Combined Aggregate Gradation As A Method for Mitigating Studded Tire Wear On PCCP

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Combined Aggregate Gradation As A Method for Mitigating Studded Tire Wear On PCCP

Contract 5947
I-90
Sprague Avenue Interchange Phase 3
MP 284.41 to 286.38

Washington State
Department of Transportation

Experimental Feature Report

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16. ABSTRACT

Two sections of pavement were built with different specifications for the gradation of the aggregates, one with the standard WSDOT specification and one with a combined gradation, to determine if the use of the combined gradation would result in a pavement more resistant to studded tire wear. The standard gradation can result in a gap-graded aggregate whereas the combined gradation produces a more uniform gradation. Wear rates calculated for the most recent data set collected in the fall of 2006 reveals no difference in wear rates between the pavements paved with the standard gradation versus those paved with the combined gradation.

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Project Design

The Eastern Region has been experiencing excessive wear in Portland cement concrete pavements due to studded tires. Various measures have been tried to mitigate the effect of studded tires on these pavements including higher strength mixes, additives that increase the abrasion resistance and switching from a standard tined finish to a carpet drag finish. One of the ideas also tried was a switch from the standard aggregate gradation specification to a combined gradation specification. The theory was that the near gap grading of the standard specification might be a contributing factor to the increased wear and that a combined gradation with its more uniform grading would help to mitigate this wear.

The portland cement concrete pavement for Sprague Avenue Interchange Phase 2 (Eastbound MP 284.36 to 286.65) that was constructed during the summers of 1999 and 2000 used the standard aggregate specification, while the project that constructed the westbound lanes, Sprague Avenue Interchange Phase 3, used the combined gradation specification. This project ran from Milepost 284.42 to 286.38 and was completed in 2001. The contract special provisions called for the aggregate grading to be plotted on a 45-power chart, and as necessary, coarse or fine aggregate were added to optimize the aggregate gradation. Figure 1 shows the actual aggregate gradations from the project before and after it was adjusted to more closely fit the 45-power chart.

These two projects provided a prime opportunity for a side-by-side comparison of PCCP constructed with aggregate grading that meets the existing specification to a PCCP constructed with aggregate grading that meets a 45-power chart or combined gradation.

Aggregate Gradations

The aggregate gradations for the two projects are plotted on a 45-power curve chart in Figure 1. The closer fit of the combined gradation to the 45-power curve is evident from this chart.

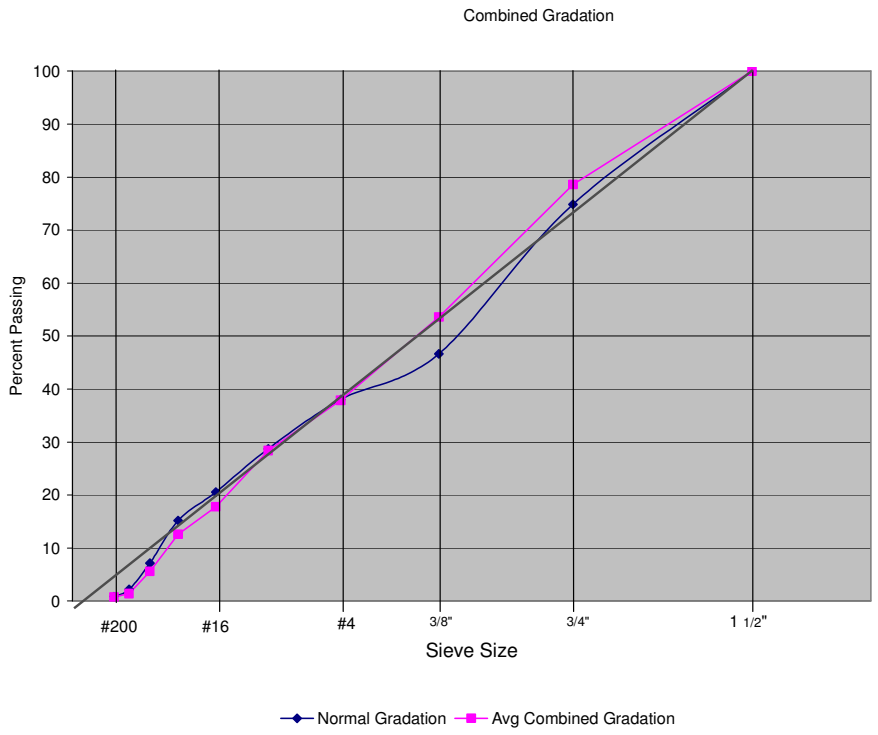

Figure 1. Normal and combined aggregate gradations for the Sprague Avenue Interchange Phase 3.

Cylinder Strengths

Compression tests of the PCCP cylinders showed some difference between the two projects. Cylinders from the combined gradation project had a higher average compressive strength, lower standard deviation indicating less variability, and fewer failed specimens. The strength data is included because there is evidence from some projects that higher strength PCC pavements have better resistance to studded tire wear.

Table 1. Comparison of cylinder strength data.

Statistic	WSDOT Standard Gradation	Combined Gradation
Total No. of Cylinder Pairs	70	116
No. of Failed Tests	11	6
Percentage of Failed Tests	15.7	5.2
Average Compressive Strength (psi)	4210	4640
Standard Deviation	730	610

Wear Data

The two projects have been monitored for pavement wear since 2004. The WSDOT Pathway Van was used to collect rutting measurements in the spring and fall of 2004, 2005 and 2006. These wear measurements are listed in Tables 1 and 2 for the center and left lane, respectively. The tables show the increase in wear over the three years of measurement.

Table 2. Wear measurements for center and left lane

Date	Center Lane		Left Lane	
	WSDOT Standard Gradation	Combined Gradation	WSDOT Standard Gradation	Combined Gradation
Spring 2004	2.4	2.1	1.5	2.4
Fall 2004	5.3	4.1	3.9	3.3
Spring 2005	6.7	5.1	4.8	4.2
Fall 2005	6.4	4.8	4.5	3.5
Spring 2006	7.6	6.0	5.2	3.9
Fall 2006	8.0	5.9	5.7	4.5

A direct one to one comparison cannot be made between the pavement built with the two aggregate specifications because they are not the same age and have not experienced the same amount of traffic. The data for the westbound lanes needs be corrected for the difference in the amount of traffic it has experienced compared to the eastbound lanes which is a year older. Traffic counts were collected for each direction of traffic from the Washington State Pavement Management System. The average daily traffic (ADT) from the most recent data available for the eastbound lanes was 48,161 and the westbound 43,919. The total traffic for the 6 years that the eastbound has been built is 105,472,765 (48,161 x 365 x 6) vehicles and for the five years the westbound has been in existence is 80,152,175. The ratio between the two directions of travel is 1.316, that is, the westbound wear readings must be multiplied by 1.316 to adjust for the added traffic. For example, the corrected wear for the center lane westbound for the latest measurement (Fall 2006) is 7.8 mm (5.9 mm x 1.316). The corrected wear values are shown in Table 3 for the center and left lanes, respectively.

Table 3. Wear values for the Fall 2006 measurements corrected for traffic.

Section	Wear (mm)		Average for Both Lanes (mm)
	Center	Left	
WSDOT Standard Gradation	8.0	5.7	6.85
Combined Gradation (corrected for differences in traffic)	7.8	5.9	6.85

The correction for the traffic differences between the two sections is admittedly somewhat crude, but in the absence of actual daily traffic counts on both directions of I-90, it is the only thing that can be done.

Conclusions

The only conclusion that can be drawn from the current data is that there is no difference in wear rates between the pavements built with the two types of aggregate gradation.

Future Research

The project will continue to be monitored for 2 more years to further verify the current data and conclusion.

APPENDIX A

Experimental Feature Work Plan

Washington State Department of Transportation

WORK PLAN

Combined Aggregate Gradation for Concrete Pavements

I-90, Contract 5947
Sprague Avenue Interchange Phase 3

Milepost 284.41 to Milepost 286.38

Prepared by

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January 2001

Introduction

The present contract utilizes WSDOT standard specifications in the determination and analysis of aggregate components. In summary, WSDOT standard specifications tests the coarse and fine aggregate constituents of PCCP individually for adherence to gradations without considering combined affects.

The eastbound lanes parallel to this section were built during the summer of 2000 under a separate contract and utilized these current standards. Premature wear of the pavement as a result of studded tires is being seen. The wear may be caused by the gap grading allowed by the aggregate gradations in the present standard specifications.

Plan of Study

Under this proposal the individual components will be analyzed as previously but these results will then be mathematically and proportionally recombined. These results will then be plotted on a 45-power chart to determine if aggregate (coarse and fine) should be added or proportioned to attain a better distribution of aggregate and possibly a more durable mixture.

This is a prime opportunity for a side-by-side comparison of PCCP constructed during the summer of 2000 with aggregate grading that meets the existing specification and PCCP constructed with aggregate grading that meets a 45-power chart.

Scope

This project will place approximately 41,000 cubic yards of Cement Concrete Pavement on the westbound lanes of SR 90 and associated ramps.

Layout

The PCCP construction will be in the westbound lanes fro MP 284.41 to MP 286.38 as well as the on and off ramps in this section.

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 Inland Asphalt Company and WSDOT Materials Laboratory (1 to 3 persons) will also be involved with the process.

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Testing

No additional testing will be required.

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 conducted over the next 5 years. At the end of the five-year period, a final report will be written which summarizes performance characteristics and recommendations for the use of this process.

Cost Estimate

Construction Costs

Description	Quantity	Unit Cost	Unit	Total Price
Gradation Adjustment	40,869	$1.06	CY	$43,321.14
Total				**$43,321.14**

Testing Costs

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

Walking Profiler – 6- surveys (2 hours each) requires traffic control = $2,000

Report Writing Costs

Initial Report – 20 hours = $1,300

Annual Report – 5 hours (2 hour each) = $500

Final Report – 10 hours = $1,000

TOTAL COST = $48,121.14

Schedule

Construction Date: June and July 2001

Date	Condition Survey	End of Construction Report	Annual Report	Final Report
August 2001		X		
August 2002	X		X	
August 2003	X		X	
August 2004	X		X	
August 2005	X		X	
August 2006	X		X	X