.

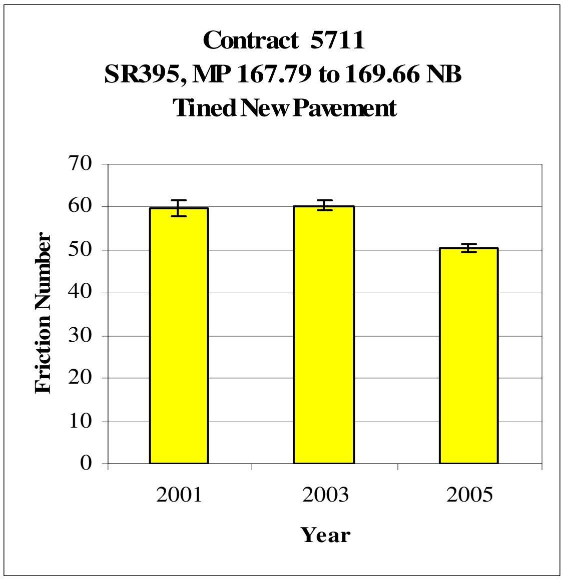


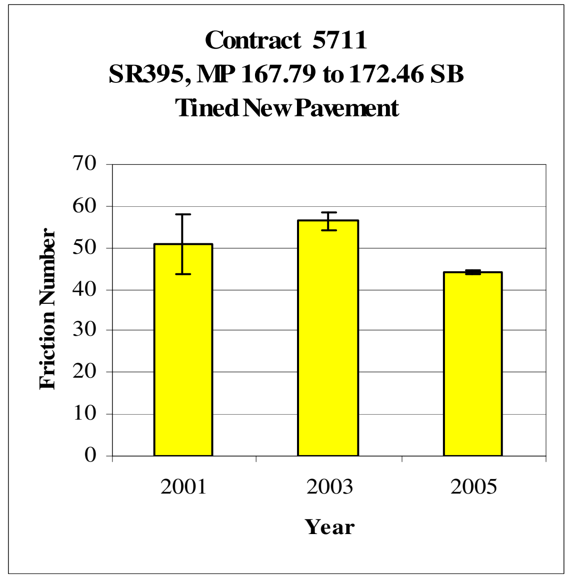


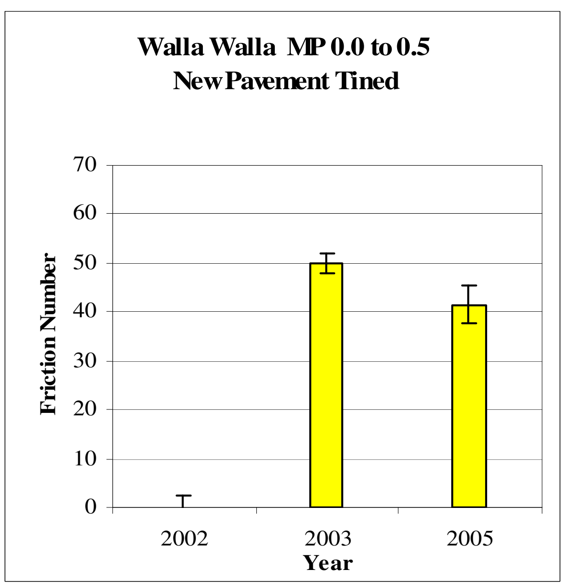




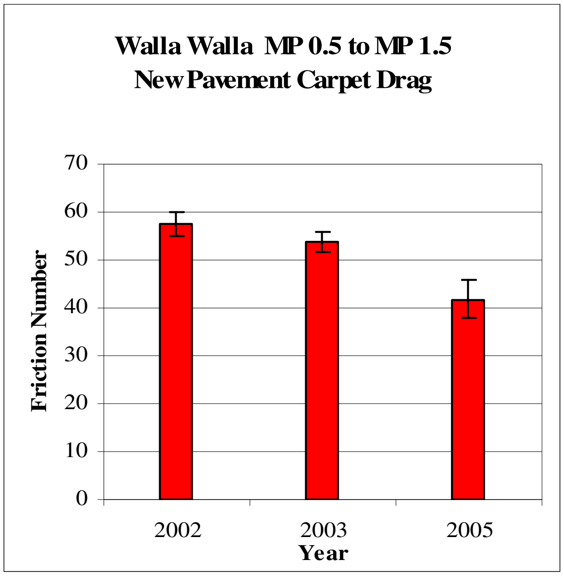
Average friction number versus year for new pavements with transverse tined finish.

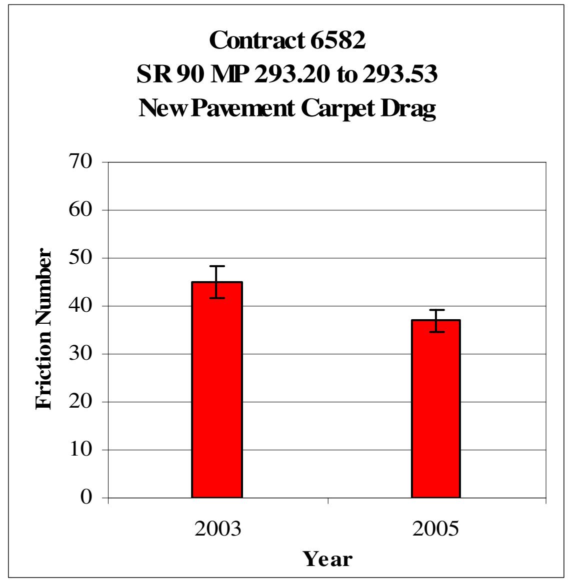


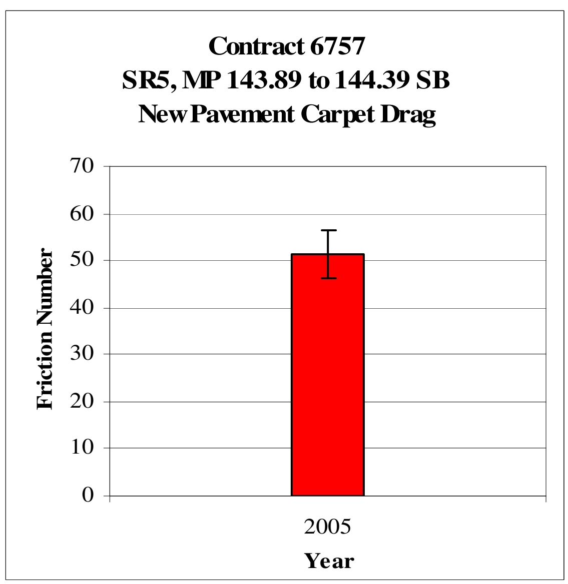




Average friction number versus year for new pavements with transverse tined finish.







Average friction number versus year for PCC pavements with carpet drag finish.

APPENDIX E

Experimental Feature Work Plan

Washington State Department of Transportation

WORK PLAN

PCCP Features

(Surface Smoothness and Noise)

I-5, Federal Way – South 317th Street HOV Direct Access
Milepost 143.25 to Milepost 144.74

Prepared by

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

February 2005

Introduction

Washington State Department of Transportation's (WSDOT) Portland Cement Concrete Pavement (PCCP) construction program has been relatively small since the construction of the Interstate system in the 1960's and early 70's. As many of these early pavements deteriorate and require reconstruction, the best possible construction practices will be essential in order to provide pavements that will last 50 years or longer.

One of the challenges facing WSDOT is to reduce the excessive wear concrete pavements received from studded tires. An Experimental Feature "Combined Aggregate Gradation for Concrete Pavements" is under study and is investigating the use of a combined aggregate gradation to curb the effects of studded tire wear. An additional WSDOT study involves the rates of stud wear on the Specific Pavement Studies (SPS) located on SR 395 south of Ritzville. To date there is definitely less wear due to studded tires in the 900-psi section as compared to the lower strength sections. Further, the tine grooves are still apparent in the high strength sections and are, in essence, gone from the lower strength ones. While these observations are far from conclusive, WSDOT wishes to explore the effects of higher strength PCCP mixes.

Another challenge observed with WSDOT PCCP construction has been with providing smooth riding surfaces, particularly in urban areas. WSDOT has built several pavements in recent years where bonuses have been paid to contractors for satisfying the smoothness specifications, however, in some cases the roadway is still perceived rough. WSDOT's current smoothness requirement is based on a 0.20 inch blanking band with an allowable daily profile index of 7.0 inches per mile or less.

A current experimental feature, I-90 - Argonne to Sullivan Experimental Feature, MP 287.98 to MP 292.16, is underway in the Eastern Region to consider PCCP features beyond the 2002 WSDOT Standard Specifications. The eastbound lanes of this feature were paved in the summer of 2004. Included in this study is the use of a carpet drag finish, increasing the flexural strength of the PCCP, and providing a zero blanking band for measuring surface smoothness. Following construction of the PCCP, the influences from the carpet drag finish and increased flexural strength specification on the pavement will be monitored to determine its ability to resist surface abrasion. Additionally, the results of using a zero blanking band to determine smoothness will be analyzed and compared with profilogragh results using the 0.20-inch blanking band.

I-5, Federal Way – South 317th Street HOV Direct Access

Since the approval of the I-90, Argonne to Sullivan Experimental feature, the Federal Highway Administration has changed its noise policy to allow states to take into consideration the effects of quiet pavements as noise mitigation with enough supporting data. The process for state DOT's to utilize pavement type to mitigate noise is found in the January 19, 2005 Memorandum titled "Highway Traffic Noise – guidance on Quiet Pavement Pilot Programs (QPPP) and Tire/Pavement Noise Research." (http://www.fhwa.dot.gov/environment/noise/qpppeml.htm)

The QPPP is intended to demonstrate the effectiveness of quiet pavement strategies and to evaluate any changes in their noise mitigation properties over time. Current knowledge on changes over time is extremely limited. Thus, the programs will collect data and information for at least a 5-10 year period, after which the FHWA will determine if policy changes to a State DOT(s) noise program are warranted.

The intent of this experimental section is to allow the placement of a carpet drag surface in Western Washington and monitor both rutting/friction and noise over time. Currently, WSDOT does not have a means for collecting noise information, however, there is discussion between the Materials Laboratory and Environmental Noise Quality to purchase equipment. The key item for WSDOT is to place a concrete pavement in Western Washington to compliment the work being performed on I-90 in Spokane. The rutting and friction information will be valuable information as WSDOT begins a QPPP.

Scope

This project involves the reconstruction and rehabilitation of 1.49 miles of southbound I-5. The reconstruction portion of the contract is 0.60 miles long and places full width 13 inches (1.08') of PCCP over 4.2 inches (0.35') of asphalt concrete over 4.2 inches (0.35') of crushed surfacing. The total 50-year design ESALs for the single direction traffic are approximately 200 million. The experimental features will be incorporated over one half of the project length.

Carpet Drag

The final pavement surface will be obtained by drawing a carpet drag longitudinally along the pavement before the concrete has taken its initial set. The carpet drag will be a single piece of carpet of sufficient length to span the full width of the pavement being placed and adjustable to allow up to 4 feet longitudinal length in contact with the concrete being finished. The target depth of the carpet drag will be about 1 millimeter.

Initial WSDOT analysis shows that the carpet drag finish provides an equal or better skid resistance than normal WSDOT transverse tined pavements. This is significant considering studded tire wear normally removes transverse tining 3 to 4 years after placing PCCP.

Mix Design

The mix design requirements will utilize PCCP concrete that has a 14-day target flexural strength of 650 psi as specified in Section 5-05 of the 2004 WSDOT Standard Specifications.

Test Section

Approximately one half of the project will utilize the carpet drag finish. The exact location has not been specified, however, it is likely the northern half of the southbound lanes will receive the carpet drag. The carpet drag will be placed on all lanes, starting and stopping at the same locations. The remainder of the project will receive a tined finish.

Construction

Concrete will be placed by a slip form paver. Except as indicated, 2004 WSDOT Standard Specifications will apply.

Staffing

The Region Project office will coordinate and manage all construction aspects. Representatives from WSDOT Materials Laboratory (one or two persons) will also be involved with documenting the construction.

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Testing

The completed PCCP will be skid tested to determine friction values. The friction values will be measured twice a year on each of the test sections for the duration of the experiment. Specific tests for determining pavement surface wear will also be taken before and after the allowance of studded tires.

Reporting

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

Cost Estimate

Construction Costs

This contract is currently under construction. The concrete contractor has agreed to provide the carpet drag at no cost to WSDOT.

Testing Costs

Condition Survey – will be conducted as part of statewide annual survey, no cost.

Rut Measurements – 10- surveys (2 hours each) requires traffic control = $12,000

Friction Measurements – 10 surveys done in conjunction with annual new pavement friction testing, no cost.

Noise Surveys – WSDOT is currently pursuing purchasing noise-monitoring equipment. The cost of this equipment is not included in this experimental feature, as this equipment will be used throughout Washington State once noise monitoring on a regular basis begins. However, about $5,000 is anticipated for funds necessary to monitoring noise for periodic surveys on this section of I-5.

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 = $20,000

Schedule

Construction Date: Westbound lanes – April 2005

Date	Condition Survey (Annual)	Rut & Friction Measurements (Annual)	End of Construction Report	Annual Report	Final Report
April 2005		X	X		
Fall 2005	X	X		X	
Spring 2006	X	X		X	
Fall 2006	X	X		X	
Spring 2007	X	X		X	
Fall 2007	X	X		X	
Spring 2008	X	X		X	
Fall 2008	X	X		X	
Spring 2009	X	X		X	
Fall 2009	X	X		X	X