SUPERPAVE - WASHINGTON DOT'S ASSESSMENT AND STATUS

WA-RD 486.1

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16. ABSTRACT

Funded by the 1987 Intermodal Surface Transportation Efficiency Act, the Strategic Highway Research Program (SHRP), was a five year, $150 million research program to improve the performance of the nation's roads by addressing four key areas: concrete and structures; highway safety and maintenance; asphalt; and long-term pavement performance. Nearly one-third of the $150 million was allocated for the study of asphalt, specifically to develop performance based specifications that would relate material properties of the binder and the mix to field performance. Superpave (Superior PERforming asphalt PAVEments) encompasses the products of the SHRP asphalt research program and consists of three interrelated elements: an asphalt binder specification with supporting tests; a mix design and analysis system with supporting tests; and performance prediction models. This report is a compilation and synthesis of Washington DOT's (WSDOT) experience with selected components and concepts of the SHRP/Superpave technology to include the following: performance graded (PG) binder usage and specification validation; gyratory mix design; the Superpave Shear Test (SST); and field performance of the Superpave mixes.

Binders typically specified by WSDOT (AR4000W and PBAs -2, -5, -6, -6GR) were classified in terms of five Superpave performance grades: PG 58-22; 64-22; 64-28; 64-34; and 70-28. Although data from 171 weather stations suggest that as many as 6 low- and 5 high-temperature grades could be specified, binder availability and regional pavement distress were used to develop guidelines for state-wide PG usage. Three binders were recommended for use in the western, northeastern and southeastern regions of the state as follows: PG 58-22; PG 58-34; and PG 64-28, respectively. Validation of the binder specification with respect to low temperature cracking was accomplished using binder and field performance data from 28 projects. The results were very encouraging: the original SHRP algorithm for binder selection correctly "predicted" field performance in 22 of 28 cases, whereas the LTPP algorithm for binder selection correctly "predicted" field performance in 26 of 28 cases.

Additionally, a laboratory experiment using the Superpave Shear Test (SST) apparatus was undertaken to test the effectiveness of binder "bumping," i.e., increasing the high temperature grade because of exceptionally high traffic volume and/or slow or standing traffic. The data clearly indicate that the SST is an effective tool for discriminating between binders and that "bumping" may be effective in reducing pavement rutting. Permanent shear strain for specimens made with a PB 70-xx binder was only 25 to 33% of the shear strain for specimens made with a PG 58-xx binder.

As originally configured, the Superpave mix design matrix included seven traffic levels and four temperature regimes for 28 possible compaction levels. Recognizing that the 28 compaction levels made for a somewhat unwieldy system, WSDOT attempted to reduce the number of compaction levels by conducting a series of mix designs at each compaction level. The results of the limited experiment suggest that it might be possible to limit the number of compaction levels required for mix design. Research by Brown et. al. (NCHRP 9-9) tends to confirm this as they have suggested reducing the number of compaction levels and provided more definitive guidance with respect to each level.

Since 1993 WSDOT has place 44 projects which include some component of the Superpave technology. For 17 of these projects parallel Hveem and Superpave mix designs were conducted. In 13 of the 17 cases, the Superpave design asphalt content was equal to or greater than the Hveem design asphalt content, though the difference was usually no more than 0.2%. A fundamental difference between Hveem and Superpave mix design methods is the compaction device. Data from these field projects indicate that the current kneading and gyratory compaction protocols (at least for 109 gyrations) yield similar air void contents.

As noted previously, Washington DOT has placed 44 projects which involve some component of the Superpave technology. For 18 of the projects a conventional Hveem mix design was conducted using a PG binder (Hveem-PG). The remaining 26 projects were truly Superpave, i.e., the materials selection and mix design were established in accordance with the Asphalt Institute's SP-2, Superpave Level 1 Mix Design. According to WSDOT practice the following numerical indices trigger maintenance: Pavement Structural Condition (PSC) ≤ 50; rutting > 10 mm; or International Roughness Index (IRI) ≥ 500 cm/km. Although relatively "young," the 44 projects are performing quite well. The average values of rutting, PSC, and IRI (4, 91, and 121, respectively) are all well below the "trigger" values. With respect to rutting and PSC, the performance of Hveem-PG and Superpave projects is virtually identical. However, the ride quality of the Superpave projects is a bit rougher than the Hveem-PG binder projects: IRI of 134 for the former and 103 for the latter. The higher values of IRI measured on the Superpave projects may be the result of the typically coarser aggregate gradation or differences in construction techniques.

WSDOT's Superpave experience has not been without challenges. Still, its overall experience has been very encouraging. Experimentation with the revised compaction matrix, continued use of the SST, field validation of the "bumping" experiment, and long-term monitoring of field performance will provide the necessary data to allow WSDOT's critical assessment of Superpave's technical merit and economic viability.

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Superpave – Washington DOT's Assessment and Status

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1. Introduction

Funded by the 1987 Intermodal Surface Transportation Efficiency Act, the Strategic Highway Research Program (SHRP), was a five year, $150 million research program to improve the performance of the nation's roads by addressing four key areas: concrete and structures; highway safety and maintenance; asphalt; and long-term pavement performance. Nearly one-third of the $150 million was allocated for the study of asphalt, specifically to develop performance based specifications that would relate material properties of the binder and the mix to field performance. Superpave encompasses the products of the SHRP asphalt research. The Superpave (SUperior PERforming Asphalt PAVEments) system was developed to give highway engineers and contractors the tools they need to design asphalt pavements that will perform better under extremes in temperature and traffic loads. The Superpave system consists of three interrelated elements: an asphalt binder specification; a mix design and analysis system; and performance tests and prediction models.

This report is a compilation and synthesis of Washington DOT's experience with selected components and concepts of the SHRP/Superpave technology to include the following: performance graded (PG) binder usage; binder specification validation; gyratory compaction matrix; volumetric mix design; and the Superpave Shear Test (SST).

2. Superpave Binder Implementation

2.1 Introduction

To develop guidelines for Superpave performance grade (PG) binder usage in the state of Washington several factors were considered: climate; pavement distress; and binder availability. Each factor in this decision-making progress is addressed in the following narrative.

2.2 Binder Availability

Binders typically specified by Washington DOT include AR4000W and PBAs -2, -5, -6 and -6GR. However, PBA-2 and PBA-5 are rarely used. These binders are usually purchased from as many as 9 suppliers. The initial step in developing guidelines for PG use involved an assessment of the performance grade of the conventionally classified (i.e., AR and PBA) binders used, the results of which are shown in Table 2-1. The data from Table 2-1 have been rearranged in Table 2-2 to illustrate the different PG classification(s) of the conventional binders. As is evident from Table 2-2 the binders typically used by Washington DOT may be classified in terms of 5 Superpave performance grades: PG 58-22; PG 64-22, -28 and -34; and PG 70-28. Although AR4000W may be purchased from 8 different suppliers it appears to be a fairly consistent product as it was classified as either a PG 58-22 or PG 64-22. With PBAs-2, -5, and -6GR, each available from only 1 supplier, it is impossible to assess the classification consistency of this binder. PBA-6, provided by 4 suppliers, seems to be the most variable, as it was classified as 3 different performance grades. The fact that PBA-6 is typically modified may help to explain some of the variability in the PG classification.

Table 2-1. Binders Typically Specified

Supplier		Binder(s) Normally Produced	PG Classification	Also Meets PG Classification
Albina	1	AR4000W	64 – 22	58 - 22
		PBA-6	64 – 34	58 - 22
				58 - 34
				64 - 28
Chevron – Portland	2	AR4000W	64 – 22	58 - 22
		PBA-2	64 – 22	58 - 22
		PBA-6	64 – 22	58 - 22
Chevron – Richmond Beach	3	AR4000W	58 – 22	
EOTT	4	???		
Idaho	5	AR4000W	58 – 22	58 - 22
		PBA-6	64 – 34	58 - 34
				64 - 28
Koch	6	AR4000W	58 – 22	
McCall	7	AR4000W	58 – 22	58 - 22
		PBA-2	64 – 22	58 - 22
		PBA-5	64 – 22	58 - 22
		PBA-6	70 – 28	64 - 28
Sound	8	AR4000W	58 – 22	
US Oil	9	AR4000W	58 – 22	58 - 22
		PBA-6GR	64 – 28	64 - 22

Table 2-2. PG Classification of Binders

Conventional	PG	Number of Suppliers
AR4000W	58 - 22 64 - 22	8
PBA – 2	64 - 22	2
PBA – 5	64 - 22	1
PBA – 6	64 - 22 64 - 34 70 - 28	4
PBA - 6GR	64 - 28	1

1994/1995 data

2.3 Binder Needs Based on Climate

Using the LTTPBIND software, data from 171 weather stations were used to determine the PG binders required throughout the state of Washington. Both the original SHRP and LTPP (Long Term Pavement Performance) algorithms were used to determine the PG binders required at the 50 and 98 percent levels of reliability. Initially, WSDOT personnel used the Canadian algorithm to determine the low temperature performance grades needed throughout the state. The two algorithms (i.e., Canadian and LTPP) used to select low temperature performance grade yielded virtually identical results. Accordingly, throughout the remainder of this report reference is made only to the LTPP algorithms when discussing selection of Superpave PG binders. These data are tabulated in Appendix A and are shown graphically in Figures 2-1 though 2-10.

Figures 2-1 and 2-2 indicate the distribution of high and low temperature performance grades, respectively. As shown in Figure 2-1 the essential difference between the 50 and 98 percent levels of reliability for the high temperature performance grade (regardless of algorithm) is a one-grade upward shift upward, i.e., to a higher PG. At the 50 percent level of reliability high temperature performance grades of 52 and 58 are appropriate for 80 to 85 percent of the state. Similarly, at the 98 percent level of reliability high temperature performance grades of 58 and 64 are appropriate for 80 to 85 percent of the state. The general trends for low temperature PGs are similar, as shown in Figure 2-2. Again, the essential difference between the 50 and 98 percent levels of reliability for the low temperature performance grade (regardless of algorithm) is a one-grade shift downward, i.e., to a lower PG. However, there are minor differences. At the 50 percent level of reliability low temperature performance grades of -10, -16 and -22 cover 83 and 100 percent of the state based on the SHRP and LTPP algorithms, respectively. At the 98 percent level of reliability low temperature performance grades of -34, -28 and -22 are appropriate for 78 percent of the state based on the SHRP algorithm, whereas -28, -22 and -16 are appropriate

Figure 2-1. Distribution of High Temperature Performance Grades

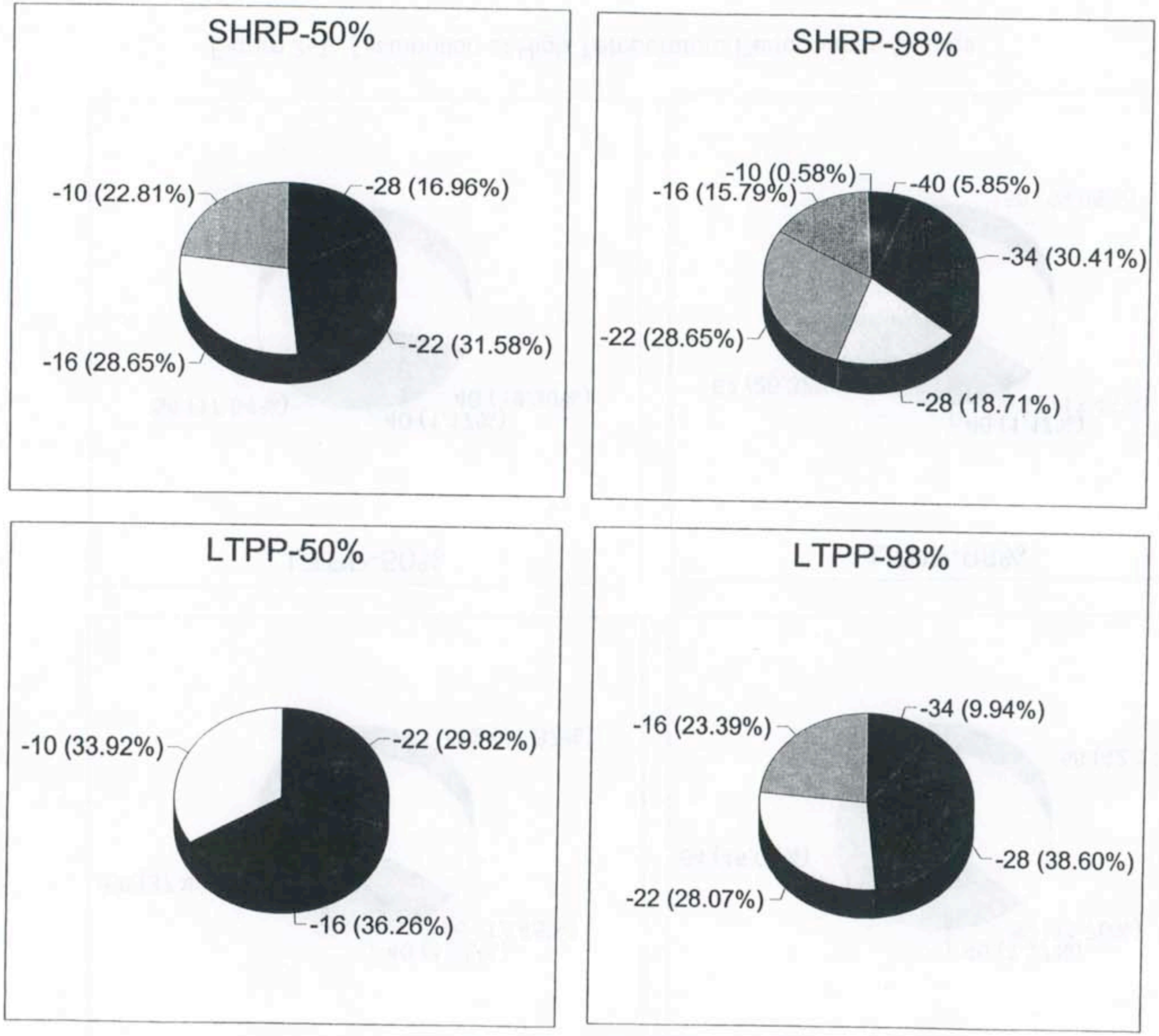


Figure 2-2. Distribution of Low Temperature Performance Grades

for 90 percent of the state based on the LTPP algorithms. Clearly, the biggest difference between the two algorithms occurs when selecting low temperature grades is at the 98 percent level of reliability. Note that the original SHRP algorithm yields a more conservative performance grade than does the LTPP algorithm at both high and low temperatures.

Shown in Figures 2-3 to 2-10 are maps of the state which clearly and colorfully illustrate the distribution of Superpave PG binders required based on climatic diversity. At the 50 percent level of reliability climatic data indicate that 11 PG binders are required; at the 98 percent level of reliability, 14 PG binders are required. For logistical as well as economic reasons the state DOT would not likely specify that many performance grades, despite the fact that there is some overlap of PGs.

The original SHRP algorithm assumes that the pavement surface temperature is equal to that of the ambient temperature, whereas the LTPP algorithm, which integrates data from the Long Term Pavement Performance (LTPP) seasonal monitoring stations, results in a pavement surface temperature that is about 5°C higher. The net result is that the LTPP algorithm typically yields a higher/warmer, i.e., less conservative, low temperature grade than does the original SHRP algorithm. For example, data from weather station 456974 located in Ferry county yields a PG 58-40 using the SHRP algorithm, and a PG 58-34 using the LTPP algorithm. A detailed discussion of these models used to determine pavement temperature is found in Appendix B.

As might be expected, the vast majority of research on low temperature cracking has been conducted in harsh climates. Accordingly, the reliability of these algorithms is questionable for warmer climates. For northern climates using the air temperature to compute the critical temperature for pavement cracking can result in differences of 15°C. This leads to more restrictive specification of PG binders, perhaps by as many as three grades. Binders specified for these climatic extremes (e.g., PG XX-34, PG XX-40) would inevitably necessitate modification of the asphalt cement thereby increasing binder costs by

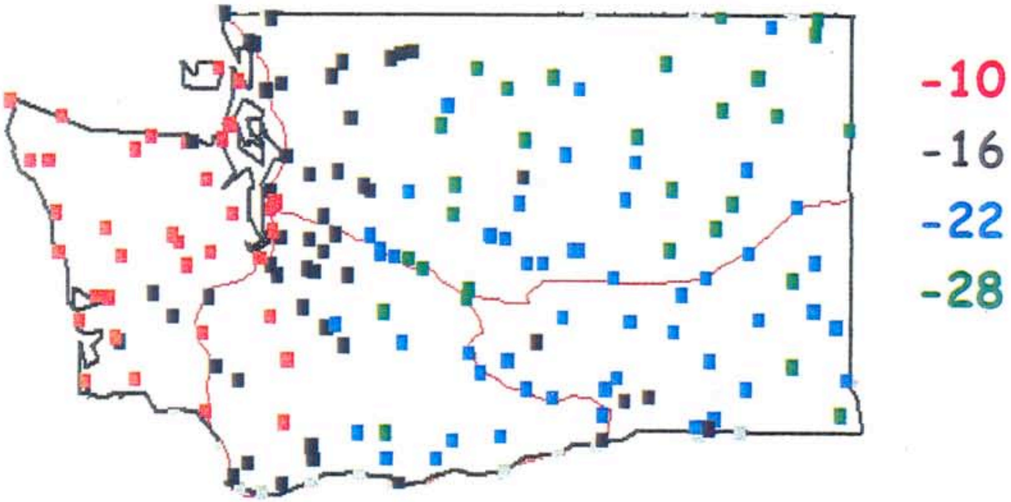


Figure 2-3. PG Binders Needed Based on Climate (Low Temperature, SHRP – 50%)

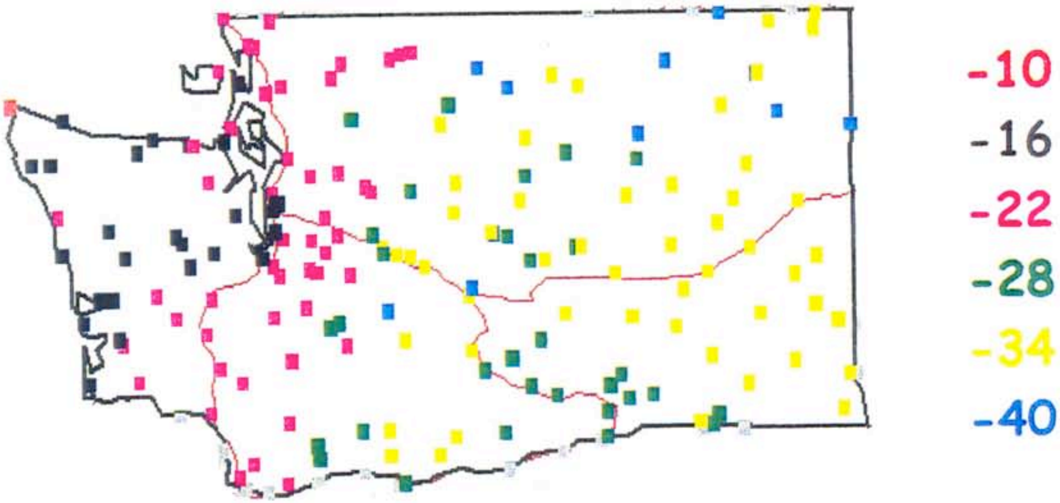


Figure 2-4. PG Binders Needed Based on Climate (Low Temperature, SHRP – 98%)

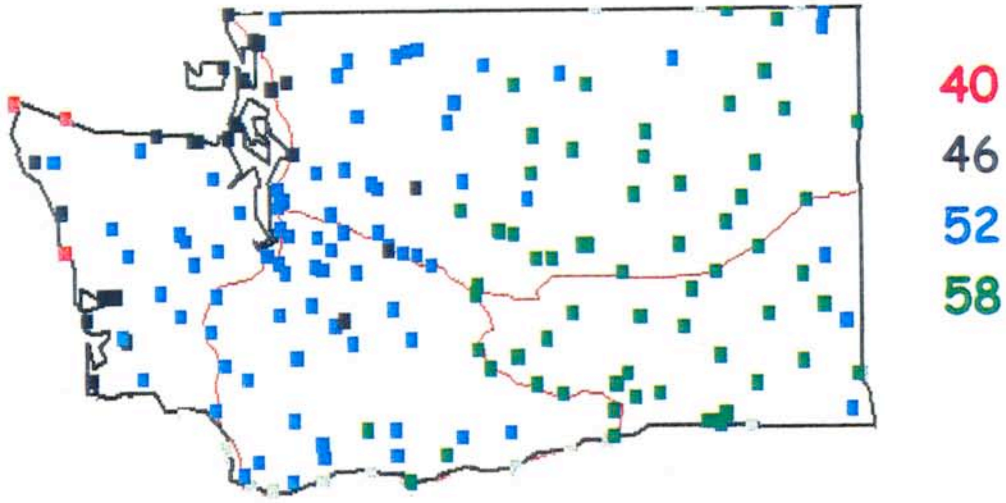


Figure 2-5. PG Binders Needed Based on Climate (High Temperature, SHRP – 50%)

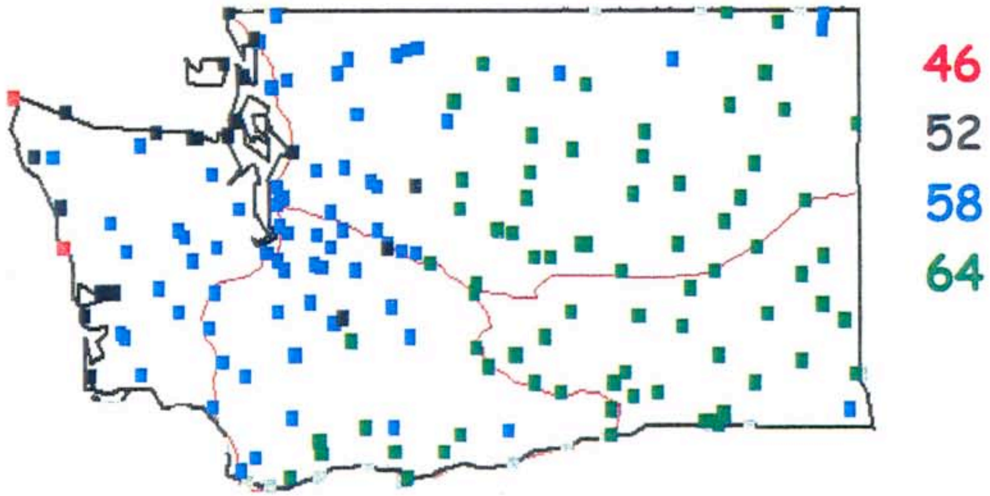


Figure 2-6. PG Binders Needed Based on Climate (High Temperature, SHRP – 98%)

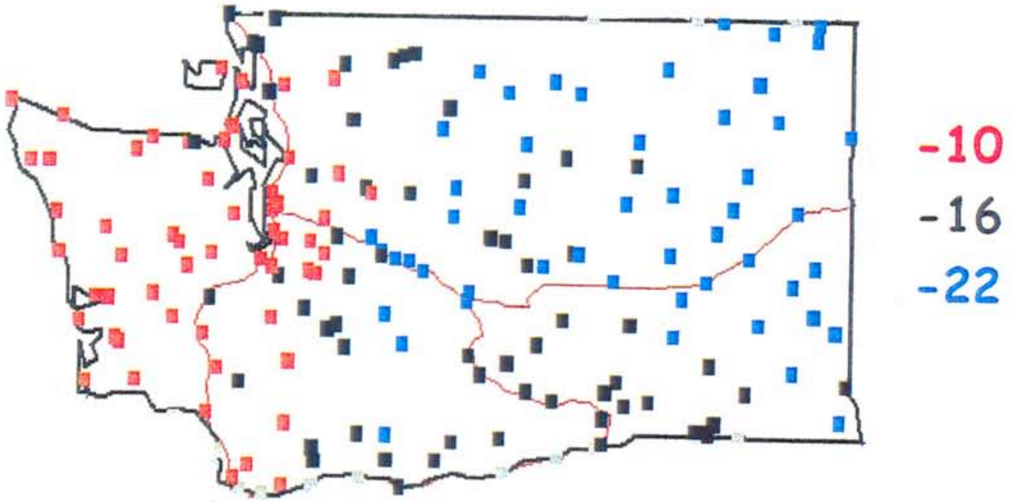


Figure 2-7. PG Binders Needed Based on Climate (Low Temperature, LTPP – 50%)

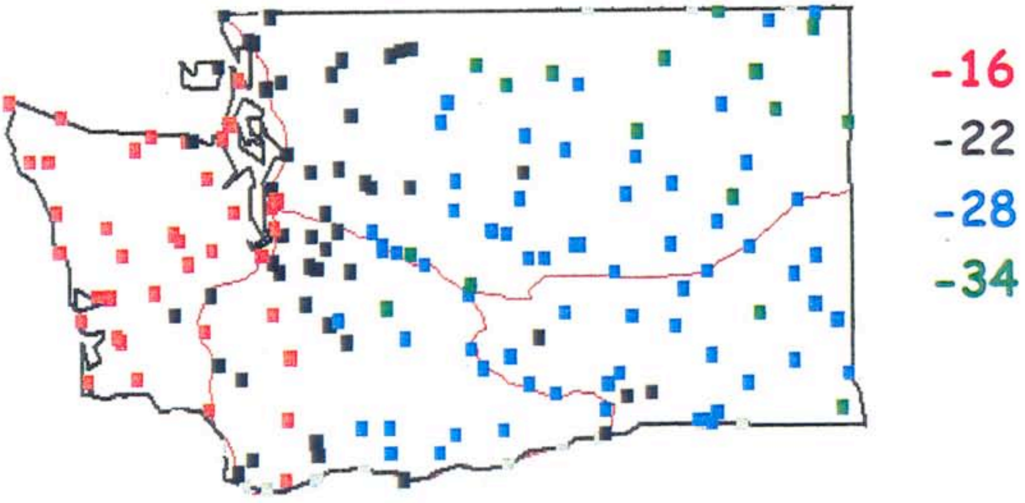


Figure 2-8. PG Binders Needed Based on Climate (Low Temperature, LTPP – 98%)

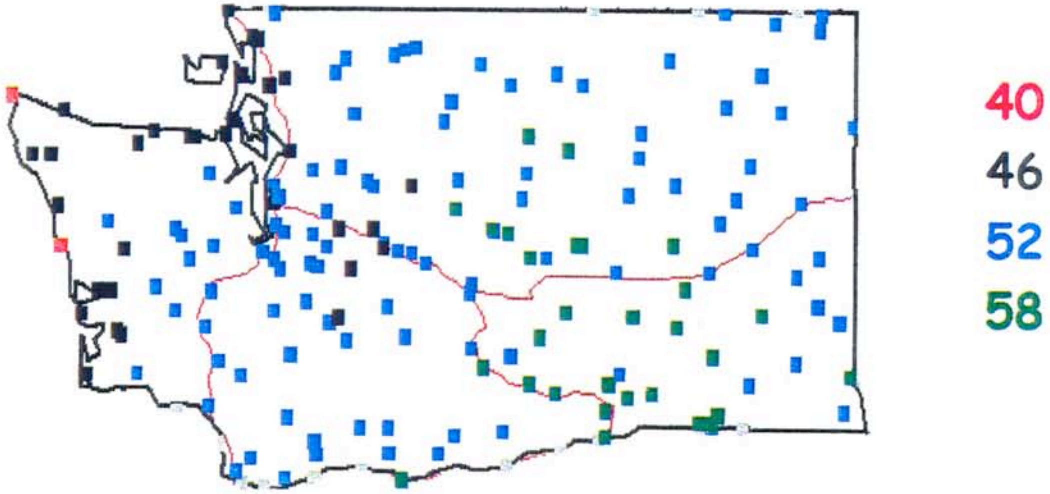


Figure 2-9. PG Binders Needed Based on Climate (High Temperature, LTPP – 50%)

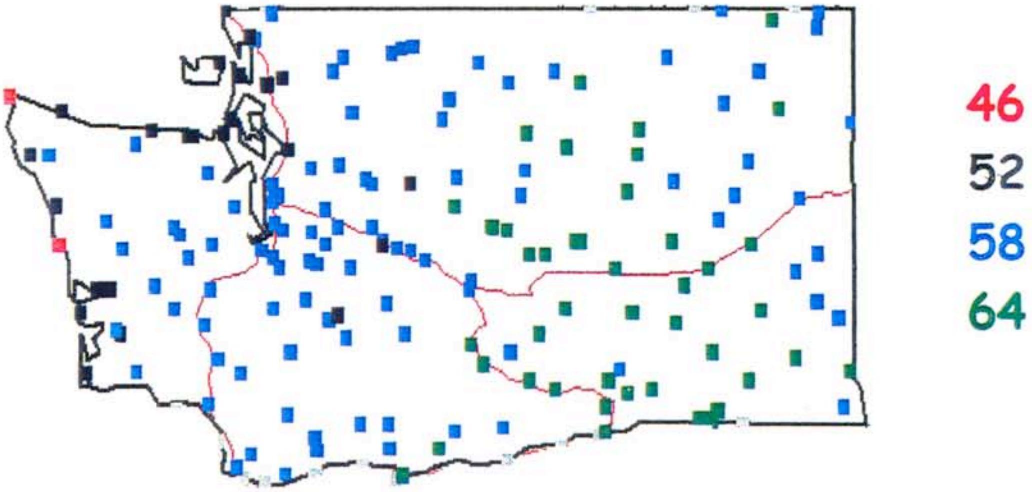


Figure 2-10. PG Binders Needed Based on Climate (High Temperature, LTPP – 98%)

as much as 50 to 100%. The Binder Expert Task Group, now operating under the auspices of the National Cooperative Highway Research Program, is trying to refine the algorithms that are used to compute the critical temperature for pavement cracking for both extremes, i.e., northern and southern climates. Until findings from the various studies are readily available the interim recommendations are as follows: For northern climates in which the mean low air temperature is below -28°C, use a reliability level less than 98%. For example, if the mean low temperature were -29°C a 50% level of reliability would require a binder of PG XX-34. Though the actual level of reliability for the PG XX-34 with a mean low temperature of -29°C might be closer to 75-80%, to reach the 98% level of reliability would require specifying a binder of PG XX-40. This approach will preclude specifying extremely low temperature, expensive binder grades.

2.4 Pavement Distress

Although similar in appearance, low temperature and reflective cracking are the result of entirely different mechanisms. Transverse low temperature cracking occurs as a result of thermally induced stresses. When the stress exceeds the strength of the material, a crack occurs at the pavement surface and may eventually propagate through the depth of the asphalt concrete layer. Reflective cracking appears as a transverse crack on the pavement surface as well. However, reflective cracking of asphalt concrete occurs as a crack (or joint) in the underlying layer (e.g., asphalt concrete or jointed portland cement concrete) propagates upward through the depth of the layer to the surface. It is critical to note that SHRP researchers did not consider reflective cracking in the development of the Superpave binder specification. Use of Superpave for binder selection may minimize, if not entirely eliminate, transverse low temperature cracking, but not transverse reflective cracking.

Validation of the Superpave binder specification, during and post-SHRP, underscores the decreasing influence of the binder in order of the following distresses: low temperature cracking; fatigue cracking; and permanent deformation. Logically extending this concept to implementation, the DOT staff considered the distribution of pavement distresses throughout the state to try to optimize the effectiveness of the new technology. The distribution of pavement distress, shown in Figure 2-11, indicates that low temperature cracking is far more prevalent than fatigue cracking or rutting (permanent deformation). Shown in Figures 2-12, 2-13 and 2-14 is the percentage of lane miles in each region with low temperature cracking, fatigue cracking and rutting, respectively. All data is from the 1996 pavement condition survey. The data in Figure 2-12 indicate that more than 50 percent of the lane miles in the Eastern, South Central and North Central regions show evidence of low temperature cracking. Contrasting that are the data in Figures 2-13 and 2-14 which suggest that fatigue cracking and rutting are not nearly as severe: only the Northwest region has more than 20 percent of its lane miles that show fatigue cracking; and only the South Central region has more than 30 percent of its lane miles that show rutting. It is clear that implementation of the Superpave binder specification could dramatically reduce, if not entirely eliminate, low temperature cracking and thereby reduce maintenance costs associated with crack-filling.

Though researchers at CalTrans hypothesize that binder properties may be used to predict fatigue behavior, SHRP researchers maintained that the thickness of the structural section was the more influential variable. As of this date there is insufficient data to suggest that implementation of the Superpave binder specification would dramatically affect fatigue behavior.

Similarly, it is widely believed that aggregate properties such as shape, texture and gradation have a much greater influence on permanent deformation than do binder properties. Still, in the SHRP literature there is a provision for binder "bumping," i.e.,

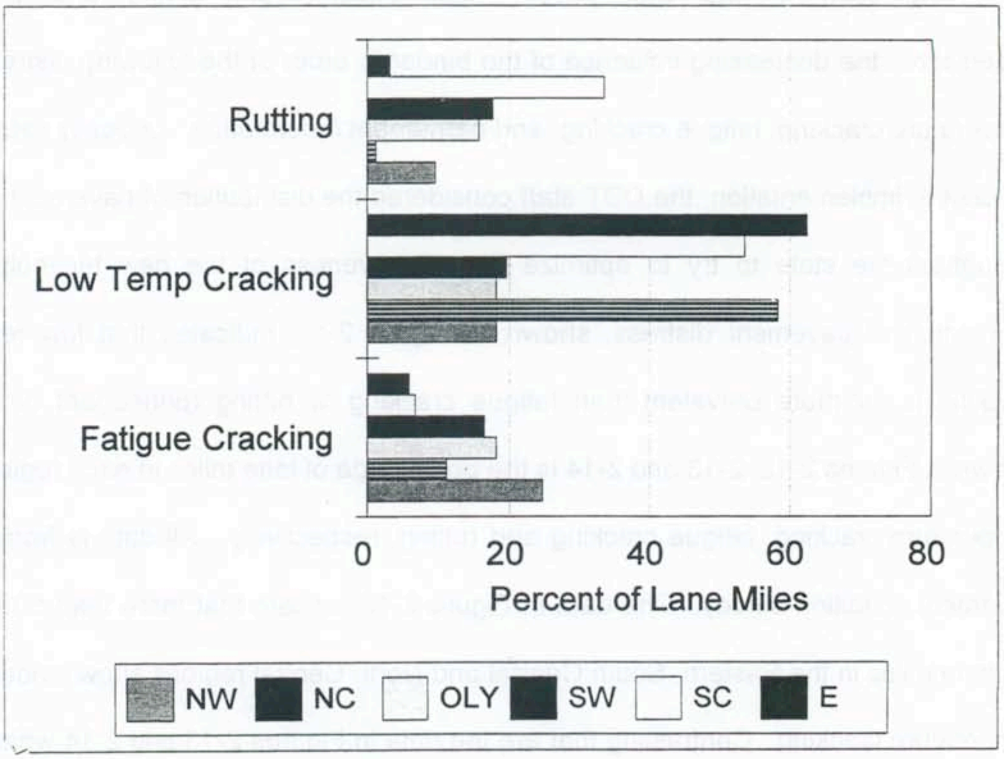


Figure 2-11. Regional Pavement Distress

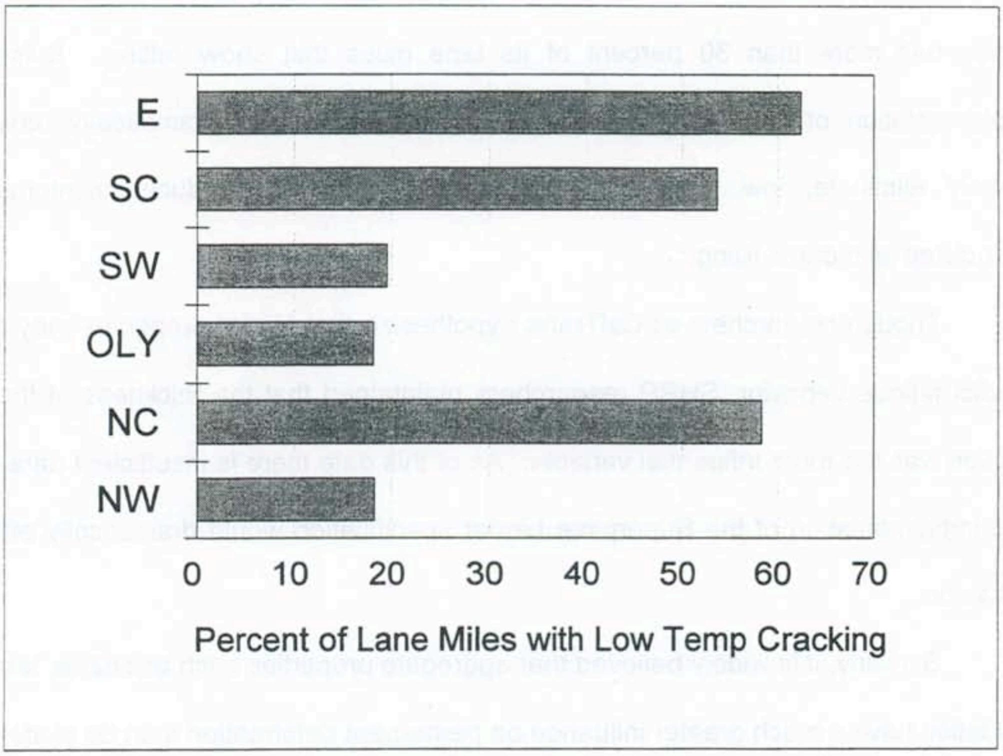


Figure 2-12. Extent of Low Temperature Cracking

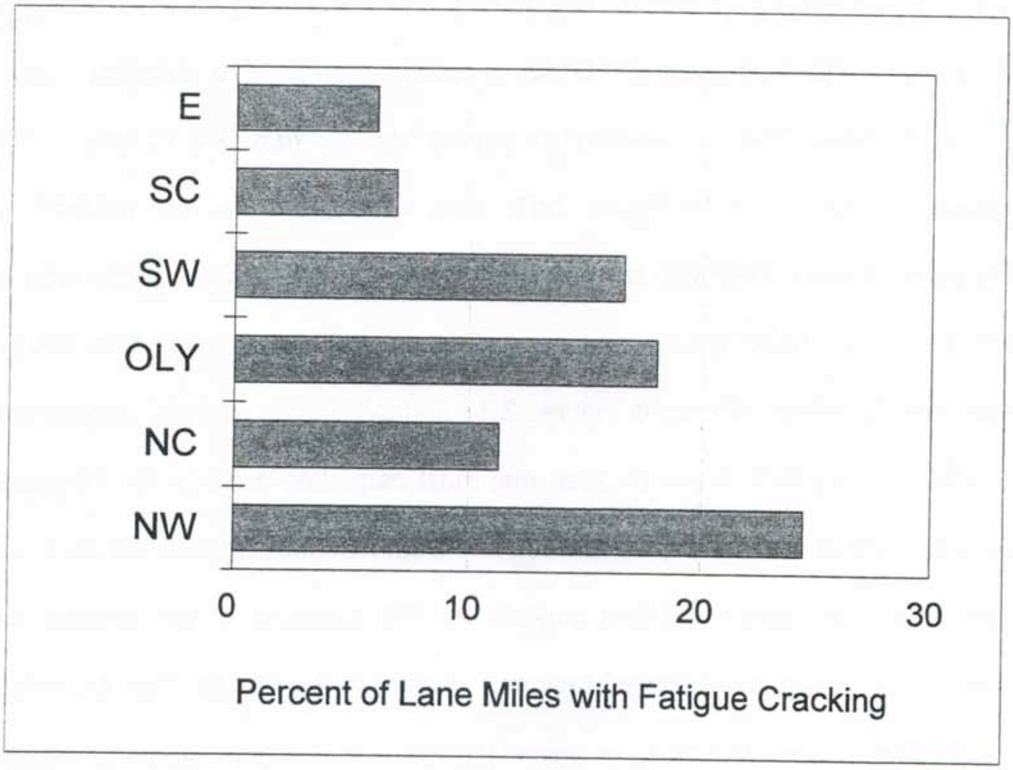


Figure 2-13. Extent of Fatigue Cracking

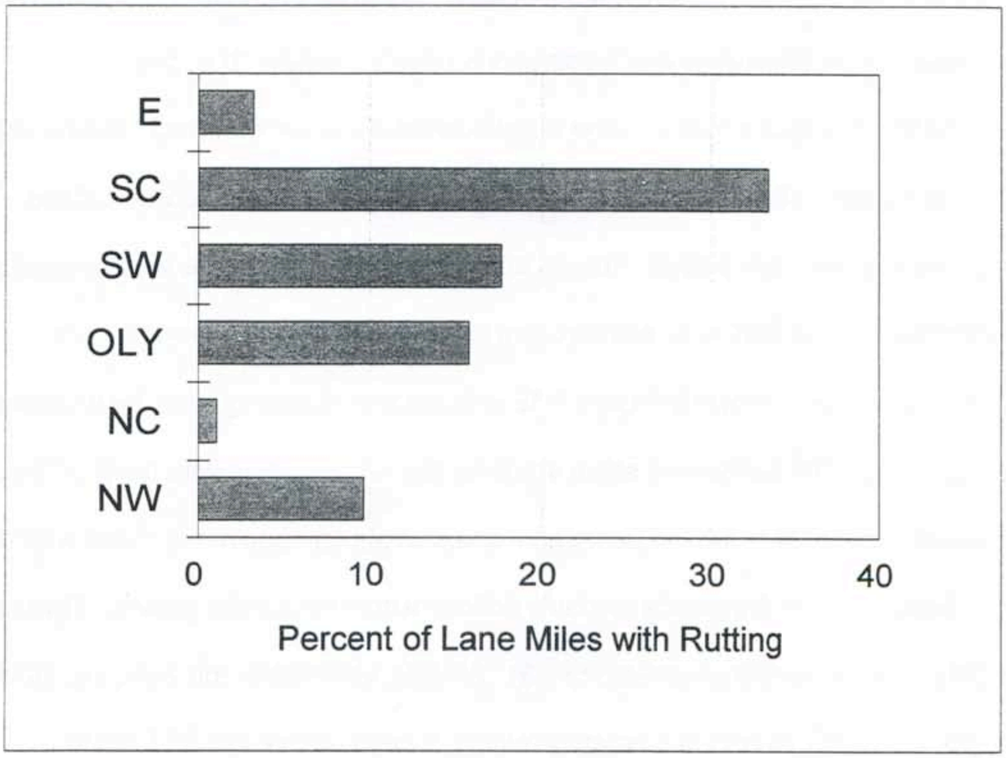


Figure 2-14. Extent of Rutting

selecting a "warmer" binder grade. Specifically, for slow moving loads selecting one grade "warmer" (e.g., PG 64 instead of PG 58) is recommended. For standing loads or traffic exceeding 10 million ESALs, selecting two grades "warmer" (e.g., PG 70 instead of PG 58) is encouraged. As shown in Figure 2-15, data extracted from the WSDOT pavement management system (WSPMS) revealed that there are approximately 2650 lane miles with design ESALs of 10-30 million and approximately 1600 lane miles with design ESALs greater than 30 million. Shown in Figures 2-16 and 2-17 is the regional distribution of these data. From Figure 2-16 it can be seen that most candidate projects for PB bumping of a single grade are in the Eastern, Northwest, and South Central regions. From Figure 2-17 it can be seen that most candidate projects for PG bumping of two grades are in the Northwest, Olympic and Southwest regions. Although the Pacific Coast Conference on Asphalt Specifications (PCCAS), of which WSDOT is a member, has an unofficial policy of "no bumping," some states have selected binder grades warmer than the environmental conditions would dictate. At the time this report was prepared field performance data were not available to validate/refute the hypothesis concerning binder "bumping."

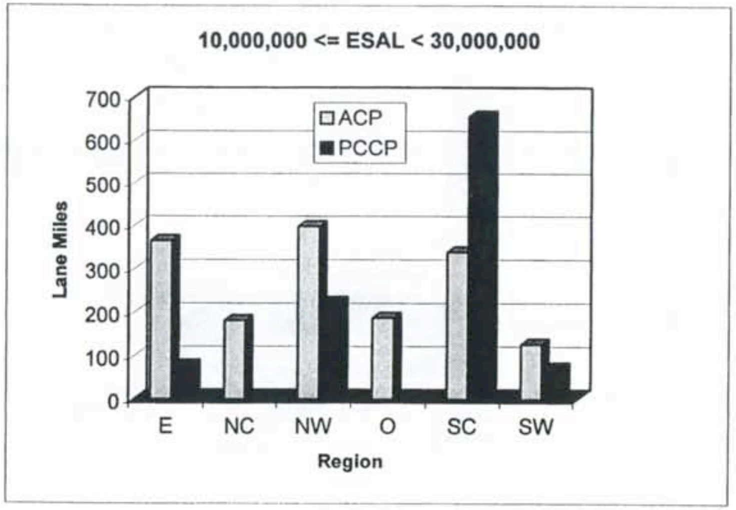
To test this hypothesis, i.e., the effectiveness of binder "bumping," the experiment outlined in Figure 2-18 was proposed. As of this date the laboratory portion of the experiment has been completed. Results of the laboratory testing are very promising: the data suggest that the SST is an effective tool for discriminating between binders. Furthermore, the data shown in Figure 2-19 indicate that "bumping" may be effective in reducing rutting. The permanent shear strain for specimens made with the PG 70 binder was approximately 1/4 to 1/3 the permanent shear strain for specimens made with the PG 58 binder. Note also that the results are fairly uniform within the binder groups. There appears to be only 1outlier (specimen labeled 58v-3). All data, volumetric and SST, are included in Appendix C. Based on limited laboratory testing, it appears that the SST could

10,000,000 <= ESAL < 30,000,000

Region		Lane Miles			Total Lane Miles
		ACP	PCCP	BST	
E	Eastern	365.32	79.58	0.00	444.9
NC	North Central	181.88	0.00	0.40	182.28
NW	Northwest	398.33	224.66	0.00	622.99
O	Olympic	187.33	9.14	0.00	196.47
SC	South Central	338.73	655.85	12.68	1007.26
SW	Southwest	126.27	72.77	0.00	199.04
Total		1597.86	1042.00	13.08	2652.94

ESAL >= 30,000,000

Region		Lane Miles			Total Lane Miles
		ACP	PCCP	BST	
E	Eastern	111.38	40.45	0.00	151.83
NC	North Central	0.00	0.00	0.00	0.00
NW	Northwest	265.63	428.98	0.00	694.61
O	Olympic	204.51	124.90	0.00	329.41
SC	South Central	23.80	109.46	0.00	133.26
SW	Southwest	255.38	69.84	0.00	325.22
Total		860.70	773.63	0.00	1634.33



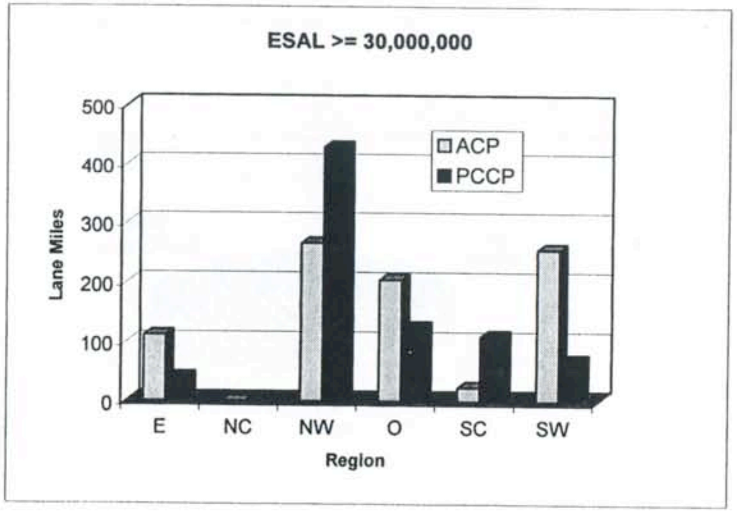


Figure 2.15. Lane Miles for Potential “Bumping” of Performance Grade

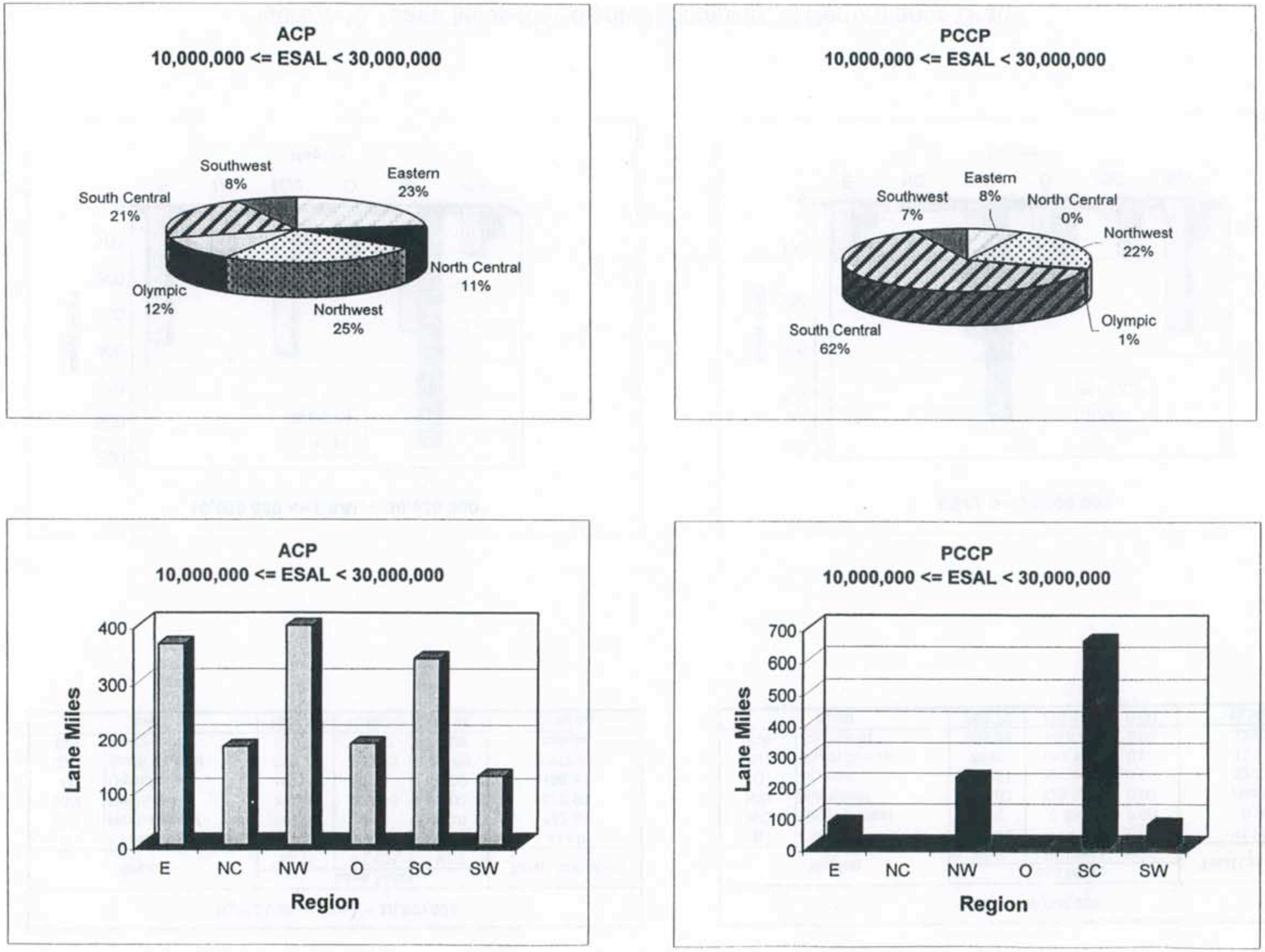


Figure 2-16. Lane Miles for Potential “Bumping” of One Performance Grade

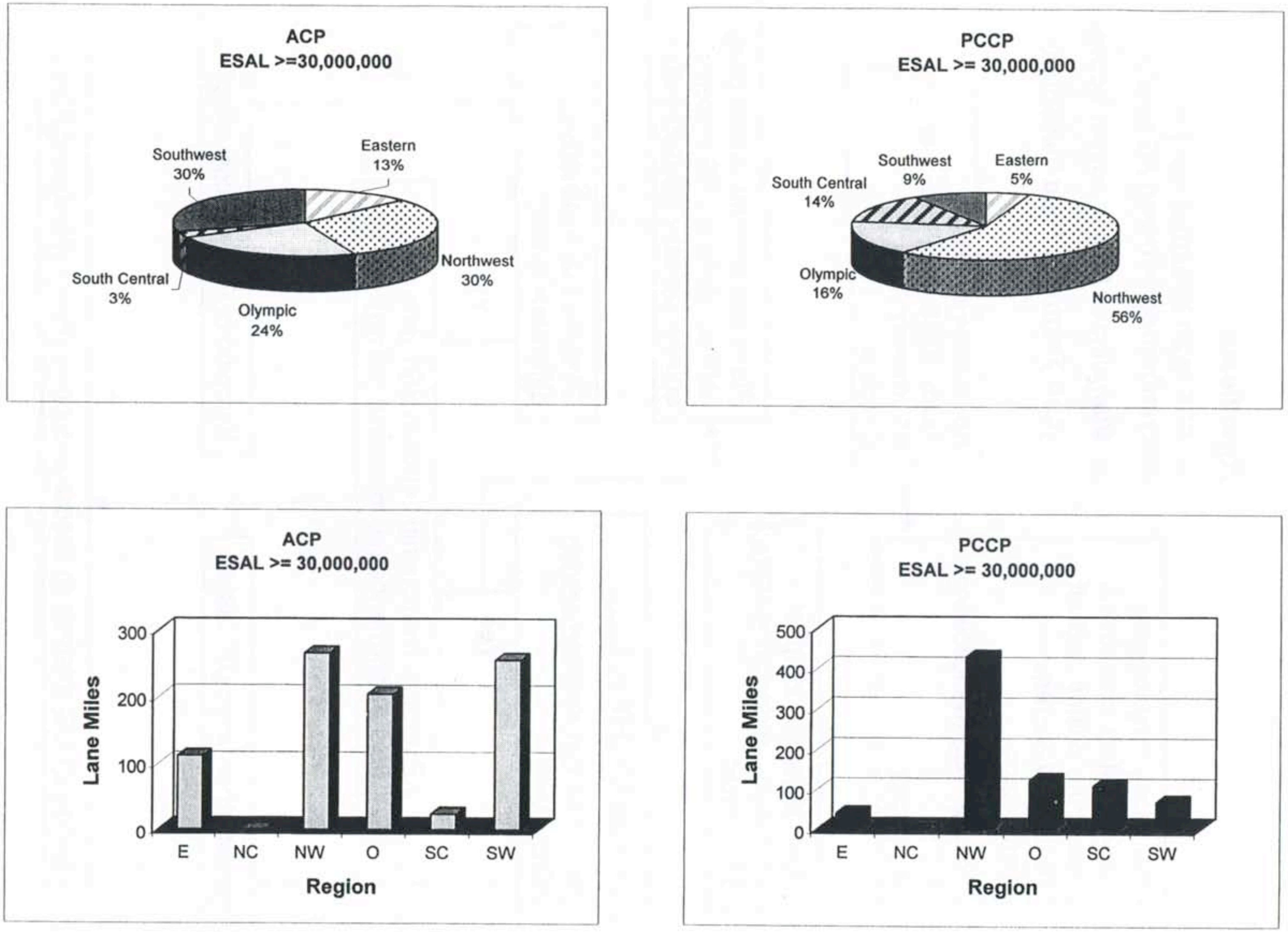


Figure 2-17. Lane Miles for Potential "Bumping" of Two Performance Grades

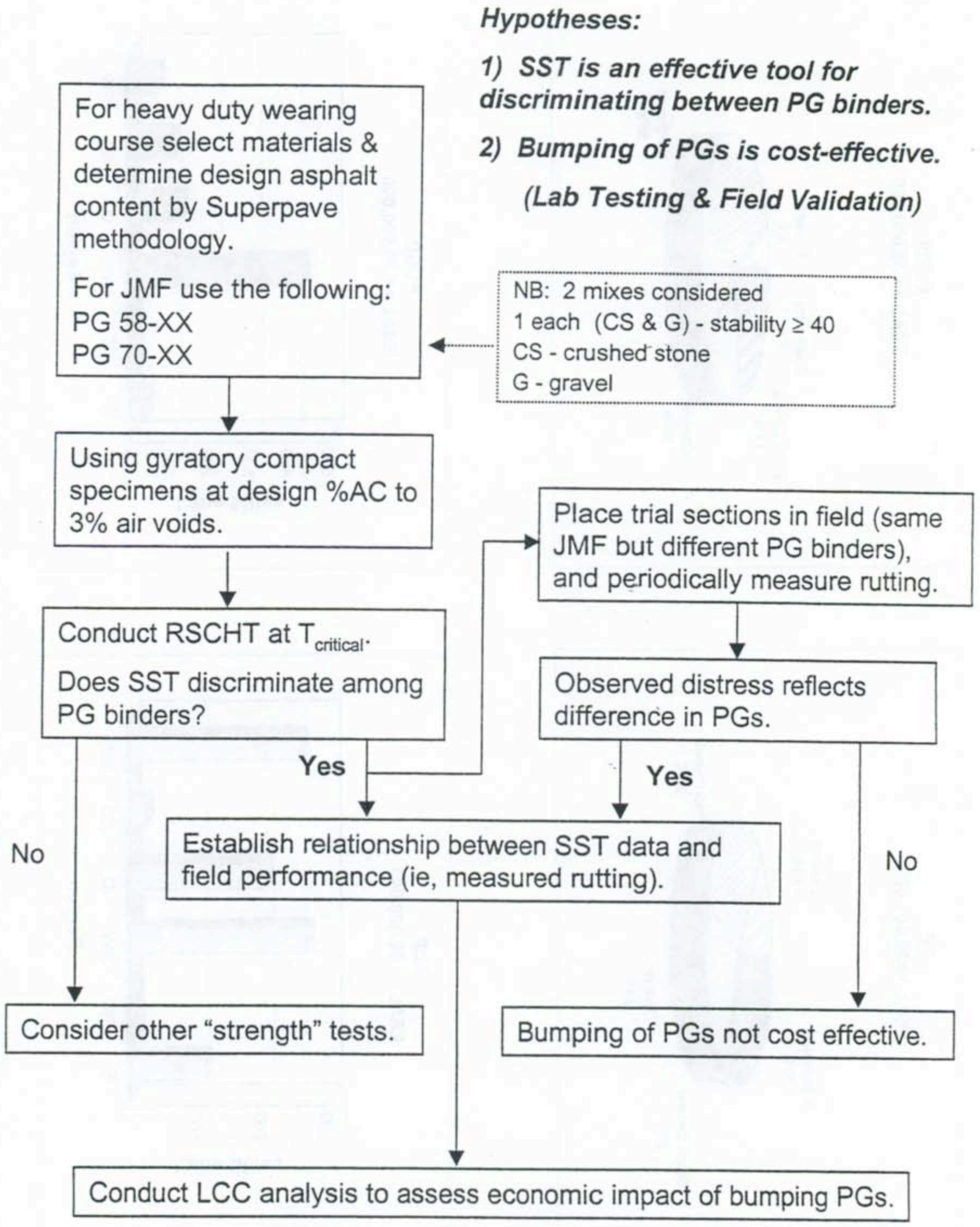


Figure 2-18. Experiment Design to Test Hypothesis on Effectiveness of PG Binder "Bumping"

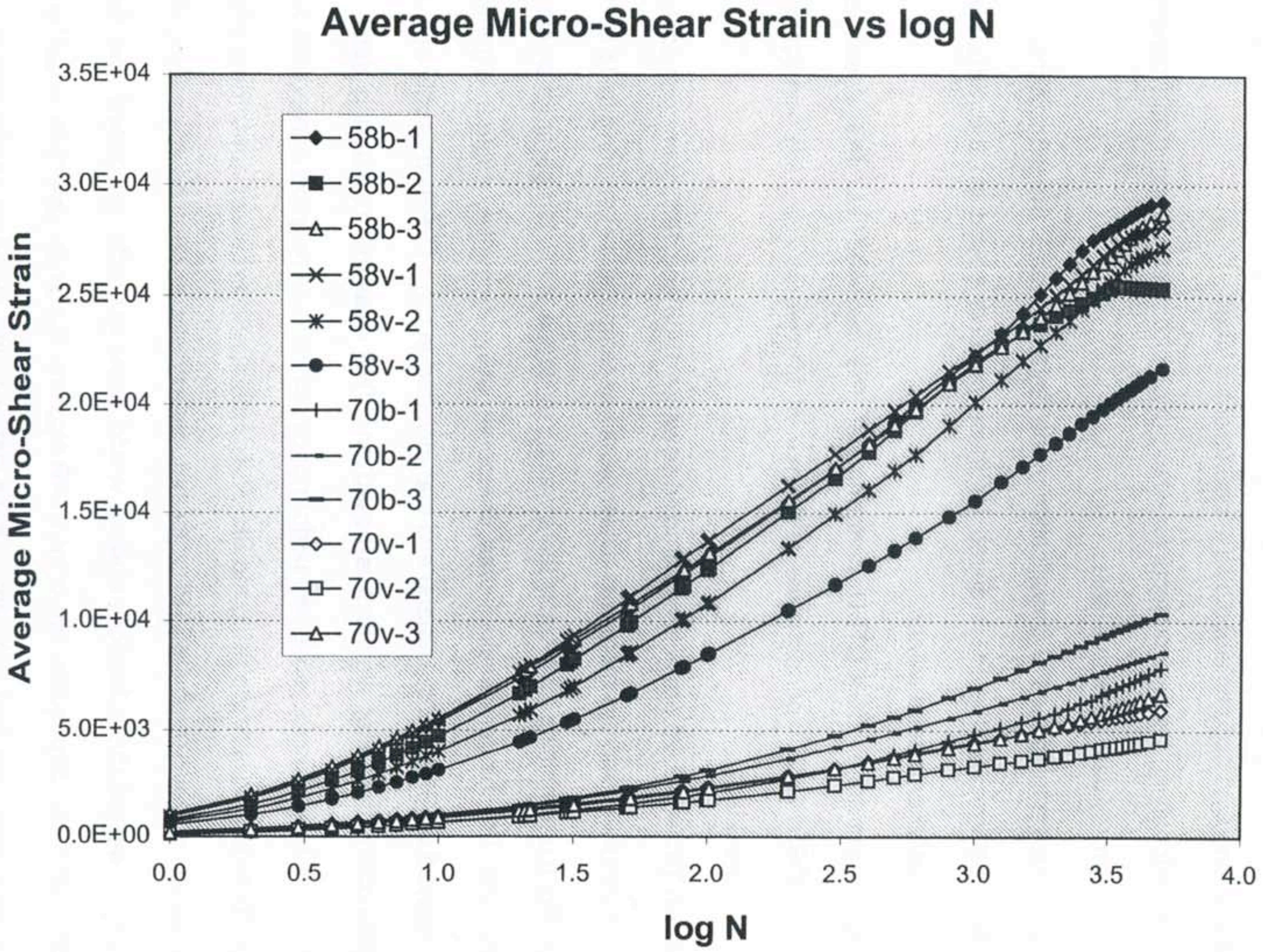


Figure 2-19. Superpave Shear Test Data

be a very effective design tool. Completing the field validation portion of this experiment would be the next logical step.

A preliminary assessment of the Superpave binder specification with respect to thermal cracking was accomplished by a 4-step forensic study:

1) identifying 28 field projects for which original binder samples and condition survey data were available;
2) determining the PG classification of the binders used in these projects;
3) determining the PG required for these projects based on the Superpave weather database; and
4) comparing EXPECTED performance (PG *required* vs. PG *used*) and OBSERVED performance (evidence of transverse, i.e., low temperature cracking).

As shown in Table 2-3, 28 projects constructed between 1973 and 1983 were considered. Based on condition surveys there was evidence of low temperature cracking in 15 of the projects. For the remaining 13 projects there was no evidence of low temperature cracking. Note that the PG binder required was computed using both the original algorithm (recommended by SHRP researchers) and that included in the LTPPBIND software. As noted previously, the latter algorithm is based on LTPP seasonal monitoring data. A comparison of *expected* vs. *observed* performance indicates very good agreement with when binder selection is made using the SHRP algorithm; and excellent agreement when binder selection is made using the LTPP algorithm. Specifically, in 22 of the 28 projects, use of the SHRP algorithm for binder selection would have correctly "predicted" the field behavior; in 26 of the 28 projects, use of the LTPP algorithm for binder selection would have correctly "predicted" the field behavior. These data provide excellent verification of the efficacy of the Superpave binder specification. Moreover, the data tend to substantiate the

Table 2-3. Relationship of PG Binders to Low Temperature Cracking

	Contract Number	Construction Year	PG Binder Required		PG Binder Used	Expected to Crack		Observed Cracking	**Expected to Crack But Did NOT**	
			SHRP	LTPP		SHRP	LTPP		**SHRP**	**LTPP**
1	1085	1978	58-34	58-28	58-16	Yes	Yes	Yes		
2	1353	1979	58-34	64-28	58-16	Yes	Yes	Yes		
3	1324	1979	64-34	64-28	58-16	Yes	Yes	Yes		
4	1192	1979	58-34	64-28	58-16	Yes	Yes	Yes		
5	1092	1979	58-34	64-28	58-16	Yes	Yes	Yes		
6	1864	1982-83	58-22	58-16	58-16	Yes	No	No	✓	
7	1944	1982-83	52-22	52-16	58-16	Yes	No	No	✓	
8	2268	1982-83	58-34	58-28	58-16	Yes	Yes	Yes		
9	2284	1982-83	64-34	64-28	58-16	Yes	Yes	Yes		
10	9223	1973	64-34	64-28	58-22	Yes	Yes	Yes		
11	9155	1973	52-22	52-16	58-22	No	No	No		
12	9269	1973	52-22	52-16	58-22	No	No	No		
13	8846	1971-72	64-34	64-28	58-22	Yes	Yes	Yes		
14	8673	1971-72	52-22	58-16	58-22	No	No	No		
15	8853	1971-72	52-16	58-16	58-22	No	No	No		
16	8927	1971-72	58-34	64-28	58-22	Yes	Yes	Yes		
17	8940	1971-72	58-34	58-28	58-22	Yes	Yes	Yes		
18	9155	1971-72	52-22	52-16	58-22	No	No	No		
19	695	1978	58-22	58-16	58-22	No	No	No		
20	839	1978	58-28	58-22	58-22	Yes	No	No	✓	
21	672	1978	58-22	58-16	58-22	No	No	No		
22	1022	1978	52-16	52-10	58-22	No	No	Yes		
23	2207	1983	64-34	64-28	58-16	Yes	Yes	No	✓	✓
24	2526	1983	64-34	64-28	58-16	Yes	Yes	Yes		
25	2170	1983	58-22	58-16	58-16	Yes	No	No	✓	
26	2251	1983	58-28	58-22	58-16	Yes	Yes	No	✓	✓
27	2310	1983	64-34	64-28	58-16	Yes	Yes	Yes		
28	9860	1975	58-40	58-34	58-28	Yes	Yes	Yes		

hypothesis that the SHRP algorithm may be too conservative for low temperature PG binder selection.

2.5 Recommended Guidelines for PG Use

To establish guidelines for Superpave PG use several factors were considered: climate; pavement distress; and binder availability. Perhaps the easiest to address is binder availability. Five binders are readily available from suppliers in the Pacific Northwest. They include the following: PG 58-22; PG 64-22, -28 and -34; and PG 70-28. Based on climatic diversity 11 PG binders are required at the 50 percent level of reliability, and 14 binders at the 98 percent level of reliability. There is some overlap in binder grades such that 11 (or 14) distinctly different binders are not absolutely necessary. Still, for logistical as well as economic reasons the state would not likely specify that many performance grades. Moreover, a pragmatic review of the climatic data reveal that two high temperature grades are adequate for nearly 80 to 85 percent of the state: PG 52 and PG 58 at the 50 percent level of reliability; and PG 58 and PG 64 at the 98 percent level of reliability. There are similar trends for the low temperature binder grades, though 3 grades instead of 2 are needed to cover an equivalent area of the state. Depending upon the algorithm chosen, low temperature performance grades of -10, -16 and -22 are appropriate for 83 to 100 percent of the state at the 50 percent level of reliability. At the 98 percent level of reliability low temperature performance grades of -22, -28 and -34 are appropriate for 78 percent of the state based on the SHRP algorithm, whereas -16, -22 and -28 are appropriate for 90 percent of the state based on the LTPP algorithms. The results of the forensic study make a compelling case to use the LTPP algorithm for selecting low temperature performance grades. In addition, the climatic data and distribution of pavement distress indicate that a logical, technically sound and cost effective approach for establishing guidelines for PG binder use is to divide the state into three geographical regions approximated as shown in

Figure 2-20. The Western portion roughly includes the Northwest, Olympic and Southwest Regions; the Northeastern includes the North Central Region and portions of the Eastern and South Central Regions; the Southeastern includes the South Central Region and portions of the Eastern and Southwestern Regions. By dividing the state as shown in Figure 2-20, the PG binders required based on the climate are as shown in Table 2-4. As noted previously, there is generally a one-grade shift from the 50 to 98 percent level of reliability, regardless of algorithm. The shaded cells in Table 2-4 correspond to the performance grades with the highest frequency of occurrence at the 98 percent level of reliability. Based on the data shown in Table 2-4 the binders that could logically be specified are shown in Table 2-5.

Considering other factors previously noted, particularly pavement distress, the binders initially recommended for use are as follows. For the Western portion of the state PG 58-22 is recommended as both algorithms agree and there is ample conservatism with the 98 percent level of reliability. For the Northeastern portion of the state PG 58-34 is recommended as rutting is not a serious problem, whereas low temperature cracking is. Hence a less conservative choice for the high temperature grade (58) and more conservative choice for the low temperature grade (-34). For the Southeastern portion of the state PG 64-28 is recommended as rutting is more frequently a problem than is low temperature cracking; hence, adhering to the conservative choice for the high temperature grade (64), and the less conservative choice for the low temperature grade (-28). For mountain passes a PG 58-34 may be considered. The recommended guidelines for use are shown graphically in Figure 2-21.

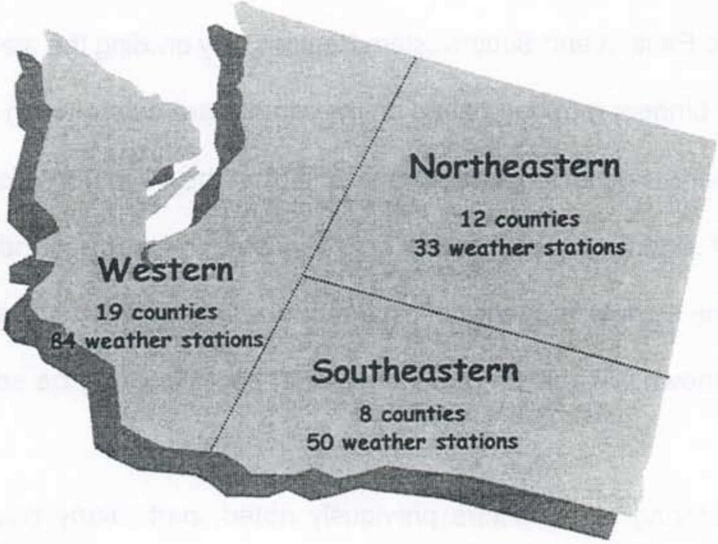


Figure 2-20. Regional Division of State for PG Selection

Table 2-4. Performance Grades (PG) Required

	SHRP Algorithm						LTPP Algorithm					
	50%			98%			50%			98%		
High Temp PG	Western	Northeastern	Southeastern	Western	Northeastern	Southeastern	Western	Northeastern	Southeastern	Western	Northeastern	Southeastern
40	3						2					
46	22		1	2			32		1	2		
52	59	9	13	19		1	50	27	28	22		1
58		24	36	59	5	8		6	21	60	21	19
64				4	28	41					12	30

	SHRP Algorithm						LTPP Algorithm					
	50%			98%			50%			98%		
Low Temp PG	Western	Northeastern	Southeastern	Western	Northeastern	Southeastern	Western	Northeastern	Southeastern	Western	Northeastern	Southeastern
-10	39			1			58					
-16	42	1	6	27			25	6	28	40		
-22	3	11	37	49			1	27	22	42	1	5
-28		21	7	7	5	19				2	20	41
-34					20	30					12	4
-40					8	1						

Table 2-5. Performance Grades by Section Based on Frequency of Occurrence

Section of State	SHRP - 98%	LTPP-98%
Western	58-22	58-22
Northeastern	64-34	58-28
Southeastern	64-34	64-28

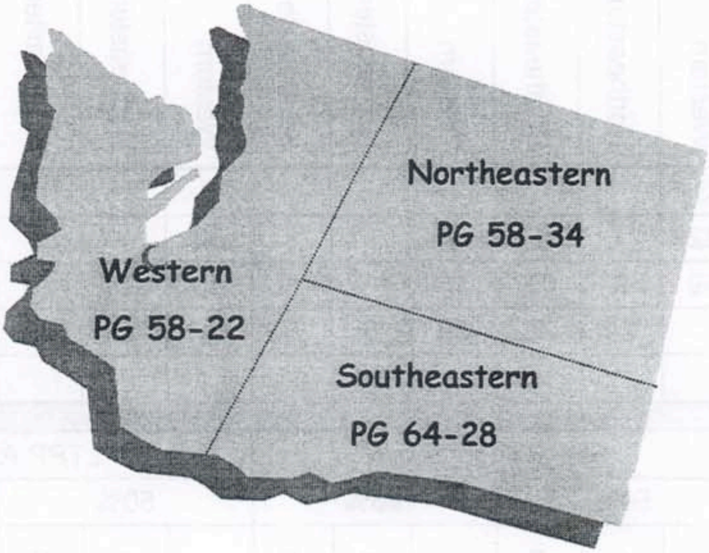


Figure 2-21. Guidelines for PG Use

3. Superpave Mix Design Studies

3.1 Introduction

Prior to a discussion of WSDOT's evaluation/implementation of the Superpave mix design and analysis technology, some introductory comments seem appropriate. As shown in Figure 3-1, WSDOT typically conducts about 225 mix designs annually such that implementation of the Superpave technology represents a significant financial investment – in equipment and personnel training. The Superpave mix design procedure is thoroughly described in an FHWA document (McGennis et al., 1994). However, SHRP-A-407, "The Superpave Mix Design Manual for New Construction and Overlays," is the single best source of information (Cominsky et al., 1994). Superpave mix design and analysis may be conducted at increasingly rigorous levels with each level providing more definitive information about the mix's likely performance. As the name implies, Superpave volumetric mix design includes material selection and proportioning. Volumetric mix design may be extended with a battery of tests to allow the design engineer a more reliable level of performance prediction in terms of permanent deformation, fatigue cracking and low temperature cracking. As with any new technology, Superpave mix design and analysis is "provisional" and continues to be evaluated and refined for incorporation into federal, state and local specifications. At the time this report was prepared several projects were underway to extend and refine work of SHRP researchers, specifically the Superpave technology. These include but are not limited to the NCHRP projects shown in Table 3-1. It is anticipated that WSDOT will carefully consider the results of these projects as it continues its evaluation/implementation of the Superpave technology.

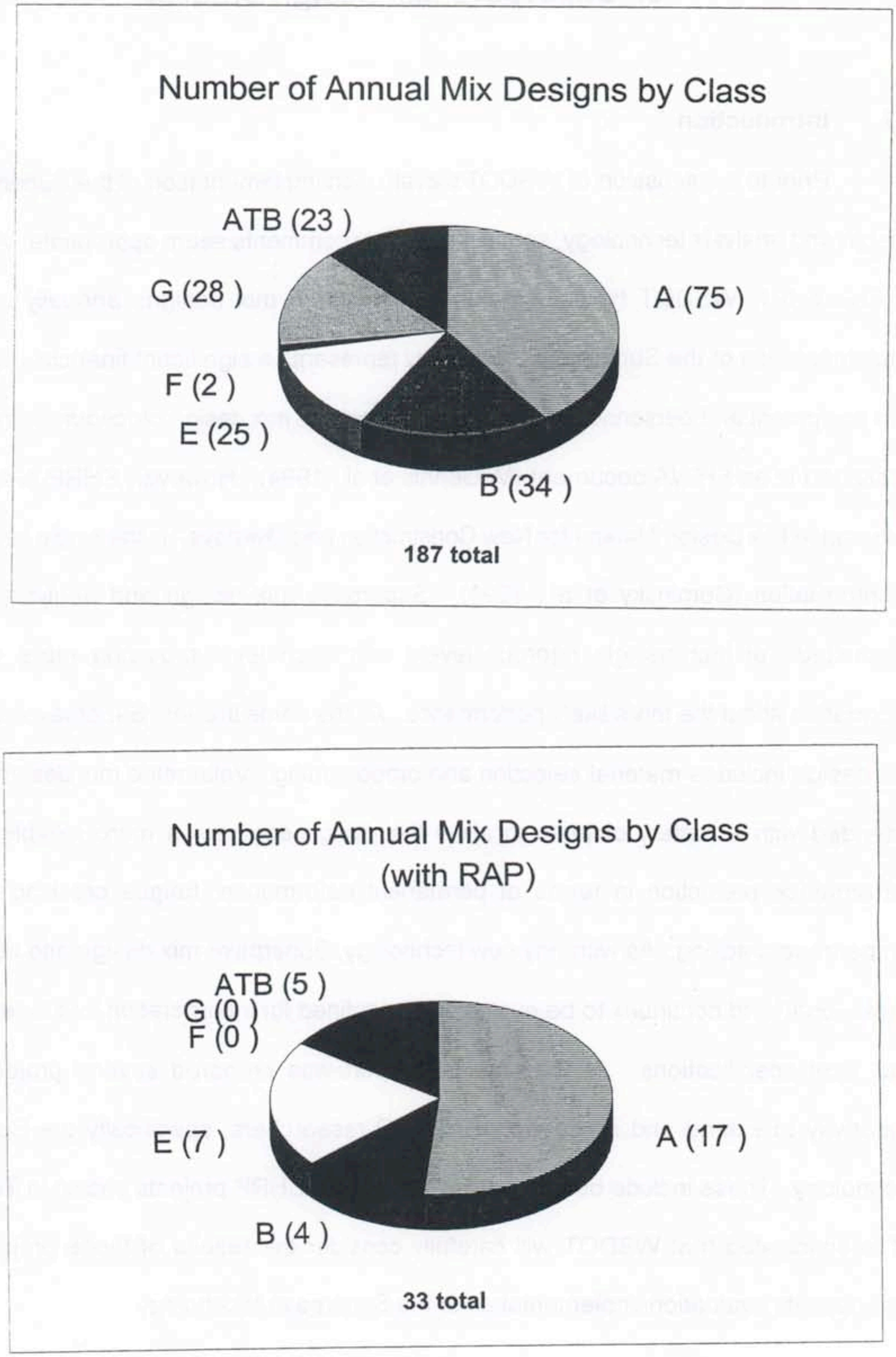


Figure 3-1: Number of Annual Mix Designs

Table 3-1. Post-SHRP Research Related to Superpave

NCHRP Project and Title	
9-7	Field Procedures and Equipment to Implement SHRP Asphalt Specifications
9-9	Refinement of the Superpave Gyratory Compaction Procedure
9-10	Superpave Protocols for Modified Asphalt Binders
9-12	Incorporation of Reclaimed Asphalt Pavement in the Superpave System
9-13	Evaluation of Water Sensitivity Tests
9-14	Investigation of the Restricted Zone in the Superpave Aggregate Gradation Specification
9-16	Relationship Between Superpave Gyratory Compaction Properties and Permanent Deformation of Pavements in Service
9-17	Accelerated Laboratory Rutting Tests: Asphalt Pavement Analyzer
9-18	Field Shear Test for Hot Mix Asphalt
9-20	Superpave Support and Performance Models Management

3.2 Mix Design Considerations –Traffic

As originally configured (Table 3-2) Superpave mix design included seven traffic levels and four temperature regimes for 28 possible compaction levels. Recognizing that the 28 compaction levels made for a somewhat unwieldy system WSDOT attempted to reduce the number of compaction levels by conducting a series of mix designs at each compaction level. It was hypothesized that a nomographic solution for selecting design asphalt content for all mix designs could be generated from the relationships of volumetric properties to asphalt content at three or four compaction levels. Selecting five commonly used job mix formuli (JMF), specimens were compacted to the Superpave-specified levels of $N_{maximum}$ as shown in Figure 3-2. All mixes were classified as 19 mm, based on nominal maximum size of aggregate. Mixes V-35, N-188 and W-295 used a quarried aggregate, whereas mixes D-47 and E-136 used a gravel. All mixes consisted of virgin materials except W-295 which contained 15% reclaimed asphalt pavement (RAP).

As expected, the design asphalt content at 4% air voids decreases with increasing compactive effort. This trend is independent of aggregate type. As shown in Figure 3-2 the five mixes fall in two distinct groups. Mixes V-35, N-188 and E-136 have design asphalt contents consistently higher (1 to 1.5%) than mixes D-47 and W-295. Note, however that the distinct groupings overlap aggregate type. This very limited laboratory experiment suggests that it might be possible to limit the number of compaction levels required for mix design; e.g., selecting a design asphalt content for $N_{maximum} = 134$ based on gyratory compaction data from $N_{maximum} = 204$. However, the data shown in Figures 3-3 and 3-4 suggest that this approach must be used with caution. The trends in the data are similar, i.e., decreasing VMA and VFA with increasing compactive effort, but the two groups contain different mixes than shown in Figure 3-2. The mixes containing the quarried aggregate (V-35, N-188 and W-295) have consistently higher VMA (voids in mineral aggregate) and VFA (voids filled with asphalt) (1 to 1.5%) than mixes containing the gravel (D-47 and E-136).

Table 3-2. Superpave Design Gyratory Compactive Effort (Asphalt Institute, 1995)

Design ESALs (millions)	Average Design High Air Temperature											
	< 39°C			39-40°C			41-42°C			43-44°		
	N_{ini}	N_{des}	N_{max}	N_{ini}	N_{des}	N_{max}	N_{ini}	N_{des}	N_{max}	N_{ini}	N_{des}	N_{max}
< 0.3	7	68	104	7	74	114	7	78	121	7	82	127
0.3-1	7	76	117	7	83	129	7	88	138	8	93	146
1-3	7	86	134	8	95	150	8	100	158	8	105	167
3-10	8	96	152	8	106	169	8	113	181	9	119	192
10-30	8	109	174	9	121	195	9	128	208	9	135	220
30-100	9	126	204	9	139	228	9	146	240	10	153	253
> 100	9	143	233	10	158	262	10	165	275	10	172	288

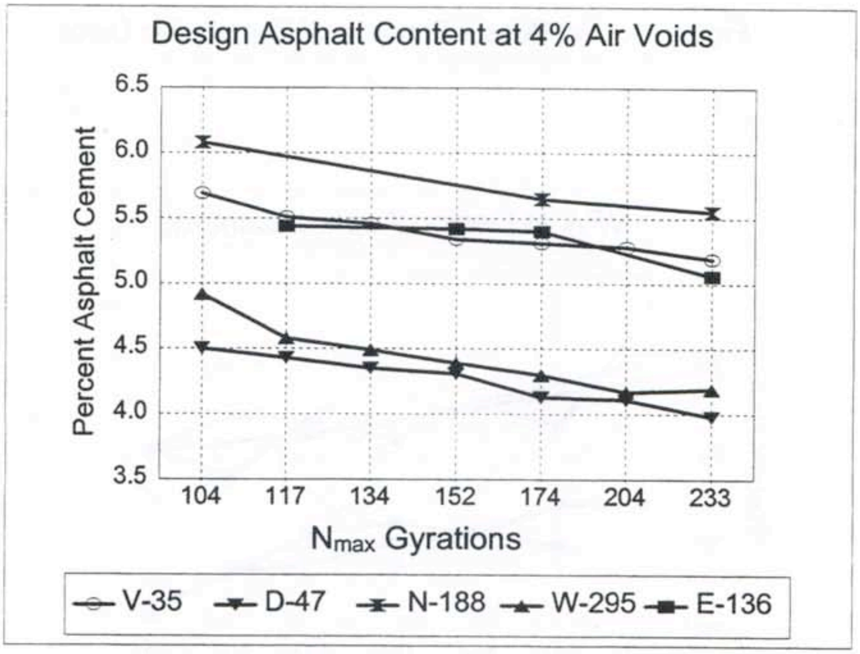


Figure 3-2. Design Asphalt Content at Various Compaction Levels

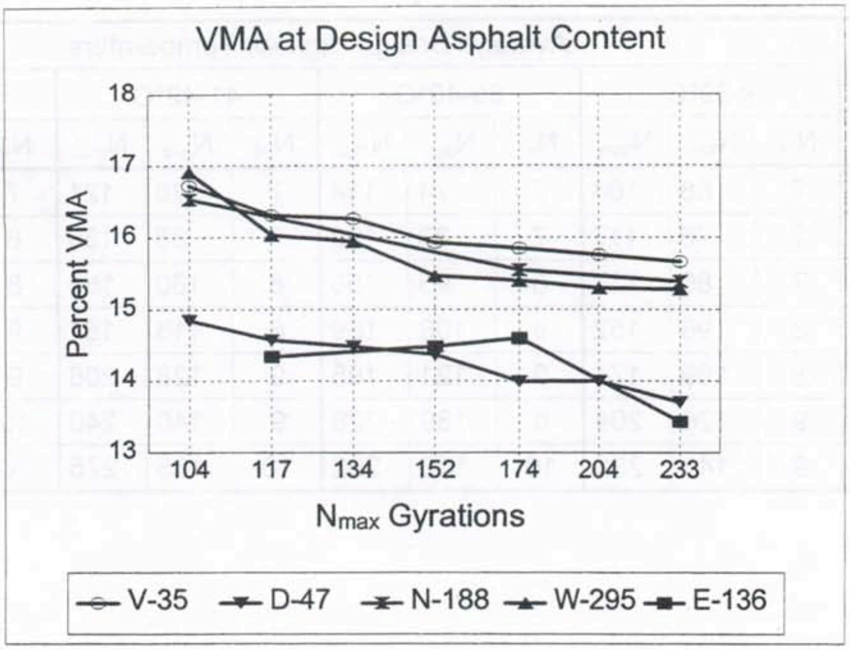


Figure 3-3. VMA as a Function of Compaction Level

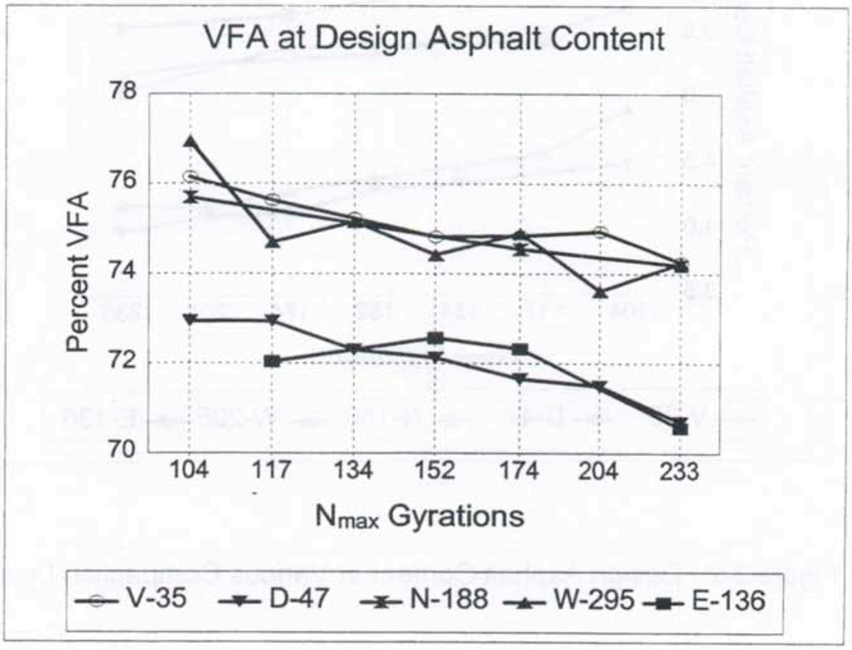


Figure 3-4. VFA as a Function of Compaction Level

On the national front it was acknowledged that limited data were used to develop the original gyratory compaction matrix such that one of the first post-SHRP research projects, NCHRP 9-9, focused specifically on this issue. Research by Brown et al. has provided a more reasonable number of compaction levels and more definitive guidance with respect to each. The consolidated design matrix is shown in Table 3-3. Although not specifically an objective of this research, some adjustment of the aggregate consensus property requirements was necessary to match the revised N_{design} levels and to make for a standard or uniform table. Consensus property requirements are shown in Table 3-4. Data extracted from the Washington State Pavement Management System (WSPMS) database, as shown in Table 3-5, indicate that two compaction levels (i.e., those associated with design ESALs of 0.1 to 1.0, and 1 to 30 million), will accommodate the preponderance of existing traffic conditions.

3.3 Comparison of WSDOT Mix Design to Superpave

At the conclusion of the Strategic Highway Research Program in 1993 most state DOTs, including Washington, began their "implementation" with a critical evaluation of the Superpave mix design and analysis technology. WSDOT considered numerous factors such as the following: mix class, aggregate gradation, and aggregate properties.

Working from the general to the specific, WSDOT began by comparing its existing mix classifications (e.g., A, B, D, etc) to the new Superpave mix designations (e.g., 19 mm, 12.5 mm, 9.5 mm, etc.). Superpave mixes are specified by nominal maximum size of aggregate, which is explicitly defined as one sieve size larger than the first sieve to retain more than 10 percent. Shown in Table 3-6 is a comparison of the current WSDOT mix classifications and the Superpave mix designations. Note that WSDOT mix classes mesh with four of the five Superpave designations, all but the 37.5 mm.

Table 3-3. Recommended Consolidation of the N_{design} Compaction Matrix (Brown et al., 1998)

Design Traffic Level (million ESALs)[a,b]	Compaction Parameters			Typical Roadway Applications[d]
	$N_{initial}$	N_{design}[c]	$N_{maximum}$	
Less than 0.1	6	50	74	Applications would include roadways with very light traffic volumes such as local roads, county roads, and city streets where truck traffic is prohibited or at a very minimal level. Traffic on these roadways would be considered local in nature and not regional, intrastate, or interstate. Special purpose roadways serving recreational sites or areas would also be applicable to this level.
0.1 to 1	7	70	107	Applications would include many collector roads or access streets. Medium trafficked city streets and the majority of county roads would be applicable to this level.
1 to 30	8	100	158	Applications would include many two-lane, multilane, and partially divided or completely controlled access roadways. Among these are medium to highly trafficked city streets, many state routes, U.S. highways, and some rural interstates. Use for Stone Matrix Asphalt.[e]
Greater than 30	9	130	212	Applications include much of the U.S. Interstate system, both rural and urban in nature. Special applications such as truck weighing stations or truck climbing lanes on two-lane roadways would also be applicable to this level.

Notes:

[a] Values shown are based on 20-year ESALs. For roadways designed for more or less than 20 years, determine the estimated ESALS for 20 years and choose the appropriate N_{design} level.

[b] When the mixture being designed is to be placed more than 100 mm from the finished surface the N_{design} requirement can be dropped one traffic level. When the mixture is more than 200 mm from the surface the N_{design} requirement can be dropped two traffic levels. However, if the mixture being designed at lower gyrations is exposed to significant traffic prior to being overlaid, significant stability problems may occur.

[c] It is recommended that Superpave mixtures be compacted to N_{design} gyrations.

[d] Typical applications as defined by *A Policy on Geometric Design of Highways and Streets*, AASHTO, 1994.

[e] When the Los Angeles Abrasion value for the aggregate used in Stone Matrix Asphalt exceeds 30 or when designing for less than 1 million ESALs, consider dropping to the next lowest compaction level (70 gyrations).

Table 3-4. Superpave Design Compactive Effort and Aggregate Consensus Property Requirements (Brown et al. , 1998)

Estimated Design Traffic Level (million ESALs)[b]	Superpave Compaction Parameters			Percent G_{mm} at $N_{initial}$ Requirement	Aggregate Consensus Properties					
					Coarse Aggregate Angularity		Fine Aggregate Angularity[g]		Clay Content[h]	Flat and Elongated[i]
	$N_{initial}$	N_{design}[a]	$N_{maximum}$		≤ 100 mm	> 100 mm	≤ 100 mm	> 100 mm	All Mixtures	All Mixtures
< 0.1	6	50	74	< 91.5	55/–	–/–	–	–	40	< 10 percent
0.1 to < 1.0	7	70	107	< 90.5	65/–	–/–	40	–	40	
1.0 to < 30.0	8	100[j]	158	< 89.0	75/–[c]	50/–	40	40	45	
					85/80[d,f]	60/–	45	40	45	
					95/90[e]	80/75	45	40	45	
≥ 30.0	9	130	212	< 89.0	100/100	100/100	45	45	50	

Notes:

[a] It is recommended that Superpave mixtures be compacted to N_{design} gyrations.

[b] Values shown are based on 20-year ESALs. For roadways designed for more or less than 20 years, determine the estimated ESALS for 20 years and choose the appropriate N_{design} level.

[c] Requirements apply to traffic levels from 1 to < 3 million ESALs.

[d] Requirements apply to traffic levels from 3 to < 10 million ESALs.

[e] Requirements apply to traffic levels from 10 to < 30 million ESALs.

[f] "85/80" denotes that 85 percent of the coarse aggregate has one fractured face and 80 percent has two or more fractured faces.

[g] Criteria are minimum presented as percent air voids in loosely compacted fine aggregate. Test to be run in accordance with AASHTO TP-33.

[h] No distinction is made between depth from surface. Test to be run in accordance with AASHTO T176.

[i] Criterion based on 5:1 maximum to minimum ratio.

[j] Use for Stone Matrix Asphalt. However, when the Los Angeles Abrasion value for the aggregate used in SMA exceed 30, consider dropping to the next lowest compaction level (70 gyrations).

Table 3-5. WSDOT Lane Miles Associated with Revised Superpave Compaction Matrix

Design ESALs (million)	Lane Miles	
	ACP	BST
< 0.1	23.8	132.2
0.1 - < 1	2038.3	3152.7
1 - < 30	7754.8	1576.3
> 30	858.8	

Table 3-6. Comparison of WSDOT Mix Classes and Superpave Designations

WSDOT Mix Class	Equivalent Superpave Designation
A	12.5
B	12.5
D	9.5 (open graded)
Modified D	25 (open graded)
E	25
	19
	9.5
	Superpave Mix Designations (mm) 9.5, 12, 19.5 25, 37.5

Aggregate gradation is a key component of mix design. Shown in Table 3-7 are the sieves required by Superpave as well as the four additional sieves traditionally used by WSDOT. Since 1993 WSDOT has used the standardized nest of sieves required by Superpave, no longer using the 31.5, 16, 6.3 and 2.00 mm sieves.

WSDOT's assessment of Superpave mix design criteria began with 1994 data. The evaluation was made in terms of gradation, specifically the Superpave control points and restricted zone. As shown in Table 3-8, 163 mix designs were initially considered. The WSDOT class F mixes were excluded as there were only two mix designs; ATB mixes were excluded since Superpave was not intended for base mixes. Of the remaining 147 mixes approximately 72% failed the Superpave gradation criteria, primarily because the WSDOT mixes passed through the restricted zone. However, it is important to note that nearly 70% of those WSDOT mixes made with multiple stockpiles could be re-blended to meet the gradation requirements. It is impossible to say if mixes made with these "re-blended" gradations would have met the Superpave volumetric criteria as no actual mix designs were conducted.

SHRP researchers surveyed pavement experts to determine which aggregate properties were critical to asphalt concrete performance. This group of experts recommended that two categories of aggregate properties be included in Superpave: "consensus" and "source" properties. The characteristics in the former category were called "consensus" because there was agreement as to their use and specified values. Consensus properties include the following: coarse and fine aggregate angularity; flat and elongated particles; and clay content. Although other aggregate properties were believed to be important, critical values of these properties could not be reached by consensus. Consequently, a set of "source" properties was recommended. Aggregate source properties include the following: toughness; soundness; and deleterious materials.

Table 3-7. Sieves Used

Superpave Sieves (mm)	WSDOT Additional Sieves (mm)
50	
37.5	
	31.5
25	
19	
	16
12.5	
9.5	
	6.3
4.75	
2.38	
	2.00
1.18	
0.600	
	0.425
0.300	
0.150	
0.075	

Table 3-8. 1994 Mix Design Assessment

	Mix Class					
	A & B	G	E	F	ATB	Total
Number of Mix Designs	97	27	23	2	14	163
Fails Superpave Criteria						
• Gradation	83	8	15			106
Control Points	0	0	2			2
Restricted Zone	83	8	13			104
• Stockpiles Re-blended to Meet Gradation	57	7	9			73

Comparisons of WSDOT and Superpave aggregate properties used in mix design are shown in Tables 3-9 to 3-13. Note that these data were taken from the same 1994 mix designs considered in Table 3-8.

Shown in Table 3-9 are WSDOT mixes that failed the Superpave criterion for coarse aggregate angularity. Approximately 33% of all WSDOT mixes failed the coarse aggregate angularity criterion. Nearly 75% of those mixes that failed this criterion had design ESALs greater than 10 million. WSDOT has since specified a minimum of 90% fractured faces for mixes 19 mm or smaller, and a minimum of 50% fractured faces for mixes larger than 19 mm.

Shown in Tables 3-10 and 3-11 are the Superpave criteria for fine aggregate angularity, and for flat and elongated particles, respectively. WSDOT did not have specification for either, but has since adopted the following requirements for all mixes: a minimum 45% for fine aggregate angularity; and a 10% maximum for flat and elongated particles.

In Table 3-12 are the Superpave and WSDOT recommended minima for sand equivalent. WSDOT's minimum sand equivalent of 45% compares favorably to the Superpave criterion at all but the highest traffic level. For design ESALs which exceed 30 million the Superpave criterion is a minimum sand equivalent of 50%. At this time WSDOT has no plans to change its requirements.

Superpave aggregate source properties are shown in Table 3-13. Shown also are WSDOT tests and criteria. Note that WSDOT's criterion for aggregate toughness is more stringent than that recommended by Superpave. WSDOT limits LA Abrasion loss to 30% whereas Superpave recommends a range of 35-45%. WSDOT has recommended that the LA Abrasion test be conducted annually. Previously, the WSDOT required that LA Abrasion be done once every 10 years. For aggregate soundness WSDOT employs a degradation

Table 3-9. Comparison of WSDOT and Superpave Criteria for Fractured Faces of Coarse Aggregate

Superpave Criterion for Coarse Aggregate Angularity		Mix Designs Failing Superpave Criterion by WSDOT Mix Class				
Design ESAL $\times 10^6$	Depth from Surface < 100 mm	A & B	G	E	F	Total
< 0.3	55/-	0	0	0	0	0
0.3 to 1	65/-	0	0	0	0	0
1 - 3	75/-	2	0	2	0	4
3 - 10	85/80	3	0	5	1	9
10 - 30	95/90	19	4	1	0	24
30 - 100	100/100	7	1	4	0	12
> 100	100/100					
	total	31	5	12	1	49
		147 mix designs considered				

NB: "85/80" denotes that 85% of the coarse aggregate has one or more fractured faces and 80% has two or more fractured faces.

Table 3-10. Superpave Criteria for Fine Aggregate Angularity

	Depth from Surface	
Design ESAL $\times 10^6$	< 100 mm	> 100 mm
< 0.3	-	-
0.3 to 1	40	-
1 - 3	40	40
3 - 10	45	40
10 - 30	45	40
30 - 100	45	45
> 100	45	45

NB: This property defined as the percent air voids present in loosely compacted aggregate smaller than 2.36 mm — based on AASHTO TP 33.

Table 3-11. Superpave Criteria for Flat and Elongated Particles

Design ESAL × 10^6	Maximum Percent
< 0.3	—
0.3 – 1	—
1 – 3	10
3 – 10	
10 – 30	
30 – 100	
> 100	

NB: This property determined from ASTM D 4791.

Table 3-12. Superpave Criteria for Clay Content

		WSDOT Mix Classification	
Design ESAL × 10^6	Sand Equivalent Minimum Percent	A, B, G & E	F
< 0.3	40	45	35
0.3 – 1			
1 – 3			
3 – 10	45		
10 – 30			
30 – 100	50		
> 100			

NB: This property determined from AASHTO T 176.

Table 3-13. Comparison of Superpave and WSDOT Tests and Criteria for Aggregate Source Properties

Property	Superpave		WSDOT
Toughness	Los Angles Abrasion ASTM C 131/535 AASHTO T 96	maximum loss 35 - 45%	maximum loss 30%
Soundness	Sodium or Magnsium Sulfate ASTM C88 AASHTO T 104	maximum loss 10 - 20% for 5 cycles	degradation 30 minimum for wearing course
Deleterious Materials	ASTM C 142 AASHTO T 112	maximum 0.2 to 10%	none specified

test and requires a 30 minimum for all wearing courses. WSDOT does not currently evaluate aggregate for the presence of deleterious materials. At this time WSDOT does not anticipate adopting the Superpave recommended tests for aggregate soundness and deleterious materials.

One particularly contentious aspect of Superpave mix design is that of the restricted zone. Its inclusion was recommended by the same panel of experts that selected the aggregate consensus and source properties and was intended to eliminate "tender mixes" by limiting the quantity of rounded natural sands. Though intended as a guide, many interpreted it to be a requirement. Several state DOTs, including Washington, indicated that violation of the restricted zone did not necessarily yield poor field performance. In conjunction with the PCCAS (Pacific Coast Conference on Asphalt Specifications), WSDOT staff compiled the data shown in Table 3-14. Though limited in number and qualitative in nature, these data suggest that an aggregate gradation that passes through the restricted zone at a "severe" angle, as depicted in Figure 3-5, is more likely to result in rutting than is an aggregate gradation that skirts the restricted zone and is nearly parallel to the maximum density line. This aspect of the Superpave design aggregate structure has generated so much interest/controversy that an NCHRP project (9-14) is now underway to try to resolve this issue.

3.4 Rutting Evaluation for Contract # 4250

One of WSDOT's first attempt to incorporate the Superpave technology began with the 1993 paving of Interstate-5 from Nisqually River to Gravelly Lake Road (MP 114.97 to MP 124.21), approximately 15 km in length. Both north and southbound lanes were paved with three test sections. A Hveem mix design was conducted for each test section using the binders shown in Table 3-15. Complete mix design and field core data may be found elsewhere (Briggs et al.), but are summarized in Table 3-16. In 1993 only Hveem mix designs were performed. In 1994 both Hveem and Superpave mix designs were performed.

Table 3-14. Number of Mixes Evaluated with Respect to Restricted Zone and Observed Field Performance

	Orientation with Respect to Maximum Density Line							
			Through the Restricted Zone					
			Above		Below		Crossing	
	Above	Below	Lot	Little	Lot	Little	Severe	Slight
WS DOT Good Performance	1	2	1	1	2	3	1	1
AZ DOT Good Performance	1	3					2	1
WS DOT Rutting		1					5	1
AZ DOT Rutting							5	

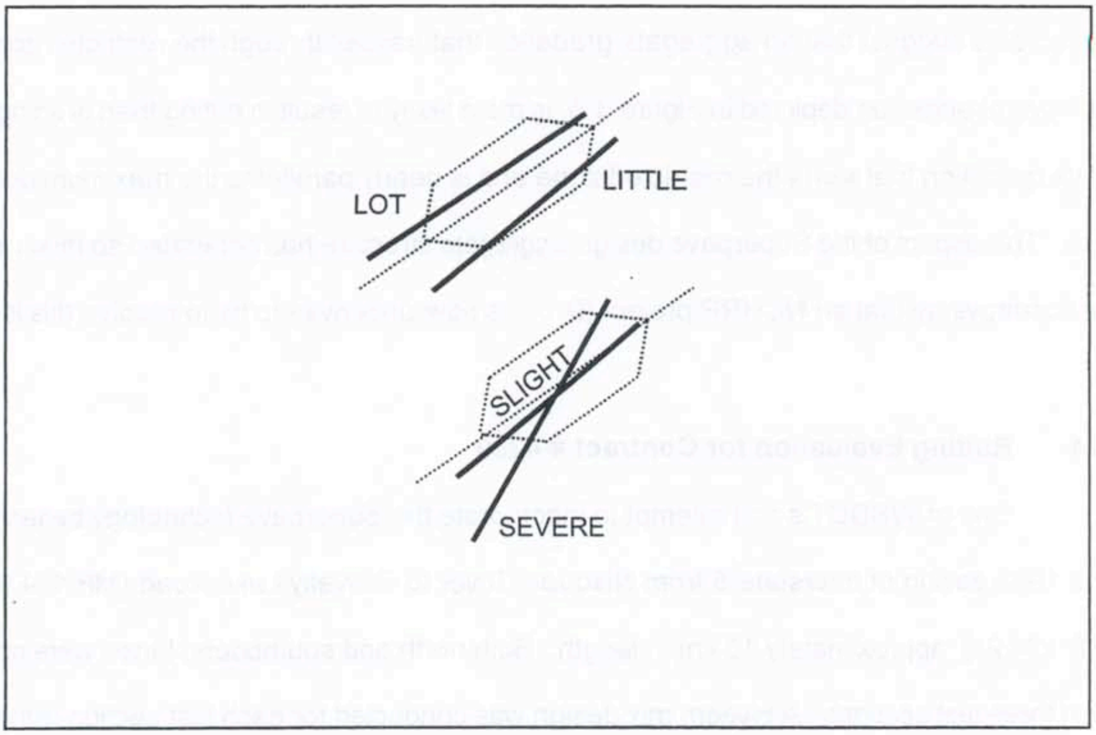


Figure 3-5. Violations of the Restricted Zone

Table 3-15. Binders Used on Contract 4250

Milepost	Binder	
	Southbound	Northbound
114.98 to 116.77		AR4000W
116.77 to 118.77	PBA-6	PBA-6
118.77 to 120.77	PBA-6GR	PBA-6GR
120.77 to 124.21	AR4000W	AR4000W

Table 3-16. Summary of Contract 4250 Data

1993 Data – Northbound Lanes				
Binder	Design Asphalt Content (%)	Air Void Content at Design Asphalt Content (%)	Hveem Stability at Design Asphalt Content	Average Air Void Content of Field Cores (%)
AR4000W	5.3	2.9	40	7.2
PBA-6GR	5.5	4.4	36	8.8
PBA-6	5.3	4.0	38	5.5

1994 Data - Southbound lanes						
Binder	Design Asphalt Content (%)		Air Void Content at Design Asphalt Content (%)		Hveem Stability at Design Asphalt Content	Average Air Void Content of Field Cores (%)
	Hveem	Superpave	Hveem	Superpave		
AR4000W	4.9	5.1	3.2	4.0	39	6.7
PBA-6GR	5.5	5.4	3.2	4.0	36	5.9
PBA-6	4.9	4.9	3.4	4.0	39	7.0

Table 3-17. Summary of SST and GLWT Results

	SST		GLWT
	1993 Data	1994 Data	1994 Data
	Million ESALs to 0.4 in Rut Depth	Million ESALs to 0.5 in Rut Depth	Average Deformation at 8000 Load Cycles (inches)
AR4000W	12.4	0.631	0.032
PBA-6GR	0.559	0.661	0.072
PBA-6	18.4	0.646	0.041

As shown in Table 3-15, the design asphalt contents vary but slightly: for the AR4000W the Superpave design asphalt content is 0.2% higher than the Hveem design asphalt content; for the PBA-6GR, the Superpave and Hveem design asphalt content differ only by 0.1%. Note, however, that the air void contents associated with the Hveem design asphalt content are lower than that of the Superpave design by 0.6 to 0.8%.

Field cores were taken immediately after paving in 1993 and 1994 and sent to commercial laboratories for evaluation with the Superpave Shear Tester (SST). Additionally, plant mix material from the 1994 paving, i.e., southbound lanes, was sent to a commercial laboratory for evaluation with the Georgia Loaded Wheel Tester (GLWT), now called the asphalt pavement analyzer (APA). The objective in sending cores and production mix to the commercial labs was to estimate the rutting performance of these mixes. Complete shear test and wheel tracking test results may be found elsewhere (Briggs et al.), but are summarized in Table 3-17 and Figures 3-6 and 3-7. As is evident from the data shown in Table 3-17, the data are conflicting as to the expected performance. The 1993 SST data rank the sections in order of decreasing rutting performance as follows: PBA-6, AR4000W and PBA-6GR. The 1994 SST data rank the sections in order of decreasing rutting performance as follows: PBA-6GR, PBA-6 and AR4000W. The GLWT data rank the sections in order of decreasing rutting performance as follows: AR4000W, PBA-6 and PBA-6GR.

As shown in Figure 3-6, the 1993 SST data suggest that the AR4000W and PBA-6 will be much more rut resistant than the PBA-6GR, whereas the 1994 SST data suggest that there would be no significant difference in performance. The GLWT data, also shown in Figure 3-6, tend to agree *qualitatively* with the 1993 SST data — that the AR4000W and PBA-6 will be more rut resistant than the PBA-6GR. Based on projected traffic of 850,000 ESALs/year, however, the 1993 SST data suggest that the AR4000W and PBA-6 would provide nearly 18 to 20 years of service, whereas the PBA-6GR would rut within the first year

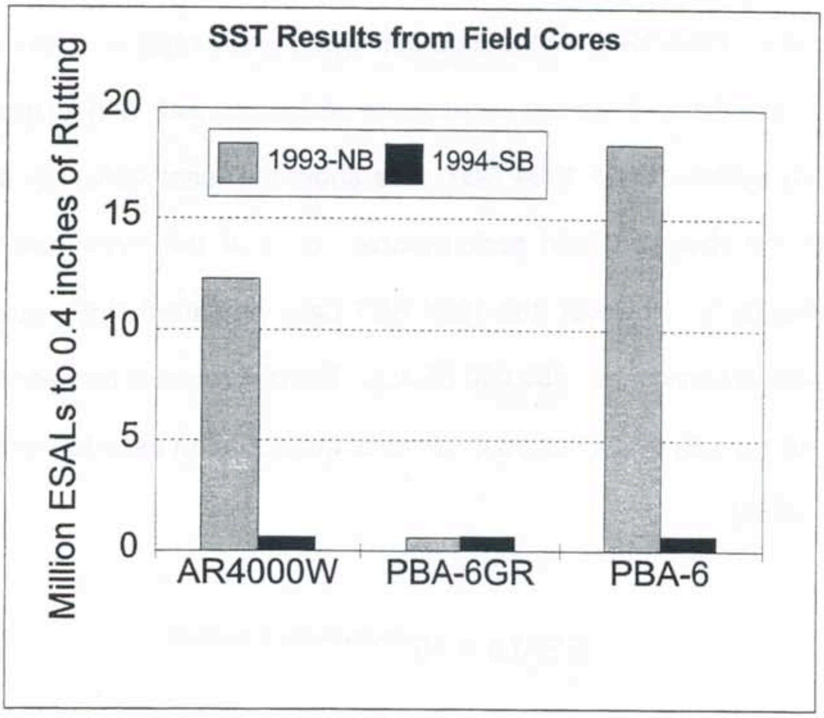


Figure 3-6. SST Results from Field Core

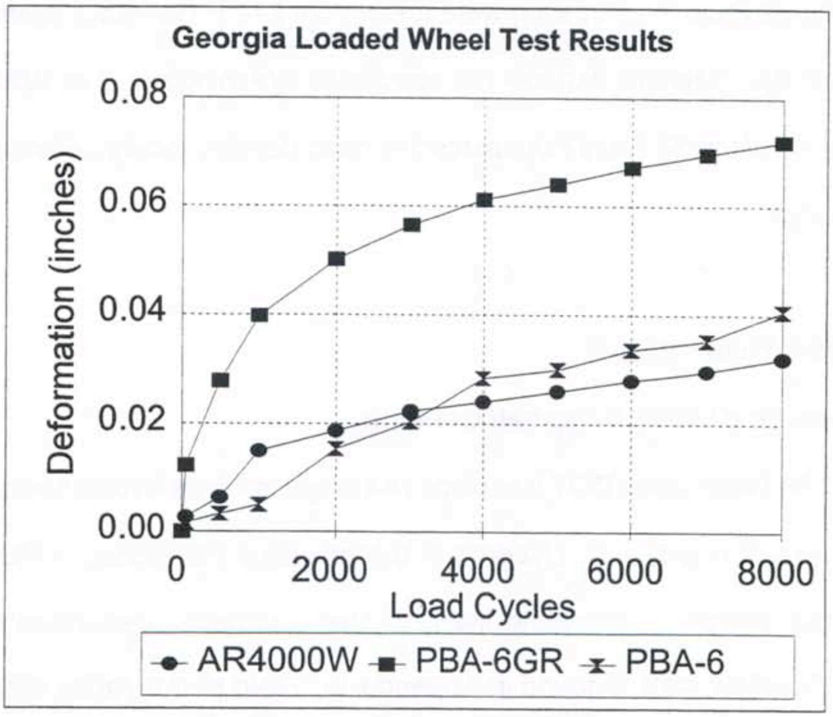


Figure 3-7. GLWT Results from Production Mix

of service. The GLWT data suggest that the AR4000W and PBA-6 would provide twice the rut resistance as the PBA-6GR. At the time this report was prepared data extracted from the WSPMS indicate that all three test sections are performing well, with no more than 4 mm or rutting on any section. The 1994 SST data show the least variability and are most consistent with the observed field performance, i.e., that the three test sections are performing comparably. However, the 1994 SST data indicate that the mixes would rut within the first year of service, i.e., 850,000 ESALs. The discrepancy between the predicted and observed rutting may be explained in terms of the equation used to predict ESALs to rutting (Sousa, 1994).

$$\text{ESALs} = 10^{((\log(\text{cycles}) + 4.36)/1.24)} \qquad (3\text{-}1)$$

where cycles = number of repetitions to 4.5% shear strain

The data used to develop this equation were taken from LTPP General Pavement Studies (GPS) which employ materials that are not specific to Washington. For WSDOT to use make effective use of the SST and this approach it must develop locally calibrated predictive rutting relationships.

3.5 Data from Field Projects

3.5.1 Comparison of Design Asphalt Contents

Since 1994 Washington DOT has placed 44 projects which involve some component of the Superpave technology; e.g., Hveem mix design with a PG binder, or PG binder with a Superpave mix design. A complete listing of these projects, generated by WSDOT Pavement Management staff, is found in Appendix D. Field performance data, extracted from the WSPMS, were available for all the projects and are shown in Appendix E.

For 14 of these 44 projects both Hveem and Superpave mix design data were available, a complete summary of which is found in Appendix F. For 7 of these 14 projects both gyratory and kneading compaction data with plant mixed material (i.e., production mix) were available.

The analyses of these data began with a comparison of design asphalt contents, summarized in Table 3-18 and Figure 3-8. Note that the Superpave methodology recommends selecting a design asphalt content associated with 4 percent air voids. Shown in Table 3-18 are not only the recommended Hveem and Superpave design asphalt contents, but also the Hveem asphalt content associated with 4 percent air voids.

The data shown in Figure 3-8a suggest that there are some differences between Hveem and Superpave mix designs. Below 5 percent the recommended Hveem design asphalt content is generally equal to or *greater* than the Superpave design asphalt content. Above 5 percent the recommended Hveem design asphalt content is generally equal to or *less* than the design asphalt content. A careful review of the data in Table 3-18 reveals the following: In 8 of the 17 cases the recommended Hveem and Superpave design asphalt contents do not differ by more than 0.2%. In 6 cases the Superpave design asphalt content is greater than that of the recommended Hveem. In 3 cases the recommended Hveem design asphalt content is greater than that of the Superpave. Comparison of the matched pairs using the student's t-test indicates that there is not a statistical difference in the design asphalt contents.

The data shown in Figure 3-8b, which includes a comparison of the recommended Hveem design asphalt content and the Hveem design asphalt content associated with 4 percent air voids, indicate that there are only slight differences. Again, the data in Table 3-18 are instructive: in 14 of 17 cases the design asphalt contents do not differ by more than 0.2%.

Table 3-18. Summary of Design Asphalt Contents

Contract Number	Hveem		Superpave
	Recommended	@ 4% Air Voids	@ 4% Air Voids
4201 (A)	5.4	5.7	6.1
4250 (A, AR4000W)	4.9	4.7	5.1
4250 (A, PBA-6)	4.9	4.7	4.9
4250 (A, PBA-6GR)	4.9	5.1	5.5
4326 (A)	4.7	4.4	4.1
4326 (E)	4.3	4.1	3.4
4362 (E)	4.0	3.7	4.0
4414 (A)	5.2	5.0	5.6
4625 (F)	4.3	4.1	4.4
4676 (A)	4.9	5.0	5.0
4692 (A-RAP) (BLEND 1)	5.6	5.6	6.4
4694 (A)	5.0	4.8	5.5
4712 (A)	5.9	5.9	5.7
4818 (A)	5.2	5.1	5.2
4871 (A)	5.0	4.9	5.0
5160 (E)	4.5	4.5	3.8
5338 (12.5 mm)	4.7	4.6	5.2

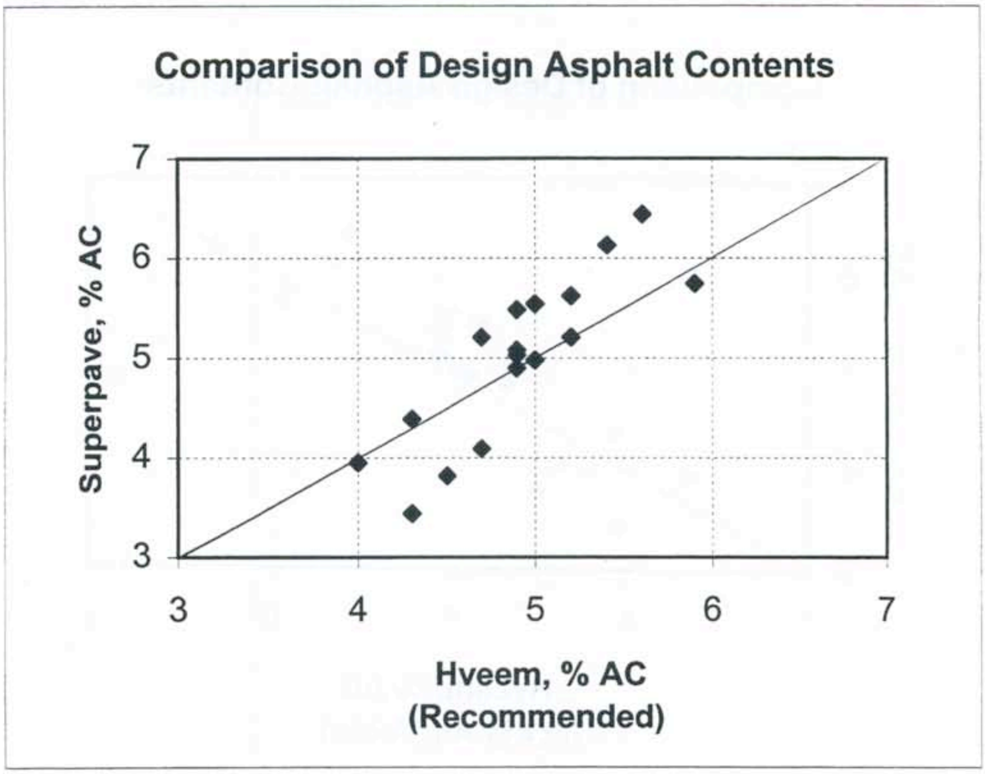


Figure 3-8a. Design Asphalt Contents (Superpave vs. Recommended Hveem)

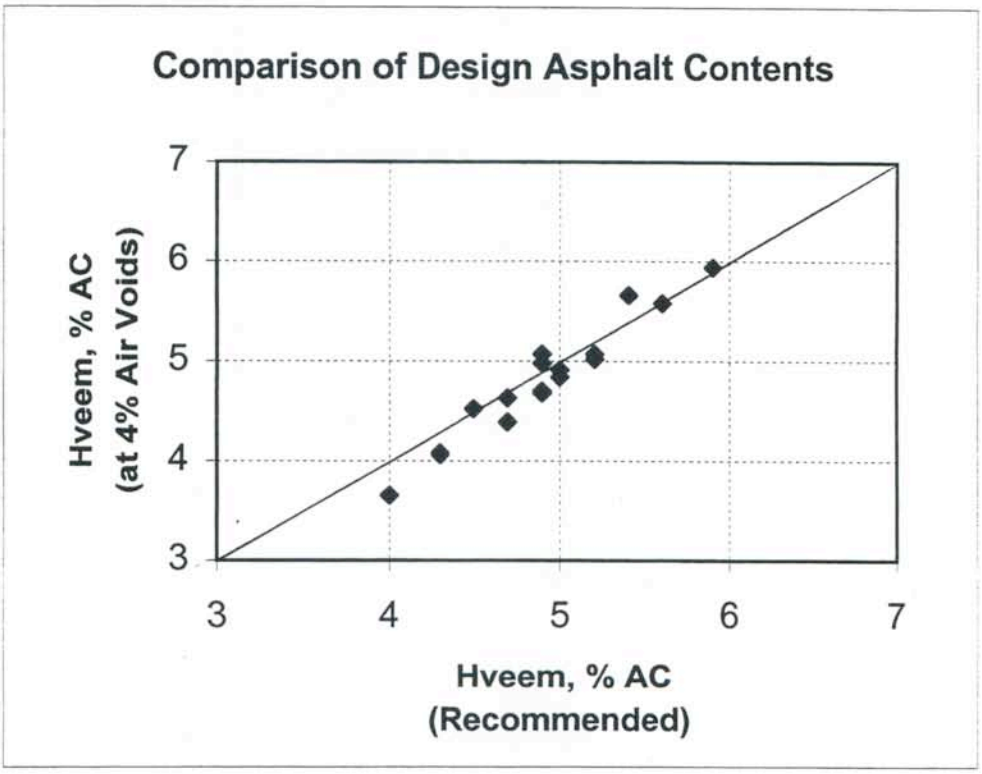


Figure 3-8b. Design Asphalt Contents (Recommended Hveem vs. Hveem at 4 Percent Air Voids)

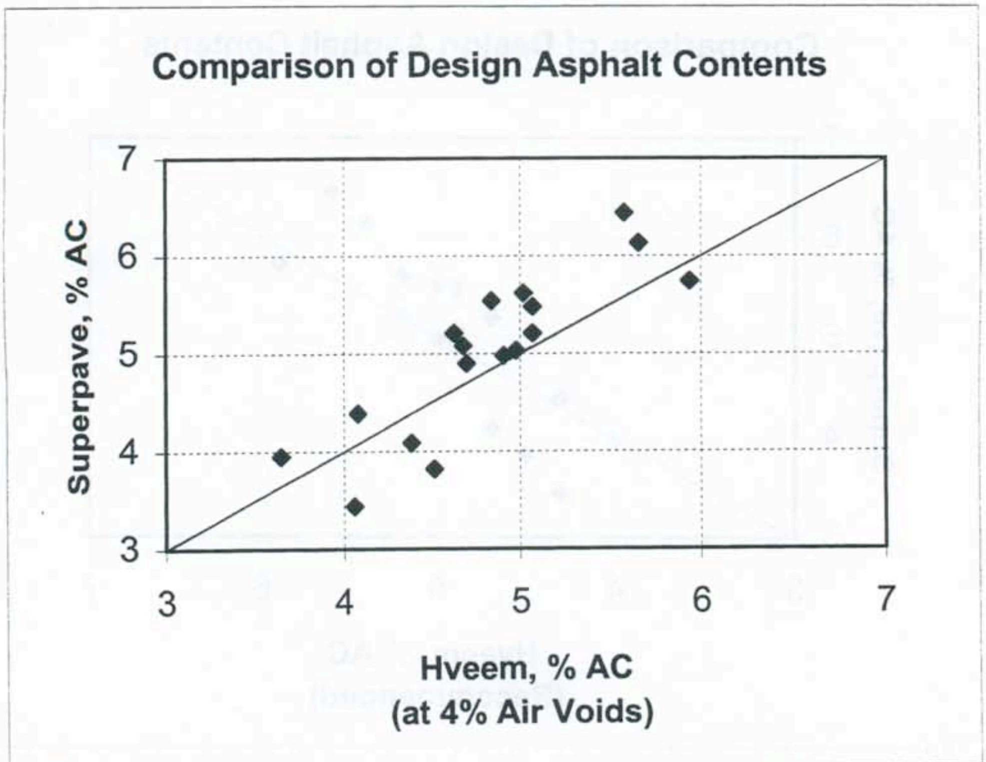


Figure 3-8c. Design Asphalt Contents (Superpave vs. Hveem at 4 Percent Air Voids)

As expected from the preceding discussion, the data shown in Figure 3-8c indicate that in most cases (13 of 17) the Superpave design asphalt content is equal to or greater than the Hveem design asphalt content associated with 4 percent air voids.

3.5.2 Comparison of Compaction Devices

A fundamental difference between Hveem and Superpave mix design methods is the compaction device. In Hveem mix design, regardless of the anticipated traffic, all specimens are compacted in accordance with ASTM D1560. Superpave mix design attempts to account for anticipated traffic by varying the compactive effort; hence the compaction matrices shown previously in Tables 3-2 and 3-3. Moreover, the kneading compactor used in Hveem design in not suitable for field quality control/assurance (QC/QA) because of its size and lack of portability. On the other hand, SHRP researchers were optimistic that the Superpave gyratory would ultimately find its way to the field for that very purpose. The Superpave gyratory compactors as originally configured have a mass of 360 to 540 kg and are not truly portable. Still, they have been widely used in mobile laboratories at project sites for various reasons: to gain familiarity with the equipment itself; to assess compactibility of Superpave mixes; to validate the compaction matrix as well as the $N_{initial}$, N_{design} and $N_{maximum}$ parameters; and QC/QA. Toward that end a limited experiment was undertaken by WSDOT to try to quantify the difference between the Hveem and gyratory compactors.

As shown in Table 3-19, production mix from 7 projects was included in the study. Note that for contract 4250 there were 3 different mixes used on the project. Production mix was sampled during construction and divided for compaction with the gyratory and kneading devices. For gyratory compaction, production mix was sampled during construction, transported to the trailer on the project site, brought to compaction temperature and compacted immediately thereafter. For kneading compaction, production mix was sampled

Table 3-19. Summary of Kneading and Gyratory Compaction Data from Field Projects

	% Air Voids			
Contract Number	Kneading	Gyratory		N Design
4201 (A)	4.7	8.1		68
4250 (A, AR4000W)	2.8	3.0		109
4250 (A, PBA-6)	3.0	3.8		109
4250 (A, PBA-6GR)	2.5	2.3		109
4326 (E)	2.9	2.6		109
4362 (E)	3.1	2.9		109
4692 (A-RAP)	4.6	N = 76 7.0	N = 109 5.9	
4694 (A)	4.8	8.1		76
4712 (A)	4.0	N = 76 3.9	N = 109 2.4	

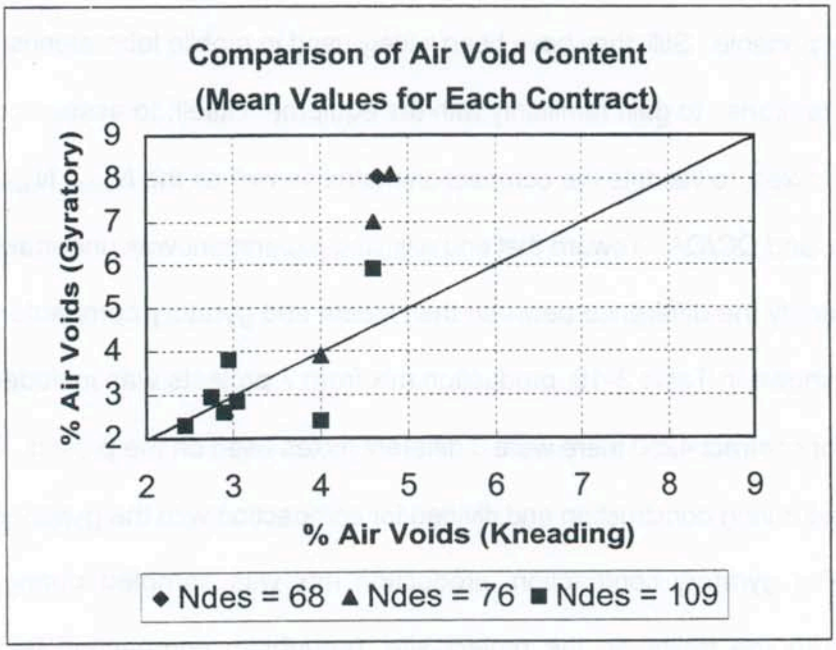


Figure 3-9. Comparison of Kneading and Gyratory Compaction Data (Average Values for Each Project)

during construction, stored in cardboard boxes or metal buckets, and returned to the headquarters laboratory for compaction at a later date. The data are summarized in Table 3-19 and Figure 3-9.

The data in Figure 3-9 indicate that there are some differences between kneading and gyratory compaction as measured by average void content, particularly when N_{design} gyrations are fewer than 109. This is seen more clearly when the data are separated into two data sets, i.e., N_{design} = 109 and all other data. Descriptive statistics for the two data sets, are shown in Table 3-20. The individual data points are shown graphically in Figure 3-10. Figure 3-10a includes all the data, whereas Figure 3-10b includes only the gyratory data for which N_{design} = 109.

As is evident from Figure 3-10a, the encircled cluster of gyratory data points reflects the higher air void contents associated with compaction to N_{design} = 68 or 76. Excluding these data, i.e., N_{design} = 68 and 76, Figure 3-10b suggests that, despite some obvious outliers and scatter in the data, the current kneading compaction and gyratory compaction protocols (at least for 109 gyrations) yield similar air void contents. Interestingly, the relationship between air void content and Hveem stability is quite good. A logarithmic fit of the data, as shown in Figure 3-11, indicates that air void content explains nearly 70 percent of the variation (R^2 = 0.67) in Hveem stability.

Table 3-20: Descriptive Statistics for Kneading and Gyratory Compaction Data

Data from the Following Contract Numbers: 4201, 4250, 4326, 4362, 4692, 4694, 4712		Air Void Content	
		Kneading	Gyratory
All Data	mean	3.5	4.2
	standard deviation	1.1	2.4
	coefficient of variation (%)	31	58
Hveem Data and Gyratory N_{design} = 109	mean	3.1	3.0
	standard deviation	0.9	1.1
	coefficient of variation (%)	28	36

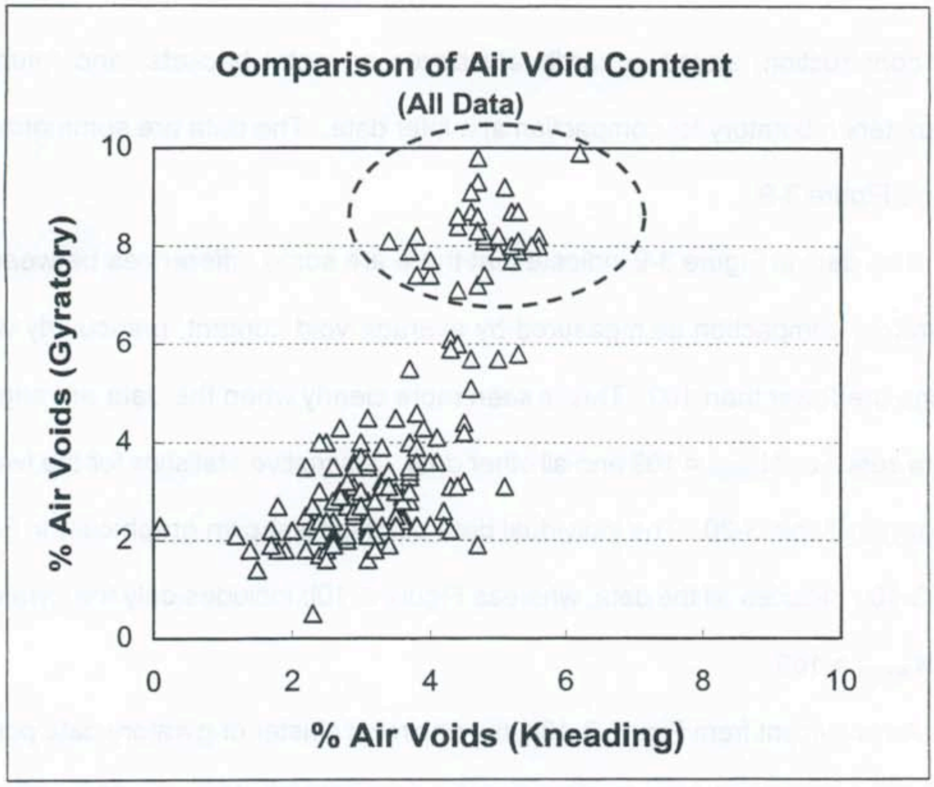


Figure 3-10a. Comparison of Kneading and Gyratory Compaction Data (All Project Data)

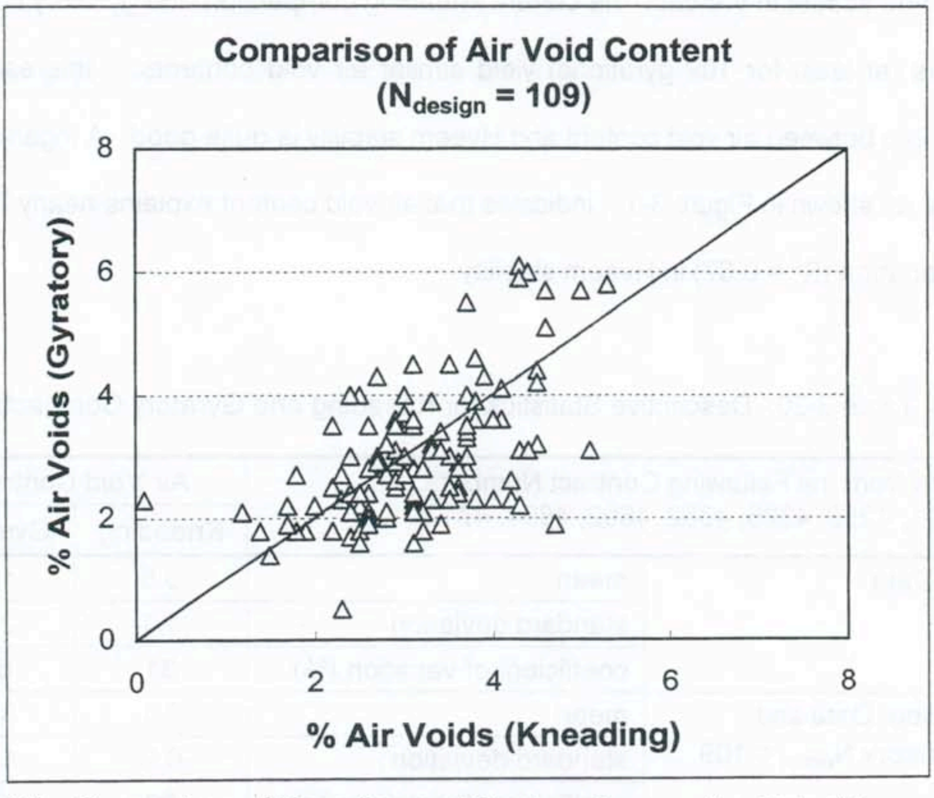


Figure 3-10b. Comparison of Kneading and Gyratory Compaction Data (N_{design} = 109)

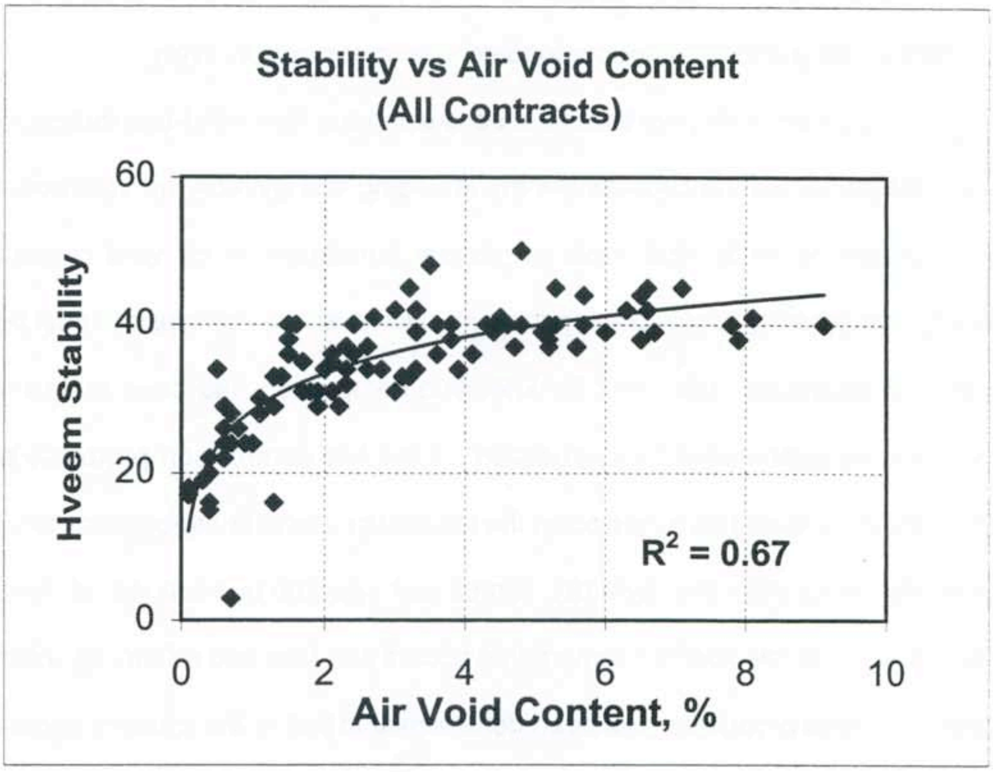


Figure 3-11. Relationship between Air Void Content and Hveem Stability

As shown in the shaded cells of Table 3-20, the average void contents are 3.1% and 3.0% for kneading and gyratory compacted specimens, respectively.

Comparison of the two sample means using the student's t-test indicates that there is not a statistical difference between the kneading and gyratory air void contents. One might logically conclude that there is general agreement in air void content between kneading and gyratory compacted specimens. However, that conclusion must be qualified. Recall that production mix used for kneading compaction had been stored for several months and reheated prior to compaction. If the two compaction protocols are indeed comparable, one would have expected the kneading compacted specimens to have higher air void contents than the gyratory compacted specimens because of the inevitable hardening/aging of the asphalt cement that occurs with time and reheating. Had kneading compaction of the production mix been done similar to that of the gyratory compaction, i.e., immediately after sampling, it is very likely that the air void contents of the kneading compacted specimens would be lower than those recorded in this experiment. Because of differences in the compaction protocols (e.g., storage time, temperature and compactive effort) it would be somewhat imprudent to conclude that the two devices, kneading and gyratory, yield similar specimens in terms of air void content, particle orientation and/or strength. A much more comprehensive experiment that includes a strength and/or performance test would be required to quantify the differences between these Superpave and Hveem mixes as well as the attendant compaction devices. Still, data from this experiment suggest that there may be a gyratory compaction protocol that is equivalent to the current kneading compaction protocol as measured by air void content. Though time consuming and somewhat tedious, it is only by continuing to evaluate parallel mix designs (both in the lab and the field) that WSDOT can rationally assess the technical merit and cost-effectiveness of the Superpave technology. Furthermore, continued use of the gyratory to compact production mix at the project site is the logical approach to assess its suitability for QC/QA purposes.

3.5.3 Performance of Field Projects

As noted previously, Washington DOT has placed 44 projects which involve some component of the Superpave technology. For 18 of the projects (approximately 160 km) a conventional Hveem mix design was conducted using a PG binder (Hveem-PG). The remaining 26 projects (approximately 250 km) were truly Superpave, i.e., the materials selection and mix design were established in accordance with the Asphalt Institute's SP-2, Superpave Level 1 Mix Design. The field performance data for these projects, extracted from the WSPMS, may be found in Appendix E.

The descriptive statistics for the field projects are summarized in Table 3-21 and Figure 3-12. According to WSDOT practice the following numerical indices trigger maintenance: Pavement Structural Condition (PSC) ≤ 50; rutting ≥ 10 mm; or International Roughness Index (IRI) ≥ 500 cm/km. Considering the data in aggregate, all 44 projects are performing quite well. The average values of rutting, PSC and IRI (4, 91 and 121, respectively) are all well below the "trigger" values. As is evident from the data in Table 3-21 and Figure 3-12, Hveem-PG projects are performing comparably to the Superpave projects. Note that the average values of rutting, PSC and IRI for the Hveem-PG binder projects are 3, 93 and 103, respectively; and for the Superpave projects 4, 89 and 134, respectively. With respect to rutting and PSC, the performance is virtually identical. Note, however that the ride quality of the Superpave projects is a bit rougher than that the Hveem-PG binder projects: IRI of 134 for the former and 103 for the latter. Note also, that the ride quality of the Superpave projects, as measured by IRI is more variable. The coefficients of variation for the Superpave and Hveem-PG projects are 55% and 18%, respectively. The higher and

Table 3-21. Descriptive Statistics for Field Performance Data

		Condition Index		
		Rutting (mm)	PSC	IRI (cm/km)
All Projects (44)	minimum	1	38	66
	maximum	11	100	391
	mean	4	91	121
	SD	2	13	60
	CV (%)	62	14	49
Hveem-PG (18)	minimum	1	66	66
	maximum	10	100	135
	mean	3	93	103
	SD	2	8	19
	CV (%)	64	9	18
Superpave (26)	minimum	1	38	69
	maximum	11	100	391
	mean	4	89	134
	SD	2	15	74
	CV (%)	60	17	55

SD = standard deviation
CV = coefficient of variation

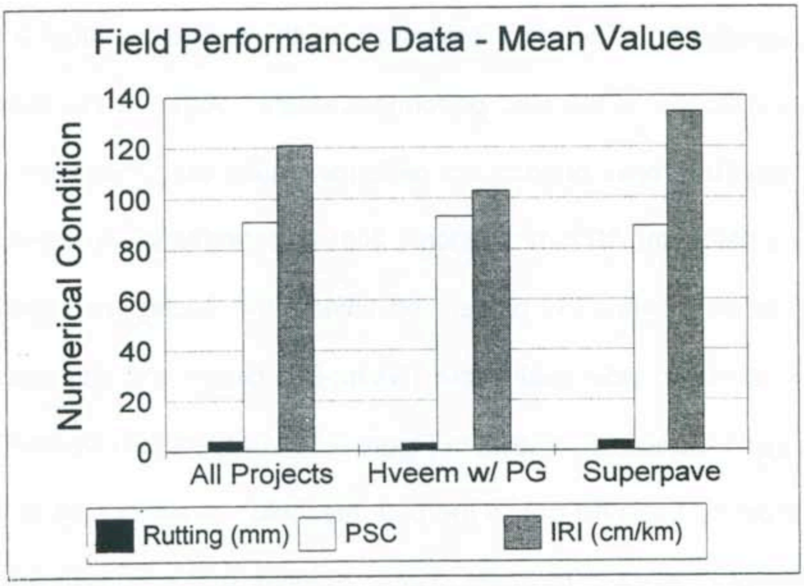


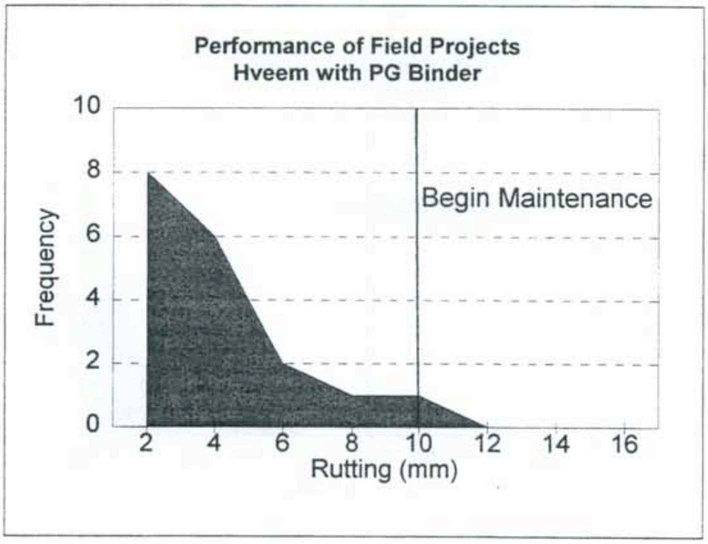
Figure 3-12. Mean Values of Rutting, PSC and IRI

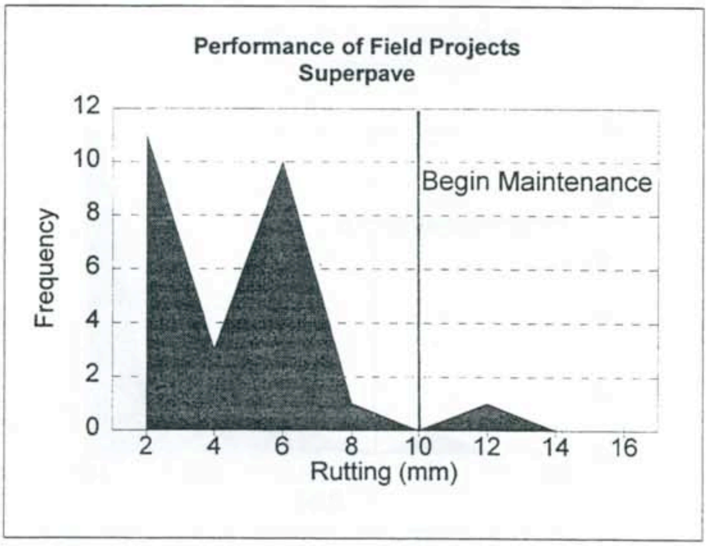
more variable IRI of the Superpave projects may be the result of the typically coarser aggregate gradation.

Shown in Figures 3-13, 3-14 and 3-15 are frequency distributions for rutting, PSC and IRI, respectively. The data presented in these figures allow a closer and more quantitative evaluation of the filed performance data. As shown in Figure 3-13, both the Hveem-PG and Superpave projects are performing quite well: measured rutting on 100% of the projects is below the 10 mm criterion. Similar performance is shown for PSC in Figure 3-14: 100% of the Hveem-PG binder and 96% of the Superpave projects exceed the 50 criterion. In terms of ride quality the Hveem-PG binder and Superpave projects show comparable performance. As shown in Figure 3-15, 100% of the Hveem-PG and 96% of the Superpave projects have IRI below the 500 threshold. A closer look at the data extracted from the WSPMS reveals, however, some isolated problems with longitudinal cracking (contract numbers 5544, 5606, 5645 and 5677) and flushing (contract number 5240).

3.6 Specific Gravity in Superpave (G_{sb} and G_{mm})

Since specific gravity (of aggregate and theoretical maximum of the mix) is a parameter used in the computation of key HMAC volumetric properties and WSDOT test methods were different from those included in Superpave, a small laboratory study was conducted to assess the effects on mix design. Currently, WSDOT test methods for bulk specific gravity of aggregate (G_{sb}) and theoretical maximum of mix (G_{mm}) are variations of AASHTO T85 and T209, respectively. For specific gravity of coarse aggregate WSDOT uses approximately 1000g of material from **one stockpile** that passes the 12.5 mm sieve and is retained on the 9.5. The Superpave procedure (AASHTO T85) requires a 3000 g sample of coarse aggregate, i.e., material that would be retained on the 4.75 mm sieve. Shown in Figures 3-16 and 3-17 are the results of the experiment.





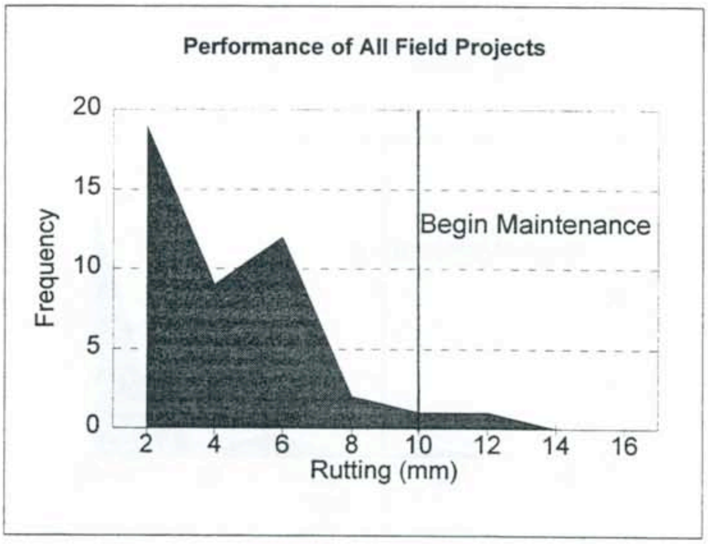


Figure 3-13. Frequency Distribution of Rutting

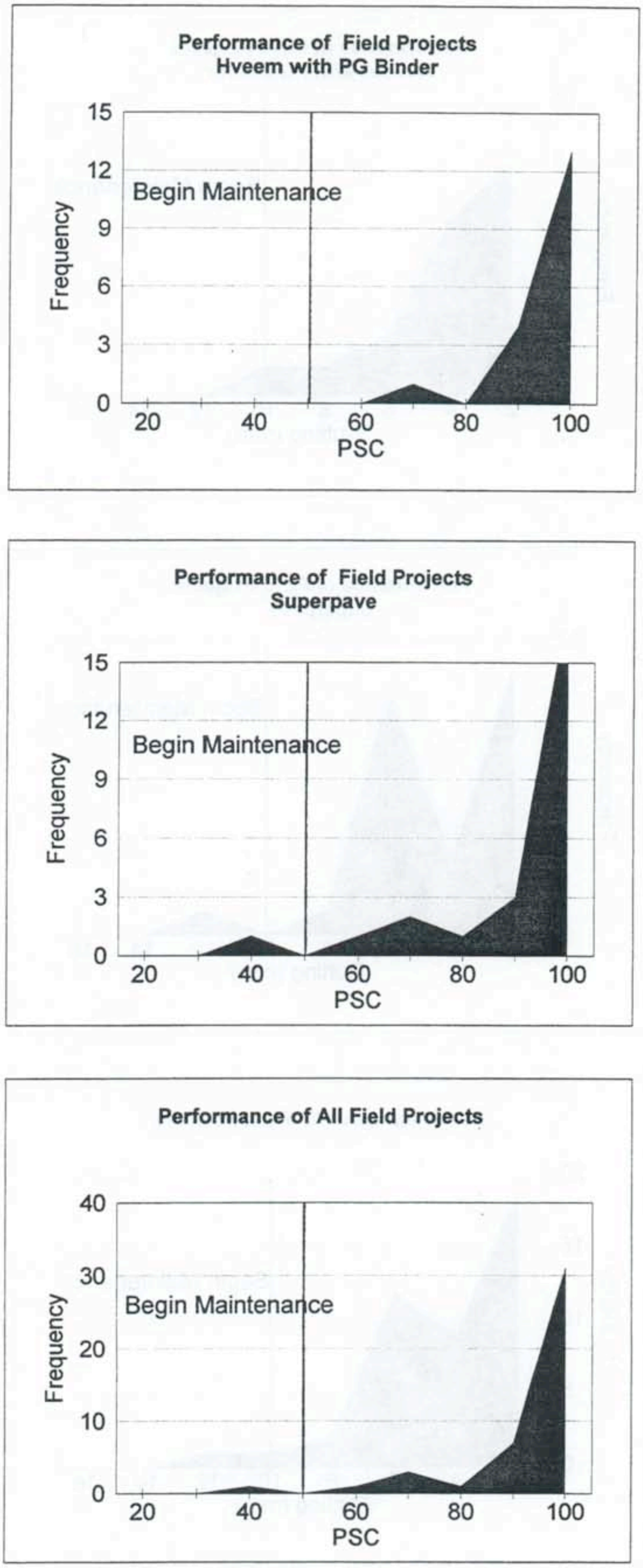
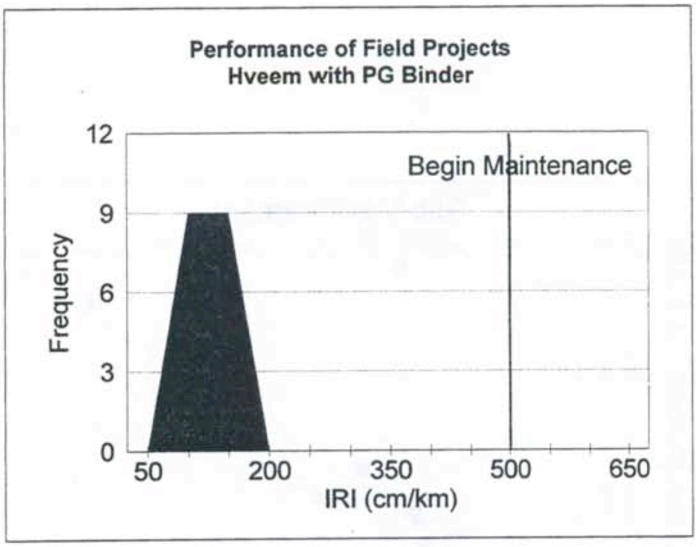
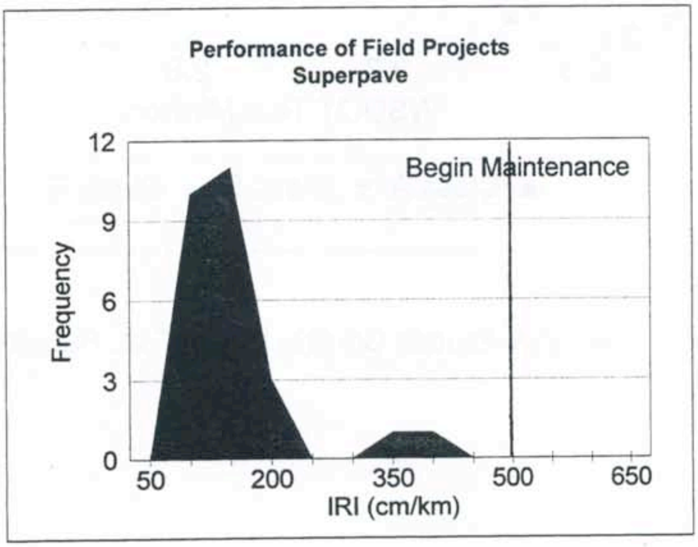


Figure 3-14. Frequency Distribution of Pavement Structural Condition





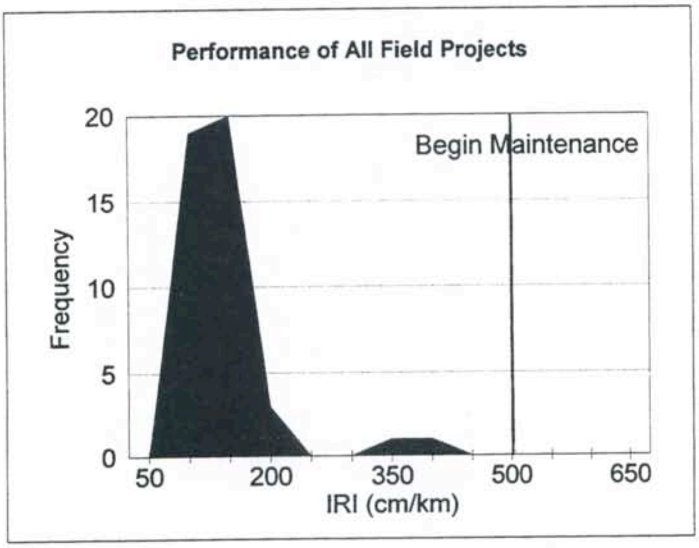


Figure 3-15. Frequency Distribution of International Roughness Index

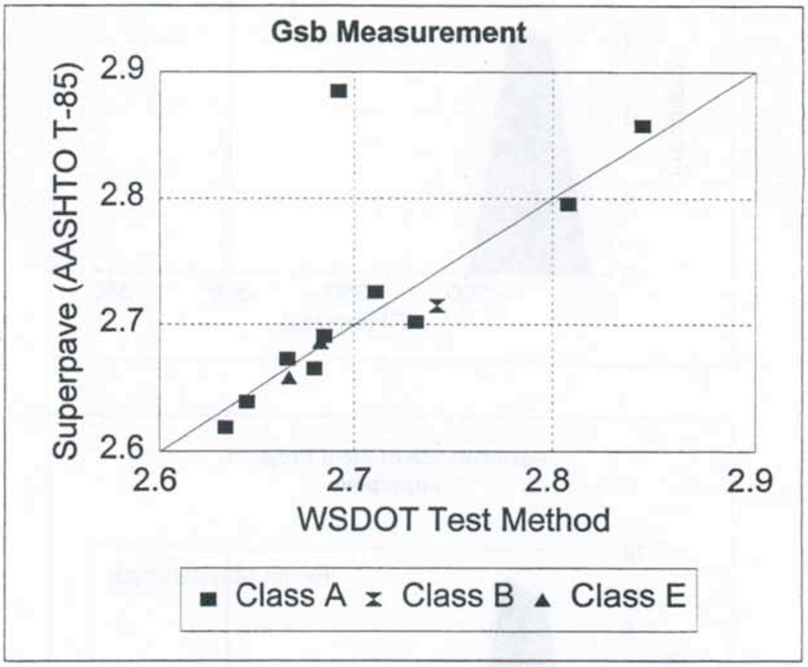
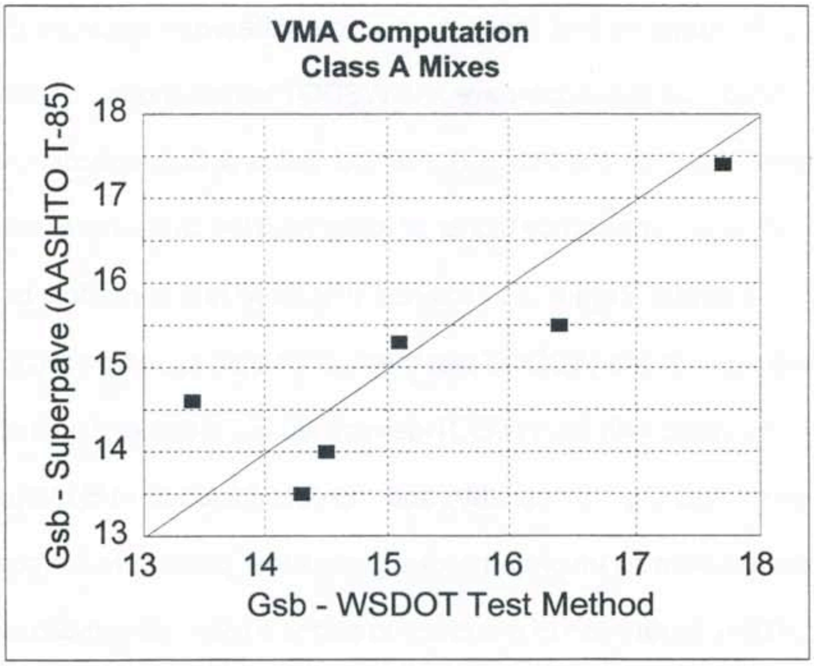


Figure 3-16. Bulk Specific Gravity - WSDOT vs. Superpave



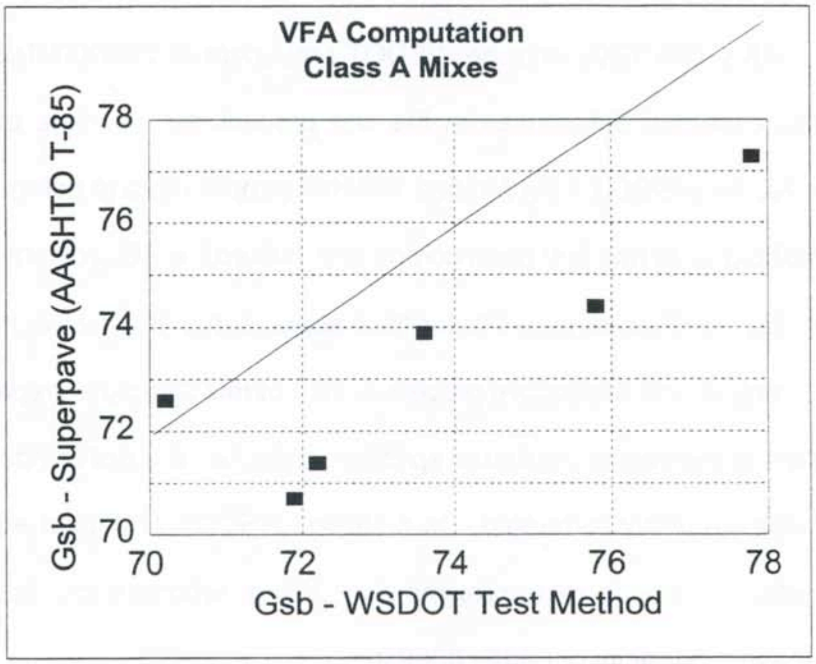


Figure 3-17. Volumetric Computations as a Function of Bulk Specific Gravity

Aggregates from 13 pits and 3 classes of mix (Class A, B and E) were included in the experiment. As shown in Figure 3-16, with only 1 exception (which appears to be an outlier) the results suggest that there is very little difference between the bulk specific gravities determined from the Superpave and WSDOT test methods. There is no consistent trend in the data, i.e., that the WSDOT method yields a bulk specific gravity of coarse aggregate (G_{sb}) that is consistently higher or lower than the Superpave method. However, the VMA and VFA data in Figure 3-17 indicate that there is a consistent trend (at least for the Class A mixes) with the WSDOT test method for bulk specific gravity. Generally the VMA and VFA calculated with the WSDOT-determined G_{sb} is higher than that computed with Superpave-determined G_{sb}. Since VMA and VFA are included in Superpave mix design criteria it seems prudent to employ the designated test procedure for coarse aggregate specific gravity (T85), regardless of mix class, to permit a rationale comparison of the Hveem and Superpave mix design approaches.

The Superpave procedure to determine theoretical maximum specific gravity (G_{mm}) is described in AASHTO T209 and the WSDOT procedure in WSDOT Test Method 705. There are two essential differences in the two procedures: sample preparation and pycnometer size. In WSDOT Test Method 705 the sample used to determine theoretical maximum specific gravity has first been compacted, bulked (i.e., G_{mb} determination), tested for Hveem stability and then reheated to facilitate separation of the hot mix into particles not larger than 6.5 mm. In the Superpave procedure the hot mix sample is prepared exclusively for determination of theoretical maximum specific gravity, i.e., it is not compacted, tested for strength and subsequently re-heated. In addition, WSDOT's method employs a glass pycnometer with a capacity of approximately 1300 g, whereas the Superpave metal pycnometers have a capacity of nearly 6000 g.

To quantify the effect of pycnometer size WSDOT gathered hot mix samples from several projects and determined theoretical maximum specific gravity of each. Shown in

Figure 3-18 are the results from contract 4250 with the AR4000W binder. Note that there is no consistent trend in the data. The means and standard deviations were virtually identical: average G_{mm} were 2.506 and 2.505 for the WSDOT (small pycnometer) and Superpave (large pycnometer), respectively. The standard deviation for both was 0.01. Shown in Figure 3-19 are results from contracts 4250 and 4201. These data include G_{mm} measurements on 3 binders and tend to confirm that the size of the pycnometer has very little effect on the G_{mm} determination.

To assess the other major difference between the WSDOT and Superpave methods for G_{mm} determination, i.e., reheating the hot mix sample, materials from contracts 4201 and 4250 were evaluated in two conditions: original – immediately after plant production; and reheated after nearly 4 months of ambient storage. As shown in Figure 3-20, G_{mm} measurements made on samples made in the headquarters laboratory indicate that there is virtually no difference between original and reheated samples. The results are within the 0.018 tolerance for single operator precision. However, the G_{mm} data generated from field samples shown in Figure 3-21 are much more variable. All exceed the acceptable tolerance except that from contract 4201 and reflect the inherent variability of plant mixing. Note also that the reheated samples yield consistently higher values for G_{mm}, likely the result of additional asphalt absorption that occurs with time and reheating.

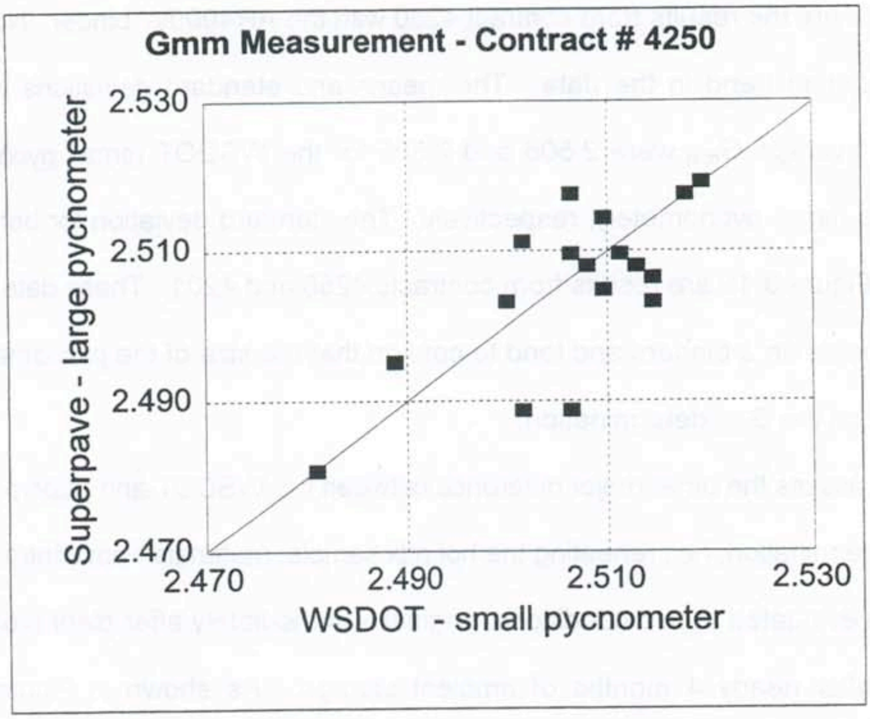


Figure 3-18. Theoretical Maximum Specific Gravity for Contract 4250 - WSDOT vs Superpave

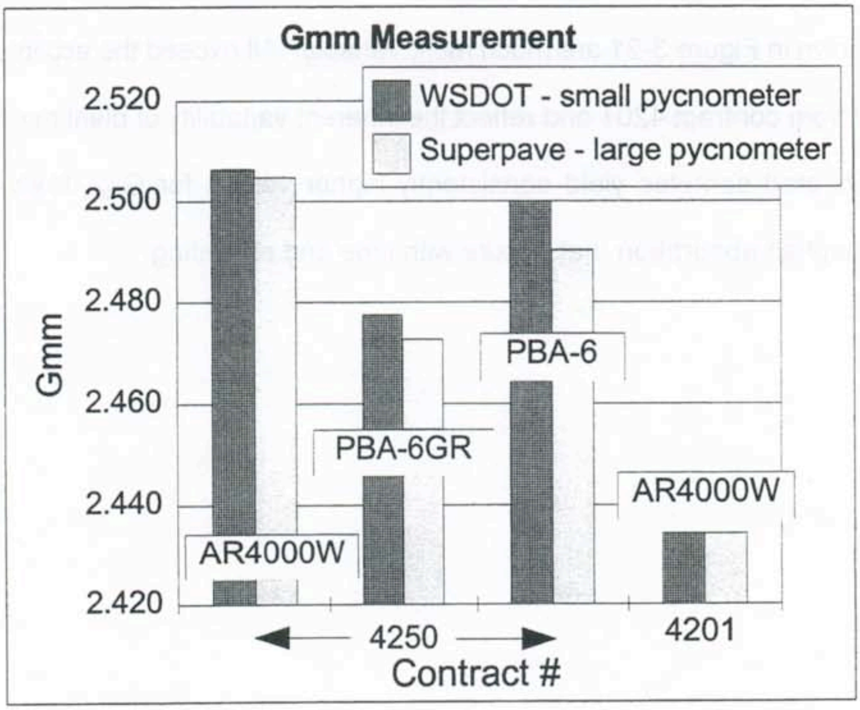


Figure 3-19. Theoretical Maximum Specific Gravity for Contracts 4201 and 4250 - WSDOT vs Superpave

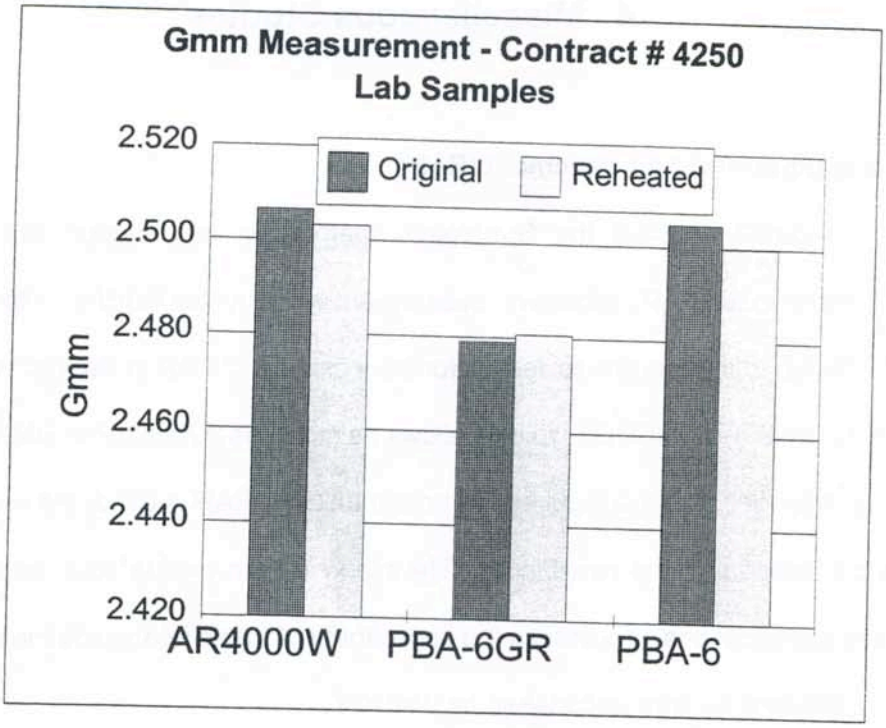


Figure 3-20. Effect of Reheating on Theoretical Maximum Specific Gravity - Lab Samples

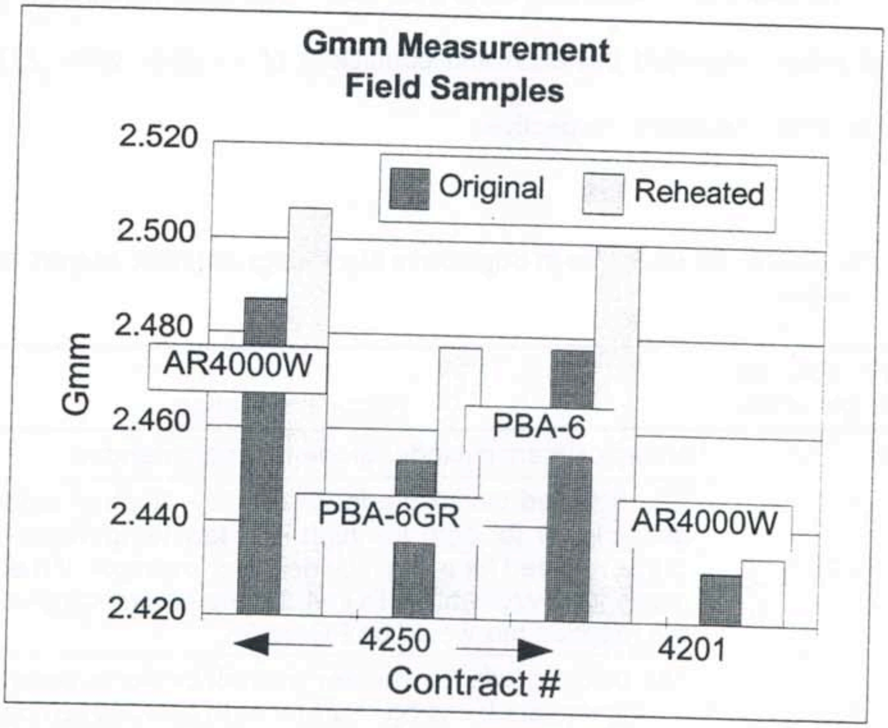


Figure 3-21. Effect of Reheating on Theoretical Maximum Specific Gravity - Field Samples

4. Miscellaneous Studies

4.1 Reclaimed Asphalt Pavement (RAP)

As originally drafted the Superpave method of mix design did not contain recommendations for RAP. However, subsequent work by the FHWA's Mix Expert Task Group (ETG) led to the current guidelines for the inclusion of RAP in Superpave mix design as shown in Table 4-1. WSDOT typically allows as much as 20% RAP in HMA for which no adjustment of binder grade is required. If more than 20% RAP is used, the recovered RAP binder is combined with the new binder. The blend is then evaluated in accordance with appropriate specifications. To assess the applicability of these new guidelines to its current practice limited testing was undertaken by WSDOT.

WSDOT began by sampling RAP from several projects. From the RAP the binder was extracted, recovered, and tested for absolute viscosity. As expected, the results shown in Figure 4-1 indicate that binders recovered from RAP have quite variable properties: the approximate mean, standard deviation and coefficient of variation were 23,000 Poise, 11,000 Poise, and 48 percent, respectively.

Table 4-1. Guidelines for RAP Use in Superpave Mix Design (FHWA, March 1997, NCAT, 1996)

Percent of RAP by Total Weight of Mix	Recommendation
≤ 15% RAP	No adjustment in binder grade is recommended.
16% to 25%	The selected binder grade for the new asphalt binder is one grade lower for both the high and low temperature than the grade required for a virgin binder. For example, if the specified grade for a virgin mix is PG 64-22, the recommended binder in the recycled mix would be PG 58-28.
> 25%	The binder grade for the new asphalt binder is selected using an appropriate blending chart for high and low temperatures.

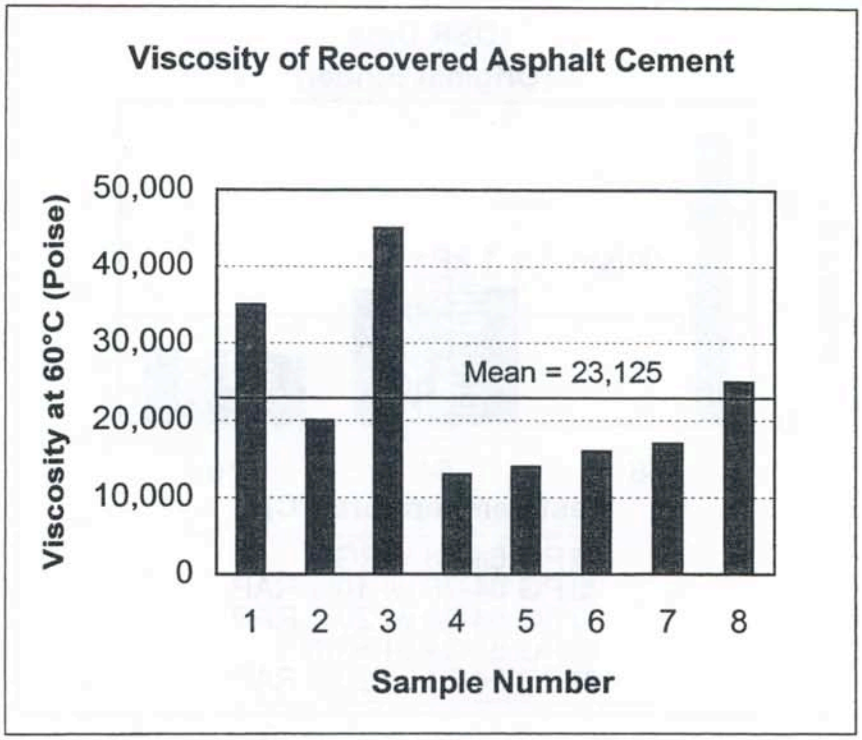


Figure 4-1. Viscosity of Binders Recovered from RAP

Additionally, WSDOT tested two commonly used PG binders (with and without binder recovered from RAP) in accordance with AASHTO PP6. The binders tested included the following: PG 64-28; PG 64-28 with 10% RAP; PG 64-28 with 20% RAP; PG 64-34; and PG 64-34 with 20% RAP. The results are shown in Figures 4-2 and 4-3.

Note from Figures 4-3a and 4-3b that all the original and RTFO aged binders met the minimum requirements at a test temperature of 64°C. From the BBR data shown in Figure 4-3a, only the PG 64-28 exceeds the maximum stiffness at any of the test temperatures (i.e., at -24°C). From the BBR data shown in Figure 4-3b, the PG 64-28 with 10% RAP and PG 64-28 with 20% RAP fail at -18°C, as does the PG 64-28 at -24°C. A summary of this limited testing may be clearly seen in Table 4-2. In view of the preceding test data WSDOT's current practice, i.e., no adjustment in binder if the RAP does not exceed 20%, seems appropriate.

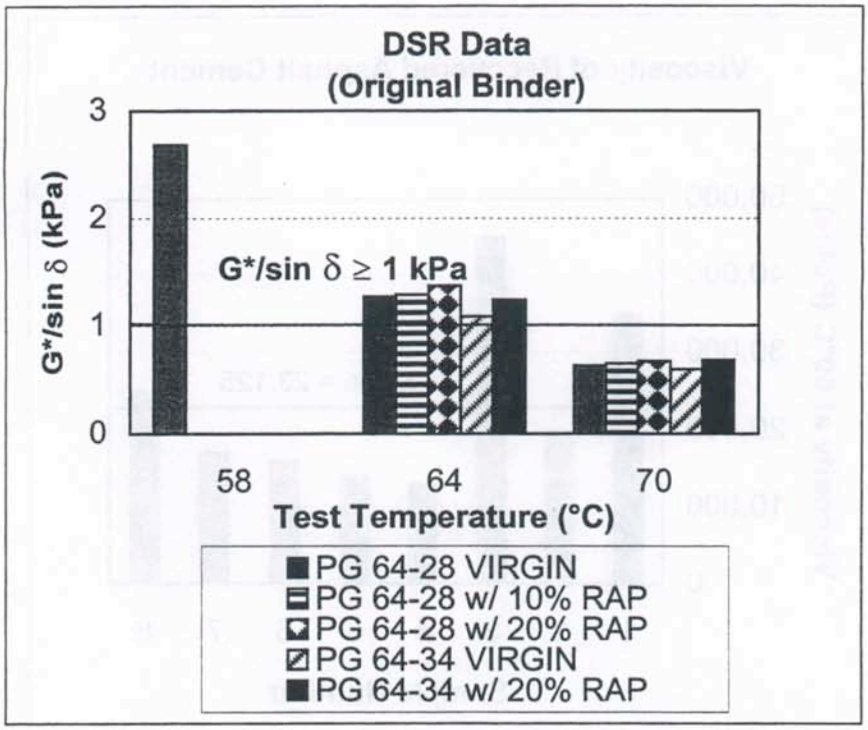


Figure 4-2a. DSR Data on Original Binders

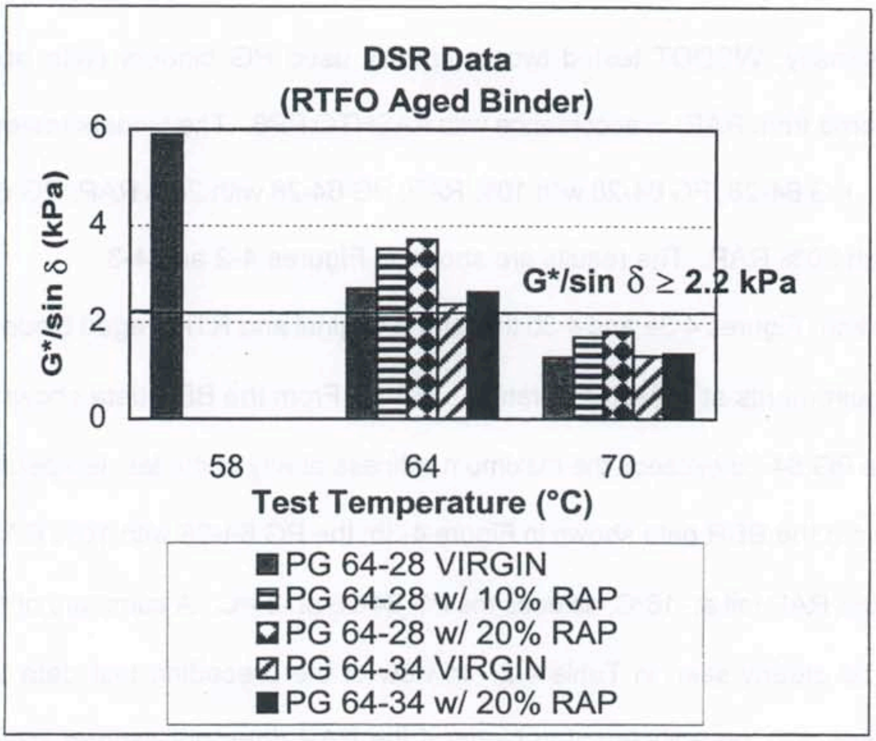


Figure 4-2b. DSR Data on RTFO Aged Binders

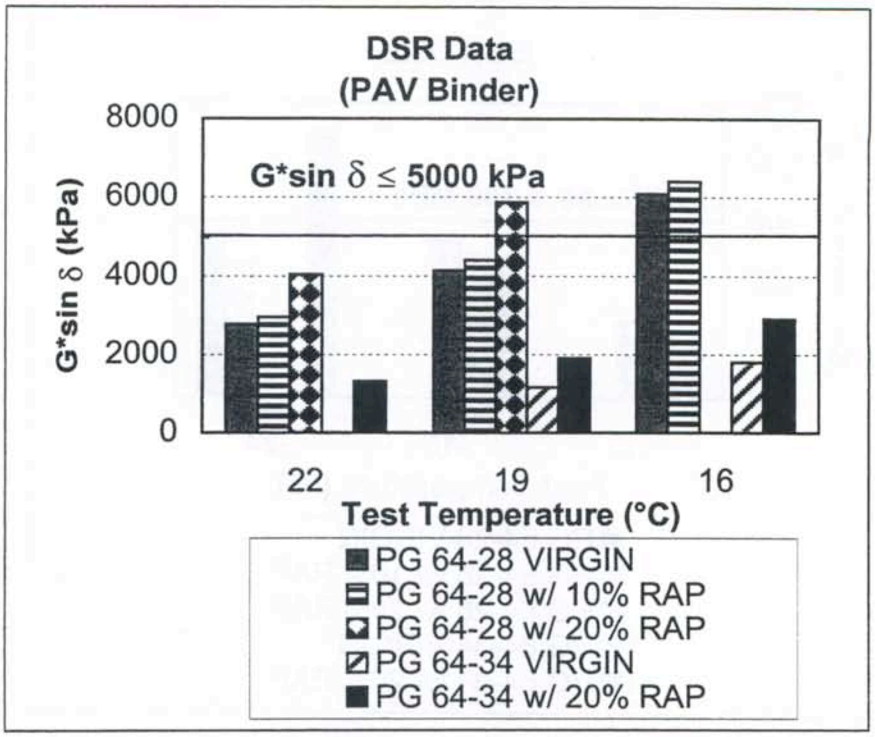


Figure 4-2c. DSR Data on PAV Conditioned Binders

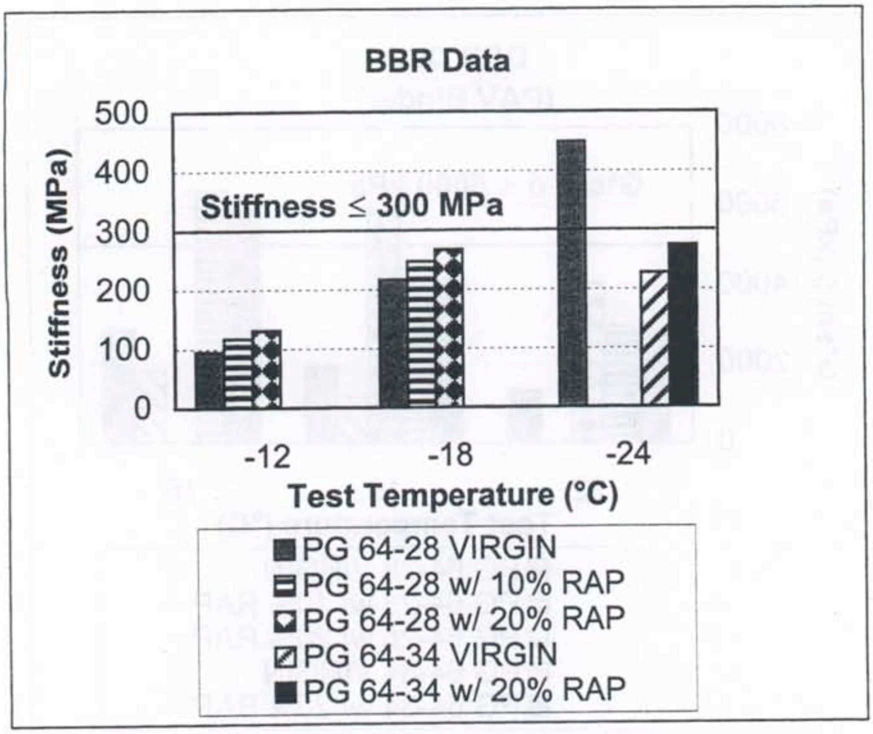


Figure 4-3a. BBR Data (Stiffness)

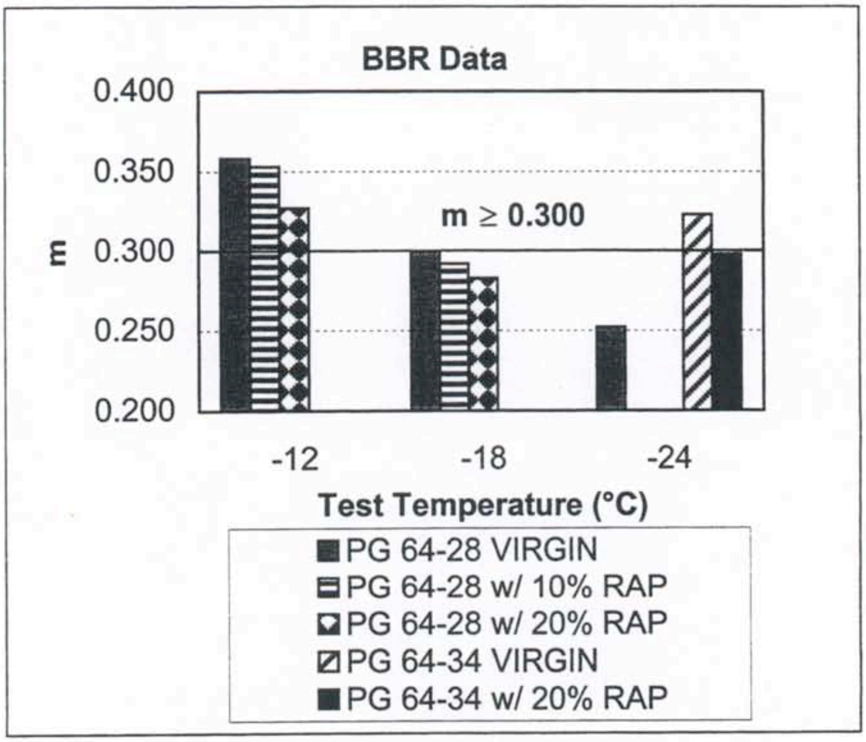


Figure 4-3b. BBR Data (m-value)

Table 4-2. Summary of Binder Testing

PG	Percent RAP	Meets PG
64-28	0	64-28
	10	64-22
	20	64-22
64-34	0	64-34
	20	64-28

4.2 Ignition Furnace

Though not a part of the Superpave technology NCAT's ignition method for the determination of asphalt content was introduced about the same time that the SHRP results emerged. Accordingly, it is included herein. Briefly, the asphalt cement in a sample of HMA is burned by ignition at approximately 538°C. The asphalt content is calculated from the mass of aggregate, with compensations for aggregate loss, moisture content and change in mass of the sample container. With the inevitable elimination of volatile solvents because of such issues as employee safety, material disposal and cost, the ignition method is very appealing. Furthermore, the time required for asphalt content determination is approximately the same as that needed for the traditional procedures (hot solvent with TCE; nuclear gauge with bio-degradable solvent).

Again, WSDOT began enthusiastically but cautiously by comparing asphalt content determinations from the ignition and nuclear gauge methods. The data from this limited testing are summarized in Table 4-3 and Figures 4-4 to 4-6.

The data shown in Figure 4-4 and 4-6 indicate that the nuclear gauge typically yields a higher value for asphalt content than does the ignition furnace. However, the results for the P200 determination (Figure 4-5) are not consistent and are much more variable. The data included in Table 4-3 represent WSDOT's initial trials with the ignition furnace and

Table 4-3. Summary Data on Asphalt Content and P200

		Ignition Furnace			Nuclear Gauge			Field		
		mean	SD	CV (%)	mean	SD	CV (%)	mean	SD	CV (%)
Asphalt Content (%)	Pit V-35	5.6	0.29	5.3	5.8	0.17	2.9			
	Pit Z-157	5.0	0.27	5.4	5.6	0.22	4.0	5.4	0.18	3.4
P200 (%)	Pit Z-157	4.9	0.71	14.3	4.8	0.76	15.8			

SD = standard deviation

CV = coefficient of variation

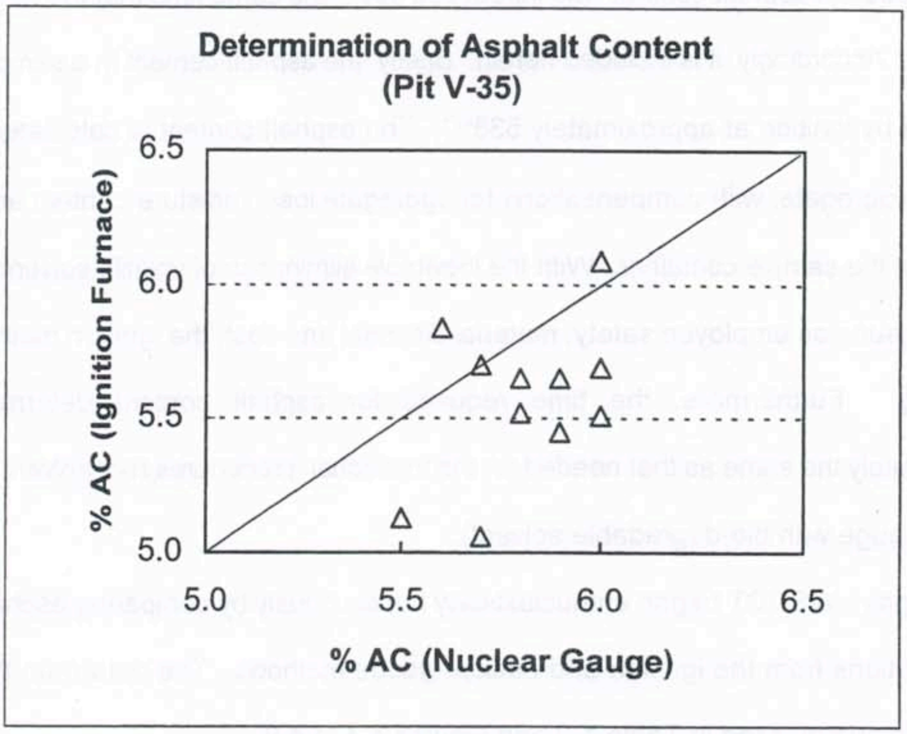


Figure 4-4. Asphalt Content Determination (Pit V-35)

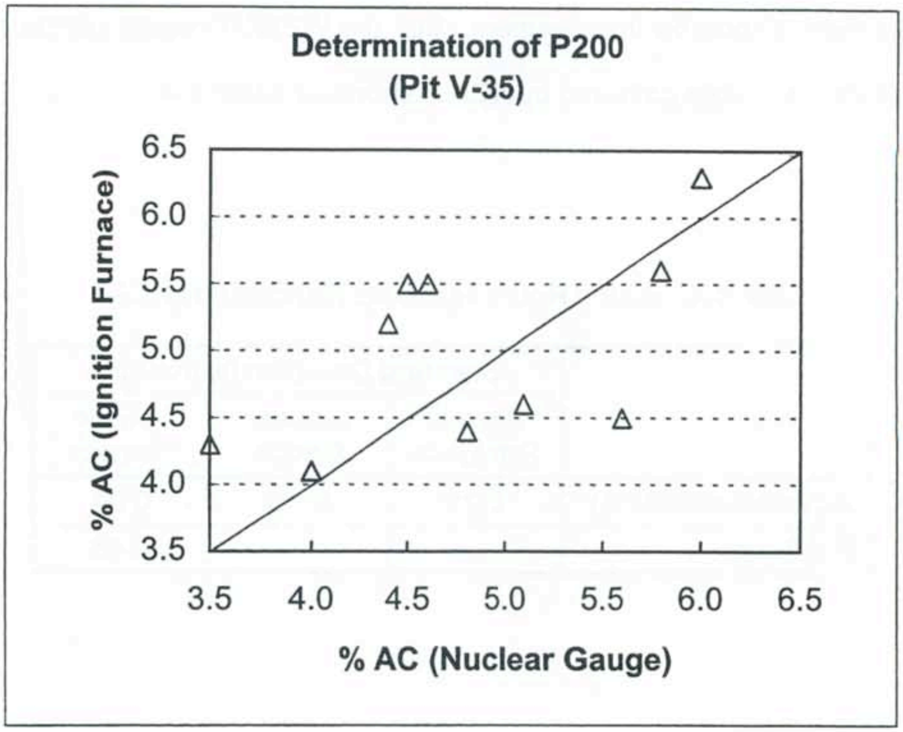


Figure 4-5. P200 Determination (Pit V-35)

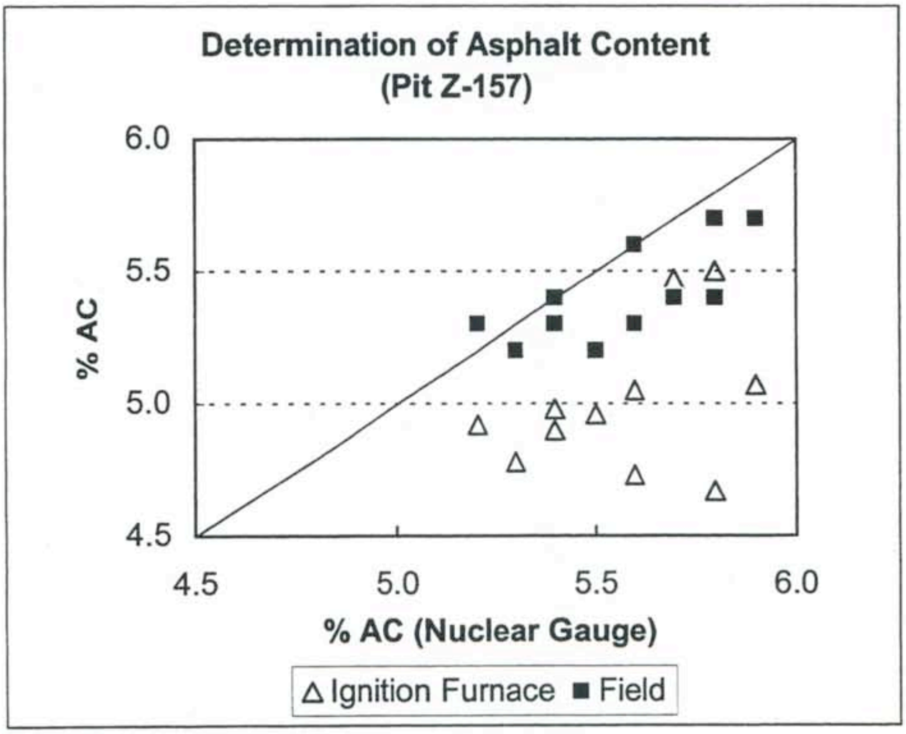


Figure 4-6. Asphalt Content Determination (Pit Z-157)

suggest that there is room for improvement. Still, the WSDOT results compare favorably to the *round robin* test data gathered by NCAT, shown in Table 4-4.

Table 4-4. Round Robin Test Data Reported by NCAT

	Standard Deviation (within lab)		
	Solvent Extraction	Nuclear Gauge	Ignition Furnace
Asphalt Content (%)	0.21	0.16	0.04
P200 (%)			0.48

5. Conclusions and Recommendations

As noted in previous chapters, WSDOT has experimented with selected components and concepts of the SHRP/Superpave technology to include the following: performance graded (PG) binder usage and specification validation; gyratory mix design; the Superpave Shear Test (SST); and field performance of Superpave mixes.

Noteworthy conclusions with respect to the SHRP/Superpave technology are as follows:

- Binders typically specified by WSDOT (AR4000W and PBA-2, -5, -6 and -6GR) were classified in terms of five Superpave performance grades: PG 58-22; 64-22, 64-28, 64-34; and 70-28.
- Although data from 171 weather stations suggest that as many as 6 low- and 5 high-temperature grades could be specified, binder availability and regional pavement distress were used to develop guidelines for state-wide PG usage. Three binders were recommended for use in the western, northeastern and southeastern regions of the state as follows: PG 58-22, PG 58-34 and PG 64-28, respectively.
- Validation of the binder specification with respect to low temperature cracking was accomplished using binder and field performance data from 28 projects. The results were very encouraging: The original SHRP algorithm for binder selection correctly "predicted" field performance in 22 of 28 cases, whereas the LTPP algorithm SHRP algorithm for binder selection correctly "predicted" field performance in 26 of 28 cases.
- A laboratory experiment using the Superpave Shear Test (SST) apparatus was undertaken to test the effectiveness of binder "bumping," i.e., increasing the high temperature grade because of exceptionally high traffic volume and/or slow or

standing traffic. The data clearly indicate that the SST is an effective tool for discriminating between binders and that "bumping" may be effective in reducing pavement rutting. Permanent shear strain for specimens made with a PG 70-xx binder was only 25 to 33% of the shear strain for specimens made with a PG 58-xx binder.

- With regard to aggregate consensus criteria, nearly 33% of all WSDOT mixes failed the coarse aggregate angularity criterion. WSDOT has since adjusted its requirements: specifying a minimum of 90% fractured faces for 19 mm (or smaller) mixes and 50% for larger mixes. Elsewhere, WSDOT has since adopted the following requirements for all mixes: a minimum 45% for fine aggregate angularity and 10% maximum for flat and elongated particles. WSDOT's minimum sand equivalent of 45% compares favorably to the Superpave criterion at all but the highest traffic level. For design ESALs which exceed 30 million the Superpave specifies a minimum sand equivalent of 50%. At this time WSDOT has no plans to change its requirements.
- As originally configured, the Superpave mix design matrix included seven traffic levels and four temperature regimes for 28 possible compaction levels. Recognizing that the 28 compaction levels made for a somewhat unwieldy system WSDOT attempted to reduce the number of compaction levels by conducting a series of mix designs at each compaction level. The results of the limited experiment suggest that it might be possible to limit the number of compaction levels required for mix design. Research by Brown et al. (NCHRP 9-9) tends to confirm this as they have suggested reducing the number of compaction levels and provided more definitive guidance with respect to each.
- Parallel Hveem and Superpave mix designs for 17 field projects yielded similar design asphalt contents. In 13 of 17 cases, the Superpave design asphalt

content was equal to or greater than the Hveem design asphalt content, though the difference was usually no more than 0.2%. In addition, data from these field projects indicate that the current kneading and gyratory compaction protocols (at least for 109 gyrations) yield similar air void contents.

- In 18 of the 44 field projects a conventional Hveem mix design was conducted using a PG binder (Hveem-PG). The remaining 26 projects were truly Superpave, i.e., the materials selection and mix design were established in accordance with the Asphalt Institute's SP-2, Superpave Level 1 Mix Design. Field performance, as measured by rutting, PSC and IRI, indicates that all the projects, though relatively "young" are performing quite well. With respect to rutting and PSC performance of the Hveem-PG and Superpave projects was virtually identical. For the Superpave projects a higher and more variable IRI was measured.
- A limited study of WSDOT's current practice concerning the inclusion of RAP indicates that no adjustment in binder grade is needed for mix design if the RAP does not exceed 20%.
- Although not part of the Superpave technology, the ignition method for the determination of asphalt content was introduced about the same time that the SHRP results emerged. The limited data suggests that the nuclear gauge typically yielded a higher value for asphalt content than did the ignition furnace. Results for P200 (i.e., 0.075 mm) were inconsistent and much more variable. Still, WSDOT's results compared favorably to round robin test data gathered by NCAT.

WSDOT's Superpave experience has not been without challenges. Still, its overall experience has been very positive. In view of the preceding the following recommendations are made:

- Currently, WSDOT test methods for bulk specific gravity of aggregate (G_{sb}) and theoretical maximum specific gravity (G_{mm}) differ slightly from those recommended in the Superpave protocol. Since computations for VMA and VFA are included in Superpave mix design criteria it seems prudent to employ the designated test procedure to permit a rationale comparison of the Hveem and Superpave mix design procedures.
- Continued experimentation with the revised compaction matrix and aggregate consensus properties outlined in Brown et al is encouraged.
- To help WSDOT make a critical assessment of Superpave's technical merit and economic viability consider the following:
  - ✓ more extensive use of the SST for mix design and analysis, performance prediction and forensic studies;
  - ✓ field validation of the "binder bumping" experiment;
  - ✓ development of a plan/protocol which incorporates the use of the Superpave gyratory compactor for field quality control; and
  - ✓ continued long-term monitoring of the performance of Superpave projects and thorough documentation of construction practices.

6. Acknowledgments

The authors wish to make the following acknowledgments: Washington DOT for funding; WSDOT materials and laboratory staff, Jim Walter, Joe DeVol and Rob Molohan; pavement management staff Linda Pierce, Kim Willoughby and Nadarajah Sivaneswaran; and research manager Keith Anderson for his Promethean patience!

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Appendix A - SHRP Algorithm

Number	Station ID	State	County/District	Station Name	50% HPG	50% LPG	98% HPG	98% LPG
1	450008	WA	GRAYS HARBOR	aberdeen	46	-10	52	-16
2	450013	WA	GRAYS HARBOR	aberdeen 20 nne	52	-10	58	-16
3	450176	WA	SKAGIT	anacortes	46	-10	52	-16
4	450184	WA	ASOTIN	anatone	52	-28	58	-34
5	450217	WA	KLICKITAT	appleton	52	-22	64	-34
6	450456	WA	KING	baring	52	-16	58	-22
7	450482	WA	CLARK	battle ground	52	-16	58	-22
8	450564	WA	WHATCOM	bellingham 2 n	46	-16	58	-22
9	450574	WA	WHATCOM	bellingham intl ap	46	-16	52	-22
10	450668	WA	KLICKITAT	bickleton 3 ese	52	-22	58	-28
11	450729	WA	WHATCOM	blaine	46	-16	52	-22
12	450844	WA	PEND OREILLE	boundary dam	52	-28	58	-34
13	450872	WA	KITSAP	bremerton navy yard	52	-10	58	-16
14	450945	WA	PIERCE	buckley 1 ne	52	-16	58	-22
15	450969	WA	YAKIMA	bumping lake	52	-28	58	-40
16	451160	WA	SKAMANIA	carson fish hatchery	52	-16	64	-28
17	451233	WA	KING	cedar lake	52	-16	58	-22
18	451276	WA	LEWIS	centralia	52	-10	58	-22
19	451350	WA	CHELAN	chelan	58	-16	64	-28
20	451395	WA	STEVENS	chewelah	58	-28	64	-40
21	451400	WA	DOUGLAS	chief joseph dam	58	-22	64	-28
22	451465	WA	CLALLAM	clallam bay 1 nne	40	-10	52	-16
23	451474	WA		clarkston heights	58	-22	64	-34
24	451504	WA	KITTITAS	cle elum	52	-28	64	-34
25	451484	WA	WHATCOM	clearbrook	52	-16	58	-22
26	451496	WA	JEFFERSON	clearwater	46	-10	52	-22
27	451586	WA	WHITMAN	colfax	58	-22	64	-34
28	451630	WA	STEVENS	colville	58	-28	64	-40
29	451650	WA	STEVENS	colville ap	58	-28	64	-34
30	451666	WA	OKANOGAN	conconully	52	-28	58	-34
31	451679	WA	SKAGIT	concrete ppl fish st	52	-10	58	-22
32	451760	WA	SKAMANIA	cougar 6 e	52	-10	58	-22
33	451767	WA	GRANT	coulee dam 1 sw	58	-22	64	-28

Number	Station ID	State	County/District	Station Name	50% HPG	50% LPG	98% HPG	98% LPG
34	451783	WA	ISLAND	coupeville 1 s	46	-10	52	-22
35	451934	WA	MASON	cushman dam	52	-10	58	-16
36	451939	WA	MASON	cushman powerhouse 2	52	-10	58	-16
37	451968	WA	KLICKITAT	dallesport fcwos ap	58	-16	64	-28
38	451992	WA	SNOHOMISH	darrington ranger st	52	-16	58	-28
39	452007	WA	LINCOLN	davenport	58	-28	64	-34
40	452030	WA	COLUMBIA	dayton 1 wsw	58	-22	64	-34
41	452157	WA	WHATCOM	diablo dam	52	-16	58	-22
42	452493	WA	PIERCE	electron headworks	52	-16	58	-22
43	452505	WA	KITTITAS	ellensburg	58	-28	64	-34
44	452508	WA		ellensburg bowers fi	58	-28	64	-40
45	452531	WA	GRAYS HARBOR	elma	52	-16	58	-22
46	452542	WA	FRANKLIN	eltopia 8 wsw	58	-22	64	-28
47	452548	WA	CLALLAM	elwha rs	52	-10	58	-16
48	452609	WA	GRANT	ephrata	58	-22	64	-28
49	452614	WA	GRANT	ephrata ap fcwos	58	-22	64	-34
50	452675	WA	SNOHOMISH	everett	46	-16	52	-22
51	452914	WA	CLALLAM	forks 1 e	52	-10	58	-16
52	453177	WA	LEWIS	glenoma 1 w	52	-10	58	-22
53	453184	WA	KLICKITAT	glenwood 2	52	-28	58	-34
54	453226	WA	KLICKITAT	goldendale	58	-22	64	-34
55	453284	WA	MASON	grapeview 3 sw	52	-10	58	-16
56	453320	WA	PACIFIC	grayland	46	-10	52	-16
57	453333	WA	PACIFIC	grays river hatchery	52	-10	58	-22
58	453357	WA	PIERCE	greenwater	52	-16	58	-22
59	453386	WA	KING	grotto	52	-16	58	-22
60	453515	WA	LINCOLN	harrington 1 nw	58	-28	64	-34
61	453529	WA	GRANT	hartline	58	-22	64	-34
62	453546	WA	ADAMS	hatton 9 se	58	-22	64	-34
63	453730	WA	CHELAN	holden village	52	-28	58	-34
64	453807	WA	GRAYS HARBOR	hoquiam ap	46	-10	52	-16
65	453883	WA	WALLA WALLA	ice harbor dam	58	-16	64	-28
66	453903	WA	FERRY	inchelium 2 nw	58	-28	64	-34

Number	Station ID	State	County/District	Station Name	50% HPG	50% LPG	98% HPG	98% LPG
67	454154	WA	BENTON	kennewick	58	-16	64	-28
68	454159	WA	BENTON	kennewick 10 sw	58	-22	64	-28
69	454169	WA	KING	kent	52	-16	58	-22
70	454201	WA	COWLITZ	kid valley	52	-16	58	-22
71	454338	WA	WHITMAN	la crosse 3 ese	58	-22	64	-34
72	454360	WA	PIERCE	la grande	52	-10	58	-22
73	454394	WA	KITTITAS	lake cle elum	52	-28	58	-34
74	454406	WA	KITTITAS	lake kachess	52	-22	58	-34
75	454414	WA	KITTITAS	lake keechelus	52	-22	58	-34
76	454486	WA	KING	landsburg	52	-16	58	-22
77	454549	WA	FERRY	laurier	58	-28	64	-40
78	454572	WA	CHELAN	leavenworth 3 s	58	-28	64	-34
79	454679	WA	ADAMS	lind 3 ne	58	-22	64	-34
80	454748	WA	PACIFIC	long beach exp stn	46	-10	52	-16
81	454764	WA	PIERCE	longmire rainier nps	52	-16	58	-28
82	454769	WA	COWLITZ	longview	52	-10	58	-22
83	455133	WA	OKANOGAN	mazama	52	-28	64	-40
84	455224	WA	PIERCE	mc millin reservoir	52	-16	58	-22
85	455231	WA	BENTON	mcnary dam	58	-16	64	-28
86	455317	WA	PEND OREILLE	metaline falls	52	-28	58	-34
87	455326	WA	OKANOGAN	methow 2 s	58	-28	64	-34
88	455525	WA	SNOHOMISH	monroe	52	-16	58	-22
89	455613	WA	GRANT	moses lake devel fm	58	-22	64	-34
90	455659	WA	KLICKITAT	mount adams rs	58	-22	64	-28
91	455678	WA	SKAGIT	mount vernon 3 wnw	46	-16	58	-22
92	455688	WA	YAKIMA	moxee city 10 e	58	-22	64	-28
93	455704	WA	KING	mud mountain dam	52	-16	58	-22
94	455832	WA	OKANOGAN	nespelem 2 s	58	-28	64	-40
95	455840	WA	WHATCOM	newhalem	52	-16	58	-22
96	455844	WA	PEND OREILLE	newport	58	-28	64	-40
97	455946	WA	STEVENS	northport	58	-22	64	-34
98	456011	WA	GRAYS HARBOR	oakville	52	-16	58	-22
99	456039	WA	LINCOLN	odessa	58	-28	64	-34

Appendix A - SHRP Algorithm

Number	Station ID	State	County/District	Station Name	50% HPG	50% LPG	98% HPG	98% LPG
100	456096	WA	SAN JUAN	olga 2 se	46	-10	52	-22
101	456114	WA	THURSTON	olympia ap	52	-16	58	-22
102	456123	WA	OKANOGAN	omak 4 n	58	-22	64	-34
103	456215	WA	ADAMS	othello 5 e	58	-22	64	-34
104	456262	WA	LEWIS	packwood	52	-16	64	-22
105	456295	WA	KING	palmer 3 ese	52	-16	58	-22
106	456534	WA	CHELAN	plain	52	-28	64	-34
107	456553	WA	WALLA WALLA	pleasant view	58	-22	64	-34
108	456584	WA	GRAYS HARBOR	point grenville	40	-10	46	-16
109	456610	WA	GARFIELD	pomeroy	58	-28	64	-34
110	456624	WA	CLALLAM	port angeles	46	-10	52	-16
111	456678	WA	JEFFERSON	port townsend	46	-10	52	-16
112	456747	WA	GRANT	priest rapids dam	58	-16	64	-28
113	456768	WA	BENTON	prosser 4 ne	58	-22	64	-28
114	456789	WA	WHITMAN	pullman 2 nw	52	-22	64	-34
115	456803	WA	PIERCE	puyallup 2 w exp stn	52	-16	58	-22
116	456846	WA	JEFFERSON	quilcene 2 sw	52	-10	58	-22
117	456858	WA	CLALLAM	quillayute ap	46	-10	52	-16
118	456864	WA	GRAYS HARBOR	quinault rs	52	-10	58	-16
119	456880	WA	GRANT	quincy 3 s	58	-22	64	-34
120	456898	WA	PIERCE	rainier paradise rng	46	-22	52	-28
121	456914	WA	PACIFIC	raymond 2 s	46	-16	58	-22
122	456974	WA	FERRY	republic	52	-28	58	-40
123	457015	WA	BENTON	richland	58	-22	64	-28
124	457038	WA	YAKIMA	rimrock tieton dam	52	-22	58	-34
125	457059	WA	ADAMS	ritzville 1 sse	58	-22	64	-34
126	457180	WA	WHITMAN	rosalia	52	-22	64	-34
127	457185	WA	WHATCOM	ross dam	52	-16	58	-22
128	457267	WA	WHITMAN	saint john	58	-22	64	-34
129	457342	WA	KLICKITAT	satus pass 2 ssw	52	-22	64	-34
130	457488	WA	KING	seattle city office	52	-10	58	-16
131	457459	WA	KING	seattle jackson park	52	-16	58	-22
132	457458	WA	KING	seattle portage bay	52	-10	58	-16

Number	Station ID	State	County/District	Station Name	50% HPG	50% LPG	98% HPG	98% LPG
133	457478	WA	KING	seattle univ of wash	52	-10	58	-16
134	457473	WA	KING	seattle-tacoma ap	52	-10	58	-16
135	457507	WA	SKAGIT	sedro woolley	46	-16	58	-22
136	457538	WA	CLALLAM	sequim	46	-10	52	-16
137	457544	WA	CLALLAM	sequim 2 e	46	-16	52	-22
138	457584	WA	MASON	shelton	52	-10	58	-16
139	457696	WA	SKAMANIA	skamania fish hatche	52	-16	64	-22
140	457727	WA	GRANT	smyrna	58	-22	64	-34
141	457773	WA	KING	snoqualmie falls	52	-16	58	-22
142	457781	WA	KING	snoqualmie pass	52	-22	58	-28
143	457938	WA	SPOKANE	spokane intl arpt	58	-22	64	-34
144	457956	WA	LINCOLN	sprague	58	-22	64	-34
145	458009	WA	KITTITAS	stampede pass	46	-22	52	-28
146	458034	WA	SNOHOMISH	startup 1 e	52	-16	58	-22
147	458059	WA	CHELAN	stehekin 4 nw	52	-22	64	-28
148	458089	WA	KING	stevens pass	46	-22	52	-28
149	458207	WA	YAKIMA	sunnyside	58	-22	64	-28
150	458278	WA	PIERCE	tacoma 1	52	-10	58	-16
151	458286	WA	PIERCE	tacoma city hall	52	-10	58	-16
152	458332	WA	CLALLAM	tatoosh island	40	-10	46	-10
153	458500	WA	LEWIS	toledo-winlock muni	52	-16	58	-22
154	458579	WA		trinidad 2 sse	58	-22	64	-28
155	458715	WA	WHATCOM	upper baker dam	52	-16	58	-22
156	458773	WA	CLARK	vancouver 4 nne	52	-16	58	-22
157	458926	WA		walla walla 3 w	58	-22	64	-34
158	458928	WA	WALLA WALLA	walla walla city-cou	58	-22	64	-28
159	458931	WA	WALLA WALLA	walla walla wso	58	-16	64	-28
160	458959	WA	YAKIMA	wapato	58	-22	64	-28
161	459012	WA	DOUGLAS	waterville	52	-22	64	-34
162	459058	WA	STEVENS	wellpinit	58	-22	64	-34
163	459074	WA	CHELAN	wenatchee	58	-22	64	-28
164	459079	WA	CHELAN	wenatchee exp stn	58	-22	64	-34
165	459082	WA	CHELAN	wenatchee pangborn	58	-22	64	-28

Appendix A - SHRP Algorithm

Number	Station ID	State	County/District	Station Name	50% HPG	50% LPG	98% HPG	98% LPG
166	459200	WA	WALLA WALLA	whitman mission	58	-22	64	-34
167	459238	WA	LINCOLN	wilbur	58	-28	64	-34
168	459291	WA	PACIFIC	willapa harbor	52	-10	58	-16
169	459342	WA	SKAMANIA	wind river	52	-16	64	-28
170	459376	WA	OKANOGAN	winthrop 1 wsw	58	-28	64	-40
171	459465	WA	YAKIMA	yakima air terminal	58	-22	64	-34

Appendix A - LTPP Algorithm

Number	Station ID	Stat	County/District	Station Name	50% HPG	50% LPG	98% HPG	98% LPG
1	450008	WA	GRAYS HARBOR	aberdeen	46	-10	52	-16
2	450013	WA	GRAYS HARBOR	aberdeen 20 nne	46	-10	58	-16
3	450176	WA	SKAGIT	anacortes	46	-10	52	-16
4	450184	WA	ASOTIN	anatone	52	-22	58	-34
5	450217	WA	KLICKITAT	appleton	52	-16	58	-28
6	450456	WA	KING	baring	52	-16	58	-22
7	450482	WA	CLARK	battle ground	52	-10	58	-22
8	450564	WA	WHATCOM	bellingham 2 n	46	-16	58	-22
9	450574	WA	WHATCOM	bellingham intl ap	46	-16	52	-22
10	450668	WA	KLICKITAT	bickleton 3 ese	52	-16	58	-28
11	450729	WA	WHATCOM	blaine	46	-16	52	-22
12	450844	WA	PEND OREILLE	boundary dam	52	-22	58	-28
13	450872	WA	KITSAP	bremerton navy yard	52	-10	58	-16
14	450945	WA	PIERCE	buckley 1 ne	52	-10	58	-22
15	450969	WA	YAKIMA	bumping lake	52	-22	58	-34
16	451160	WA	SKAMANIA	carson fish hatchery	52	-16	58	-22
17	451233	WA	KING	cedar lake	46	-16	58	-22
18	451276	WA	LEWIS	centralia	52	-10	58	-16
19	451350	WA	CHELAN	chelan	52	-16	58	-22
20	451395	WA	STEVENS	chewelah	52	-22	64	-34
21	451400	WA	DOUGLAS	chief joseph dam	58	-16	64	-28
22	451465	WA	CLALLAM	clallam bay 1 nne	46	-10	52	-16
23	451474	WA		clarkston heights	58	-16	64	-28
24	451504	WA	KITTITAS	cle elum	52	-22	58	-28
25	451484	WA	WHATCOM	clearbrook	52	-16	58	-22
26	451496	WA	JEFFERSON	clearwater	46	-10	52	-16
27	451586	WA	WHITMAN	colfax	52	-22	58	-28
28	451630	WA	STEVENS	colville	52	-22	58	-34
29	451650	WA	STEVENS	colville ap	52	-22	58	-34
30	451666	WA	OKANOGAN	conconully	52	-22	58	-34

Number	Station ID	Stat	County/District	Station Name	50% HPG	50% LPG	98% HPG	98% LPG
31	451679	WA	SKAGIT	concrete ppl fish st	52	-10	58	-22
32	451760	WA	SKAMANIA	cougar 6 e	52	-10	58	-16
33	451767	WA	GRANT	coulee dam 1 sw	52	-16	64	-28
34	451783	WA	ISLAND	coupeville 1 s	46	-10	52	-16
35	451934	WA	MASON	cushman dam	52	-10	58	-16
36	451939	WA	MASON	cushman powerhouse 2	52	-10	58	-16
37	451968	WA	KLICKITAT	dallesport fcwos ap	58	-16	64	-22
38	451992	WA	SNOHOMISH	darrington ranger st	52	-16	58	-22
39	452007	WA	LINCOLN	davenport	52	-22	58	-34
40	452030	WA	COLUMBIA	dayton 1 wsw	52	-16	64	-28
41	452157	WA	WHATCOM	diablo dam	52	-16	58	-22
42	452493	WA	PIERCE	electron headworks	52	-16	58	-22
43	452505	WA	KITTITAS	ellensburg	52	-22	58	-28
44	452508	WA		ellensburg bowers fi	52	-22	58	-34
45	452531	WA	GRAYS HARBOR	elma	52	-10	58	-16
46	452542	WA	FRANKLIN	eltopia 8 wsw	52	-16	58	-28
47	452548	WA	CLALLAM	elwha rs	46	-10	58	-16
48	452609	WA	GRANT	ephrata	58	-16	64	-28
49	452614	WA	GRANT	ephrata ap fcwos	58	-22	64	-28
50	452675	WA	SNOHOMISH	everett	46	-10	52	-22
51	452914	WA	CLALLAM	forks 1 e	46	-10	58	-16
52	453177	WA	LEWIS	glenoma 1 w	52	-10	58	-16
53	453184	WA	KLICKITAT	glenwood 2	52	-22	58	-28
54	453226	WA	KLICKITAT	goldendale	52	-16	64	-28
55	453284	WA	MASON	grapeview 3 sw	52	-10	58	-16
56	453320	WA	PACIFIC	grayland	46	-10	52	-16
57	453333	WA	PACIFIC	grays river hatchery	52	-10	58	-16
58	453357	WA	PIERCE	greenwater	46	-16	58	-22
59	453386	WA	KING	grotto	52	-10	58	-22
60	453515	WA	LINCOLN	harrington 1 nw	52	-22	58	-28

Number	Station ID	Stat	County/District	Station Name	50% HPG	50% LPG	98% HPG	98% LPG
61	453529	WA	GRANT	hartline	52	-22	64	-28
62	453546	WA	ADAMS	hatton 9 se	58	-22	64	-28
63	453730	WA	CHELAN	holden village	52	-22	58	-28
64	453807	WA	GRAYS HARBOR	hoquiam ap	46	-10	52	-16
65	453883	WA	WALLA WALLA	ice harbor dam	58	-16	64	-22
66	453903	WA	FERRY	inchelium 2 nw	52	-22	58	-28
67	454154	WA	BENTON	kennewick	58	-16	64	-22
68	454159	WA	BENTON	kennewick 10 sw	58	-16	64	-28
69	454169	WA	KING	kent	52	-10	58	-22
70	454201	WA	COWLITZ	kid valley	52	-16	58	-22
71	454338	WA	WHITMAN	la crosse 3 ese	58	-22	64	-34
72	454360	WA	PIERCE	la grande	52	-10	58	-16
73	454394	WA	KITTITAS	lake cle elum	52	-22	58	-34
74	454406	WA	KITTITAS	lake kachess	52	-22	58	-28
75	454414	WA	KITTITAS	lake keechelus	52	-22	58	-28
76	454486	WA	KING	landsburg	52	-10	58	-22
77	454549	WA	FERRY	laurier	52	-22	58	-34
78	454572	WA	CHELAN	leavenworth 3 s	58	-22	64	-28
79	454679	WA	ADAMS	lind 3 ne	58	-22	64	-28
80	454748	WA	PACIFIC	long beach exp stn	46	-10	52	-16
81	454764	WA	PIERCE	longmire rainier nps	52	-16	58	-22
82	454769	WA	COWLITZ	longview	52	-10	58	-16
83	455133	WA	OKANOGAN	mazama	52	-22	58	-34
84	455224	WA	PIERCE	mc millin reservoir	52	-16	58	-22
85	455231	WA	BENTON	mcnary dam	58	-16	64	-22
86	455317	WA	PEND OREILLE	metaline falls	52	-22	58	-34
87	455326	WA	OKANOGAN	methow 2 s	58	-22	64	-28
88	455525	WA	SNOHOMISH	monroe	52	-16	58	-22
89	455613	WA	GRANT	moses lake devel fm	52	-22	64	-28
90	455659	WA	KLICKITAT	mount adams rs	52	-16	58	-28

Number	Station ID	Stat	County/District	Station Name	50% HPG	50% LPG	98% HPG	98% LPG
91	455678	WA	SKAGIT	mount vernon 3 wnw	46	-16	52	-22
92	455688	WA	YAKIMA	moxee city 10 e	52	-16	58	-28
93	455704	WA	KING	mud mountain dam	52	-10	58	-22
94	455832	WA	OKANOGAN	nespelem 2 s	52	-22	64	-34
95	455840	WA	WHATCOM	newhalem	52	-16	58	-22
96	455844	WA	PEND OREILLE	newport	52	-22	58	-34
97	455946	WA	STEVENS	northport	52	-22	64	-28
98	456011	WA	GRAYS HARBOR	oakville	52	-10	58	-22
99	456039	WA	LINCOLN	odessa	58	-22	64	-28
100	456096	WA	SAN JUAN	olga 2 se	46	-10	52	-22
101	456114	WA	THURSTON	olympia ap	52	-16	58	-22
102	456123	WA	OKANOGAN	omak 4 n	52	-22	64	-28
103	456215	WA	ADAMS	othello 5 e	58	-16	64	-28
104	456262	WA	LEWIS	packwood	52	-16	58	-22
105	456295	WA	KING	palmer 3 ese	52	-10	58	-22
106	456534	WA	CHELAN	plain	52	-22	58	-28
107	456553	WA	WALLA WALLA	pleasant view	58	-16	64	-28
108	456584	WA	GRAYS HARBOR	point grenville	40	-10	46	-16
109	456610	WA	GARFIELD	pomeroy	52	-22	64	-28
110	456624	WA	CLALLAM	port angeles	46	-10	52	-16
111	456678	WA	JEFFERSON	port townsend	46	-10	52	-16
112	456747	WA	GRANT	priest rapids dam	58	-16	64	-22
113	456768	WA	BENTON	prosser 4 ne	58	-16	64	-28
114	456789	WA	WHITMAN	pullman 2 nw	52	-22	58	-28
115	456803	WA	PIERCE	puyallup 2 w exp stn	52	-10	58	-22
116	456846	WA	JEFFERSON	quilcene 2 sw	52	-10	58	-16
117	456858	WA	CLALLAM	quillayute ap	46	-10	52	-16
118	456864	WA	GRAYS HARBOR	quinault rs	52	-10	58	-16
119	456880	WA	GRANT	quincy 3 s	52	-22	64	-28
120	456898	WA	PIERCE	rainier paradise rng	46	-16	52	-28

Number	Station ID	Stat	County/District	Station Name	50% HPG	50% LPG	98% HPG	98% LPG
121	456914	WA	PACIFIC	raymond 2 s	46	-10	52	-16
122	456974	WA	FERRY	republic	52	-22	58	-34
123	457015	WA	BENTON	richland	58	-16	64	-28
124	457038	WA	YAKIMA	rimrock tieton dam	52	-22	58	-28
125	457059	WA	ADAMS	ritzville 1 sse	52	-22	64	-28
126	457180	WA	WHITMAN	rosalia	52	-22	58	-28
127	457185	WA	WHATCOM	ross dam	52	-16	58	-22
128	457267	WA	WHITMAN	saint john	52	-22	58	-28
129	457342	WA	KLICKITAT	satus pass 2 ssw	52	-16	58	-28
130	457488	WA	KING	seattle city office	46	-10	58	-16
131	457459	WA	KING	seattle jackson park	52	-10	58	-22
132	457458	WA	KING	seattle portage bay	46	-10	58	-16
133	457478	WA	KING	seattle univ of wash	52	-10	58	-16
134	457473	WA	KING	seattle-tacoma ap	52	-10	58	-16
135	457507	WA	SKAGIT	sedro woolley	46	-10	52	-22
136	457538	WA	CLALLAM	sequim	46	-10	52	-16
137	457544	WA	CLALLAM	sequim 2 e	46	-16	52	-22
138	457584	WA	MASON	shelton	52	-10	58	-16
139	457696	WA	SKAMANIA	skamania fish hatche	52	-10	58	-16
140	457727	WA	GRANT	smyrna	58	-16	64	-28
141	457773	WA	KING	snoqualmie falls	52	-10	58	-22
142	457781	WA	KING	snoqualmie pass	46	-22	58	-28
143	457938	WA	SPOKANE	spokane intl arpt	52	-22	58	-28
144	457956	WA	LINCOLN	sprague	52	-22	64	-28
145	458009	WA	KITTITAS	stampede pass	46	-16	52	-28
146	458034	WA	SNOHOMISH	startup 1 e	52	-10	58	-22
147	458059	WA	CHELAN	stehekin 4 nw	52	-16	58	-28
148	458089	WA	KING	stevens pass	46	-16	52	-22
149	458207	WA	YAKIMA	sunnyside	58	-16	64	-28
150	458278	WA	PIERCE	tacoma 1	52	-10	58	-16

Number	Station ID	Stat	County/District	Station Name	50% HPG	50% LPG	98% HPG	98% LPG
151	458286	WA	PIERCE	tacoma city hall	52	-10	58	-16
152	458332	WA	CLALLAM	tatoosh island	40	-10	46	-16
153	458500	WA	LEWIS	toledo-winlock muni	52	-10	58	-22
154	458579	WA		trinidad 2 sse	58	-16	64	-28
155	458715	WA	WHATCOM	upper baker dam	52	-16	58	-22
156	458773	WA	CLARK	vancouver 4 nne	52	-10	58	-22
157	458926	WA		walla walla 3 w	58	-16	64	-28
158	458928	WA	WALLA WALLA	walla walla city-cou	58	-16	64	-28
159	458931	WA	WALLA WALLA	walla walla wso	58	-16	64	-28
160	458959	WA	YAKIMA	wapato	58	-16	64	-28
161	459012	WA	DOUGLAS	waterville	52	-22	58	-28
162	459058	WA	STEVENS	wellpinit	52	-22	58	-28
163	459074	WA	CHELAN	wenatchee	52	-16	64	-28
164	459079	WA	CHELAN	wenatchee exp stn	58	-16	64	-28
165	459082	WA	CHELAN	wenatchee pangborn	58	-16	64	-28
166	459200	WA	WALLA WALLA	whitman mission	58	-16	64	-28
167	459238	WA	LINCOLN	wilbur	52	-22	58	-28
168	459291	WA	PACIFIC	willapa harbor	46	-10	58	-16
169	459342	WA	SKAMANIA	wind river	52	-16	58	-22
170	459376	WA	OKANOGAN	winthrop 1 wsw	52	-22	58	-34
171	459465	WA	YAKIMA	yakima air terminal	52	-16	64	-28

Appendix B

Models Incorporated in LTPPBIND Software

SHRP Models

In order to compute the design pavement temperatures required in the PG binder grade selection process, SHRP used an equation contained in the SHRP-A-648A report, which relates design air temperature to design pavement temperature for both high and low design air temperatures. The high design pavement temperature is determined 20 mm below the layer surface, while the low design pavement temperature is determined at the layer surface.

The high pavement surface temperature is based upon net heat flow at the pavement surface:

Net heat flow - [direct solar radiation] + [diffuse radiation] x [convection] x [conduction]
- [black body radiation]

Energy balance at the pavement surface is a transient phenomenon, continually changing with changing climatic conditions. For the purpose of calculating pavement surface temperature during the hottest 7-day period of the year, solar absorption, radiation transmission through air, atmospheric radiation, and wind speed were set at the following typical values:

Solar Absorption	0.90
Transmission Through Air	0.81
Atmospheric Radiation	0.70

Wind Speed	4.5 m/s

The resulting energy balance is non-deterministic. The equation contains latitude, with air temperature and surface temperature raised to the fourth power, requiring a trial and error solution. Using results of a theoretical analysis (see reference at the end of this section) and five data bases of actual measured air and pavement temperature combinations, a deterministic equation was developed relating temperature difference between surface and air to latitude.

$$T(surf) - T(air) = -0.00618\ lat^2 + 0.2289\ lat + 24.4 \qquad (1)$$

where T(surf) and T(air) are in C and the latitude, lat is in degrees.

Below the pavement surface, the temperature is predicted using heat flow models contained in the Federal Highway Administration's Environmental Effects Model. During the hottest 7-day period in the heat of the day, pavement surface temperature is increasing and heat flows downward into the pavement. Using data from the temperature data bases, an equation was developed that expresses the change in temperature with depth:

$$T(d) = T(surf)\ (1 - 0.063\ d + 0.007\ d^2 - 0.0004\ d^3) \qquad (2)$$

where T(d) and T(surf) are in F and the depth, d, is in inches.

For low temperature, the surface temperature was assumed to be equal to the air temperature. An equation was developed for the change in temperature with depth for low temperature as follows:

$$T(d) = T(air) + .051\ d - .000063\ d^2 \qquad (3)$$

where T(d) and T(air) are in C and the depth, d, is in mm.

LTPP Models

The LTPP models are empirical models developed from LTPP seasonal monitoring data (ref. 1). These models relate pavement temperatures (low and high) to air temperature, latitude, and depth. For more information on the LTPP models see reference 5. References 6 and 7 also contain similar information.

LTPP Low Pavement Temperature Model

$$\text{Tpav} = -1.56 + 0.72\ \text{Tair} - 0.004\ \text{Lat}^2 + 6.26\ \log10(\text{H}+25) - z\ (\ 4.4 + 0.52\ \text{Sair}^2\ )^{0.5}$$

Where:

Tpav	Low AC pavement temperature below surface, °C
Tair	Low air temperature, °C
Lat	Latitude of the section, degrees
H	Depth to surface, mm
Sair	Standard deviation of the mean low air temperature, °C
z	Standard normal dist. table, z = 2.055 for 98% reliability

Statistics: R2 = 96%, N = 411, SEE = 2.1

LTPP High Pavement Temperature Model

$$\text{Tpav} = 54.32 + 0.78\ \text{Tair} - 0.0025\ \text{Lat}^2 - 15.14\ \log10(\text{H}+25) + z\ (\ 9 + 0.61\ \text{Sair}^2\ )^{0.5}$$

Where:

Tpav	High AC pavement temperature below surface, °C
Tair	High air temperature, °C
Lat	Latitude of the section, degrees
H	Depth to surface, mm
Sair	Standard deviation of the high 7day mean air temperature, °C
z	Standard normal dist. table, z = 2.055 for 98% reliability

Statistics: R2 = 76%, N = 309, SEE = 3.0

References

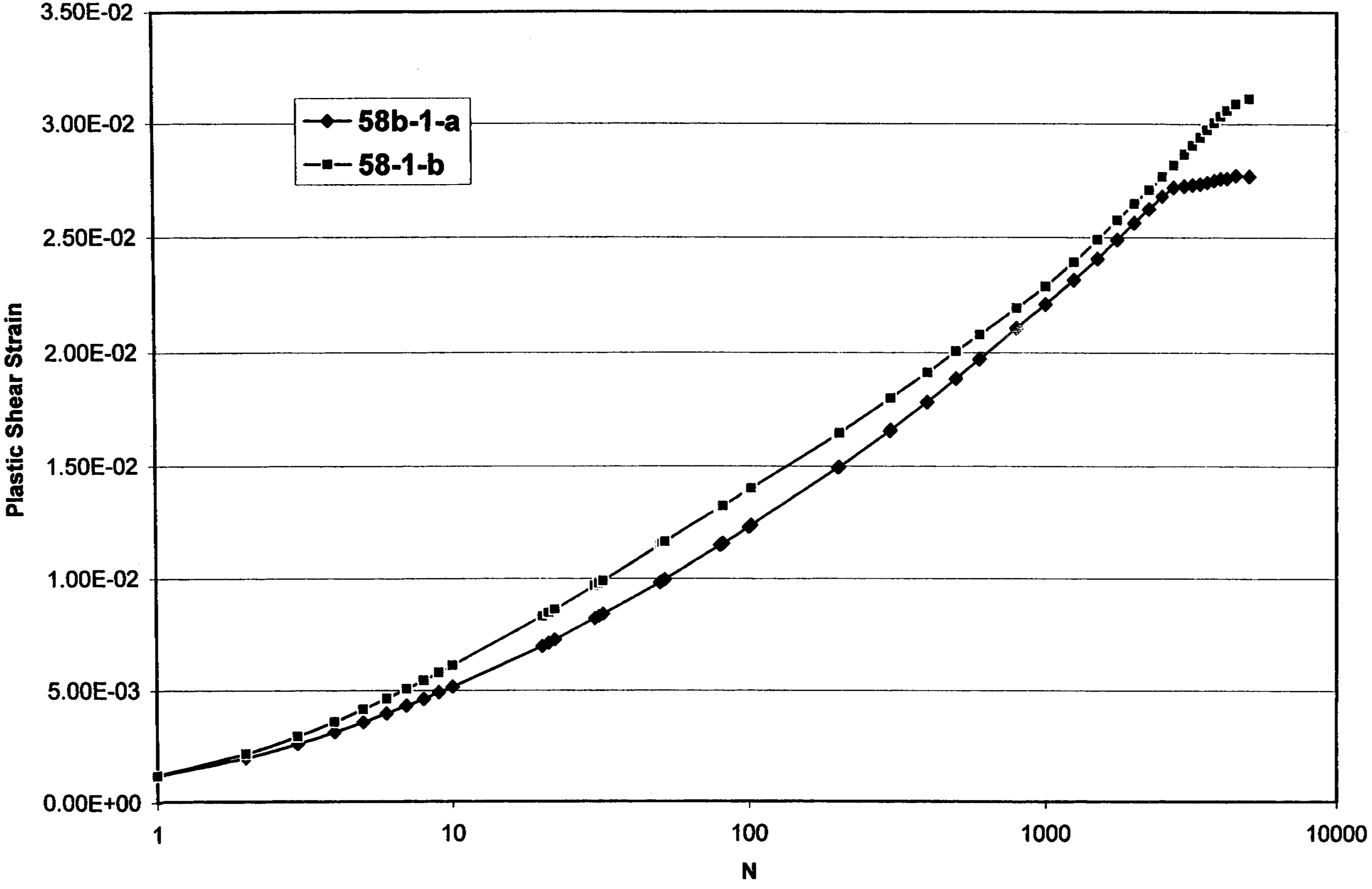
1. LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guide, *FHWA-RD-94-110*, April 1994.
2. Robertson, W.D. "Using the SHRP Specification to Select Asphalt Binders for Low Temperature Service," Presented at the SUPERPAVE Conference, Reno, 1993.
3. Huber, G.A., "Weather Data Base for the SUPERPAVE Mix Design System," *SHRP-A-648A*, February, 1994.
4. Solaimanian, M. and P. Bolzan, "Analysis of the Integrated Model of Climatic Effects on Pavements: Sensitivity Analysis and Pavement Temperature Prediction," *SHRP-A-637*.
5. "LTPP Seasonal Asphalt Concrete (AC) Pavement Temperature Models," *FHWA-RD-97-103*.
6. Mohseni, A. and M. Symons, "Improved AC Pavement Temperature Models from LTPP Seasonal Data." prepared for presentation at 77th Annual TRB Conference, Washington, DC, 1998.

7. Mohseni, A. and M. Symons, "Effect of Improved LTPP AC Pavement Temperature Models on SUPERPAVE PGs," prepared for presentation at 77th Annual TRB Conference, Washington, DC, 1998.

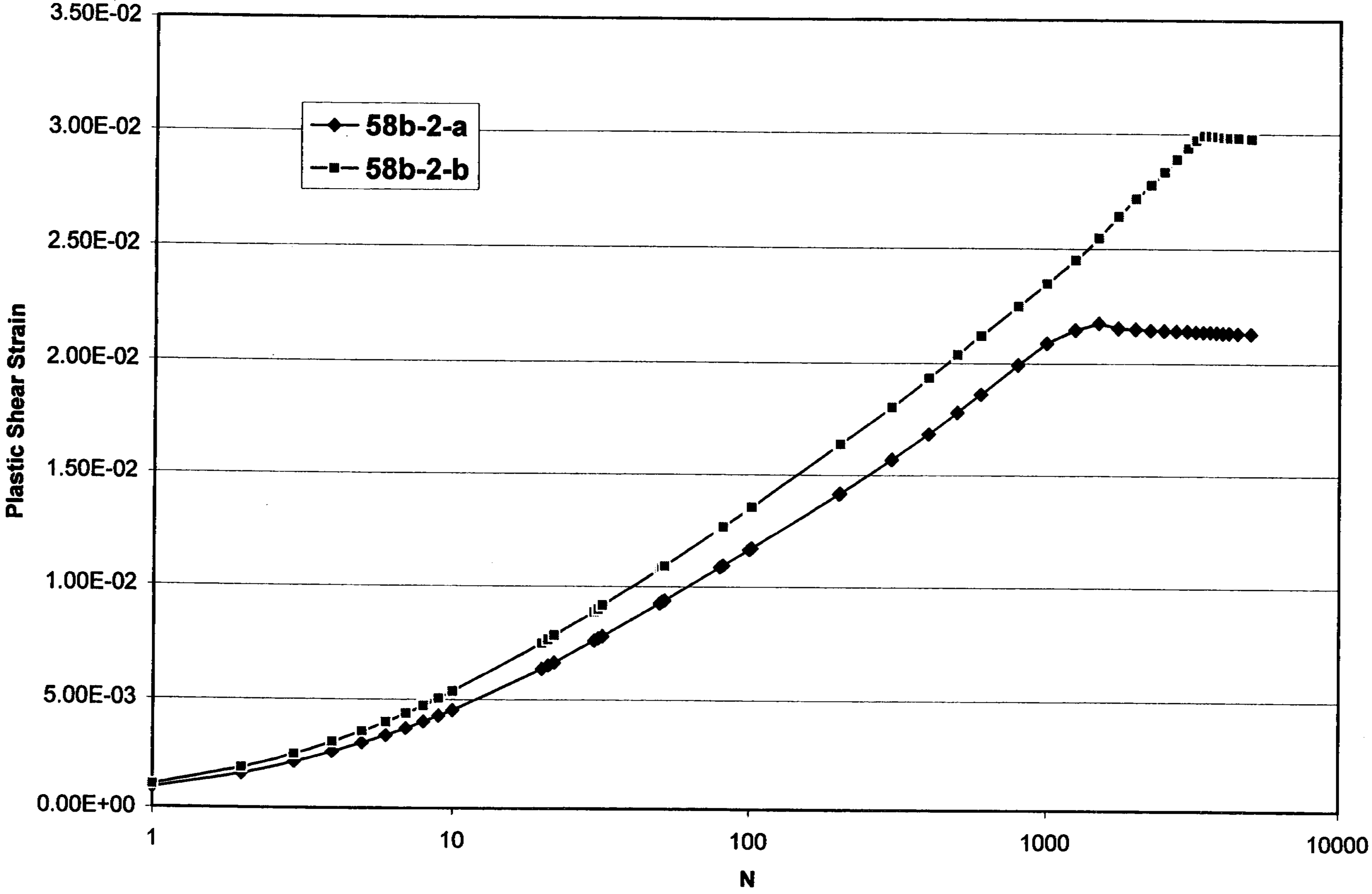
Appendix C - Superpave Shear Test Data

Sample #	Gmb	Gmm	%Gmm @ Ndes	% Air Voids	% VMA	Gsb	Height (mm)
58V-1-A	2.487	2.580	96.4	3.6	15.5	2.783	52.73
58V-1-B	2.487	2.580	96.4	3.6	15.5	2.783	50.30
58V-2-A	2.495	2.580	96.7	3.3	15.2	2.783	50.40
58V-2-B	2.495	2.580	96.7	3.3	15.2	2.783	52.30
58V-3-A	2.491	2.580	96.6	3.4	15.3	2.783	53.60
58V-3-B	2.491	2.580	96.6	3.4	15.3	2.783	50.20
AVE.	2.491	2.580	96.6	3.4	15.3	2.783	51.59
70V-1-A	2.513	2.586	97.4	2.8	14.8	2.783	49.97
70V-1-B	2.513	2.586	97.4	2.8	14.8	2.783	51.77
70V-2-A	2.522	2.586	97.5	2.5	14.5	2.783	51.10
70V-2-B	2.522	2.586	97.5	2.5	14.5	2.783	51.77
70V-3-A	2.514	2.586	97.2	2.8	14.8	2.783	52.23
70V-3-B	2.514	2.586	97.2	2.8	14.8	2.783	49.80
AVE.	2.516	2.586	97.4	2.7	14.7	2.783	51.11
58B-1-A	2.393	2.481	96.5	3.5	15.3	2.673	52.30
58B-1-B	2.393	2.481	96.5	3.5	15.3	2.673	49.93
58B-2-A	2.391	2.481	96.4	3.6	15.4	2.673	53.30
58B-2-B	2.391	2.481	96.4	3.6	15.4	2.673	50.70
58B-3-A	2.391	2.481	96.4	3.6	15.4	2.673	49.97
58B-3-B	2.391	2.481	96.4	3.6	15.4	2.673	53.53
AVE.	2.392	2.481	96.4	3.6	15.4	2.673	51.62
70B-1-A	2.395	2.523	94.9	5.1	15.3	2.673	53.30
70B-1-B	2.395	2.523	94.9	5.1	15.3	2.673	49.97
70B-2-A	2.393	2.523	94.8	5.2	15.4	2.673	51.80
70B-2-B	2.393	2.523	94.8	5.2	15.4	2.673	52.60
70B-3-A	2.401	2.523	95.2	4.8	15.0	2.673	52.33
70B-3-B	2.401	2.523	95.2	4.8	15.0	2.673	52.43
AVE.	2.396	2.523	95.0	5.0	15.2	2.673	52.07

Replicate Testing
(58b-1-a & 58b-1-b)



Replicate Testing
(58b-2-a & 58b-2-b)



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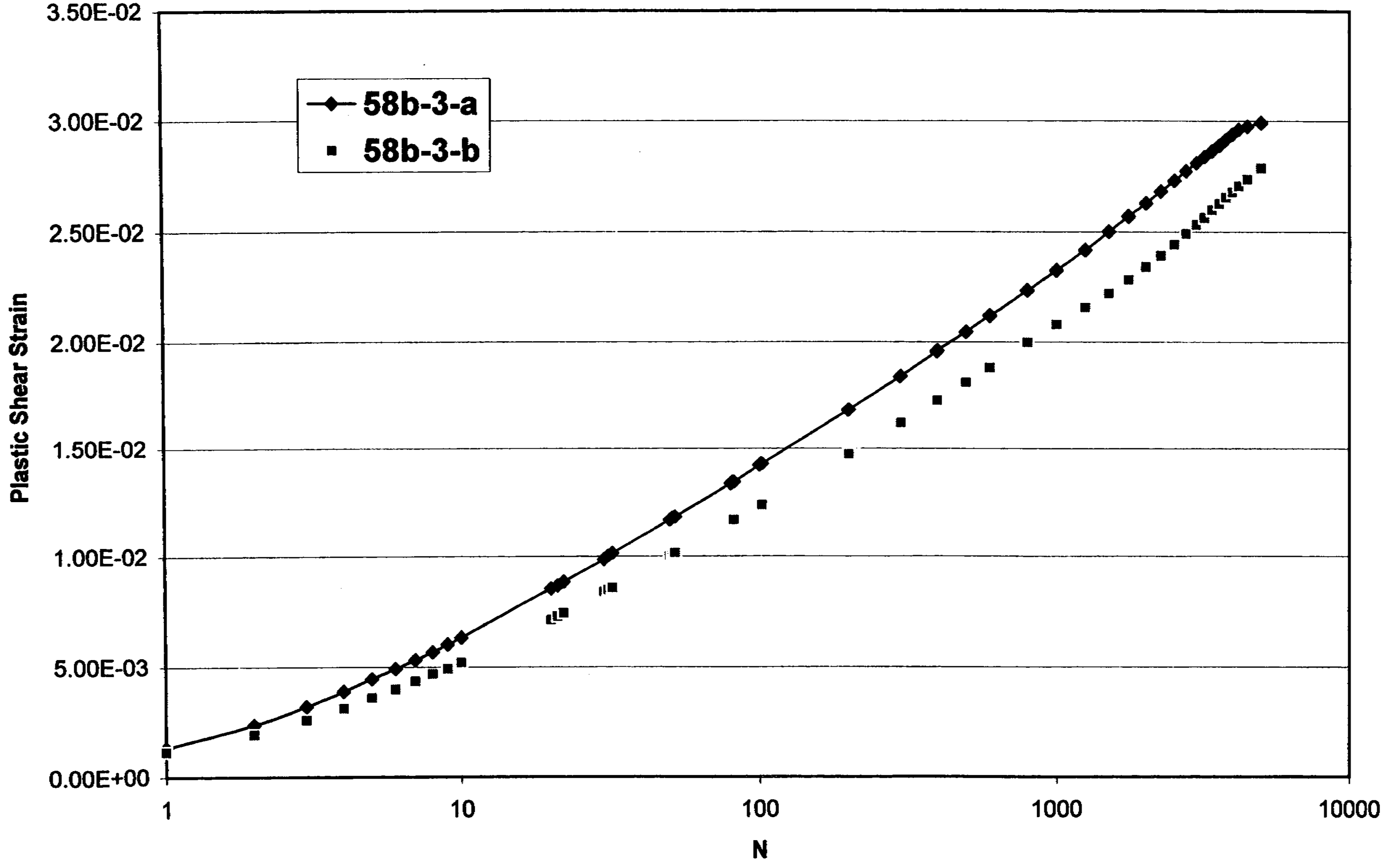
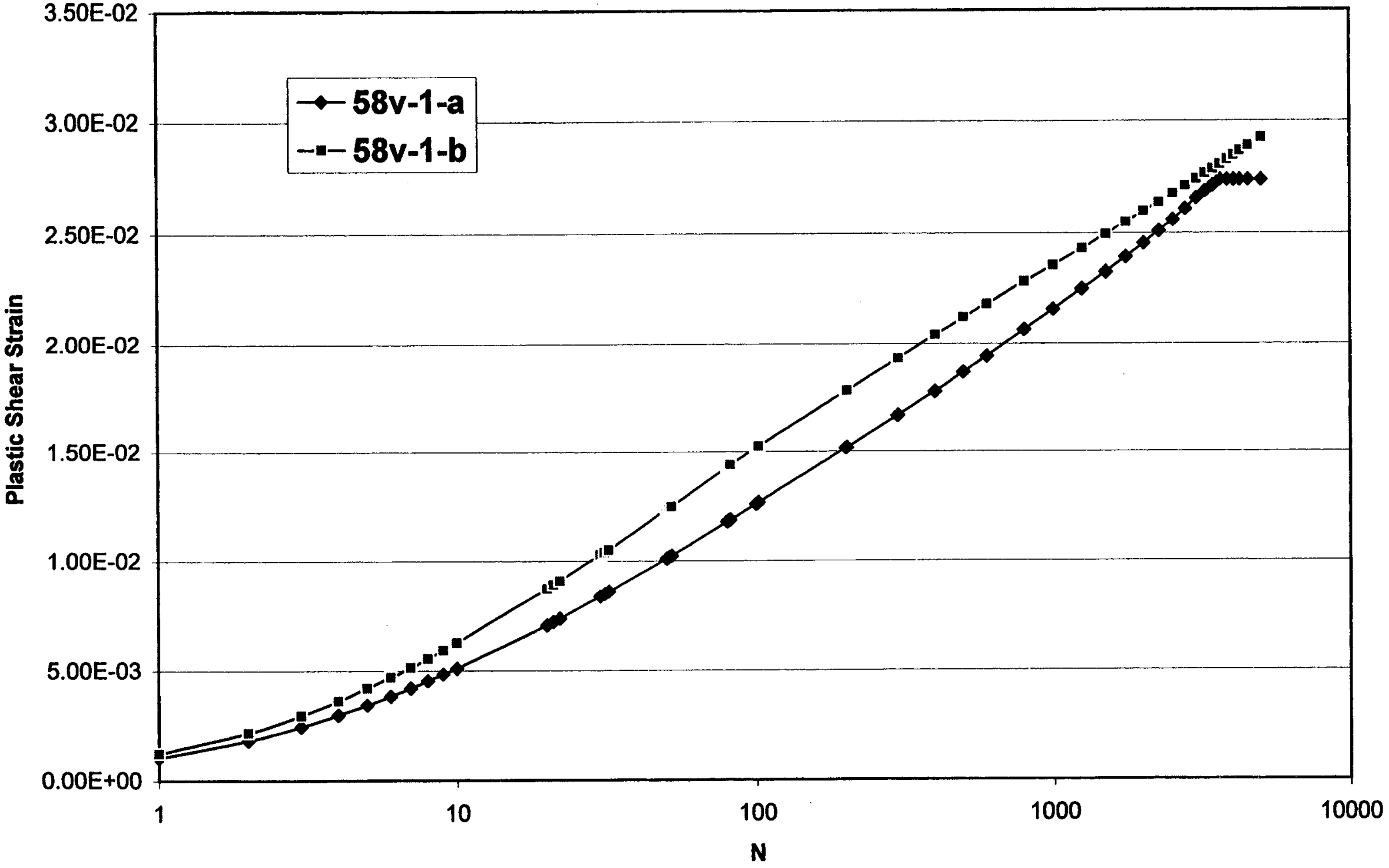
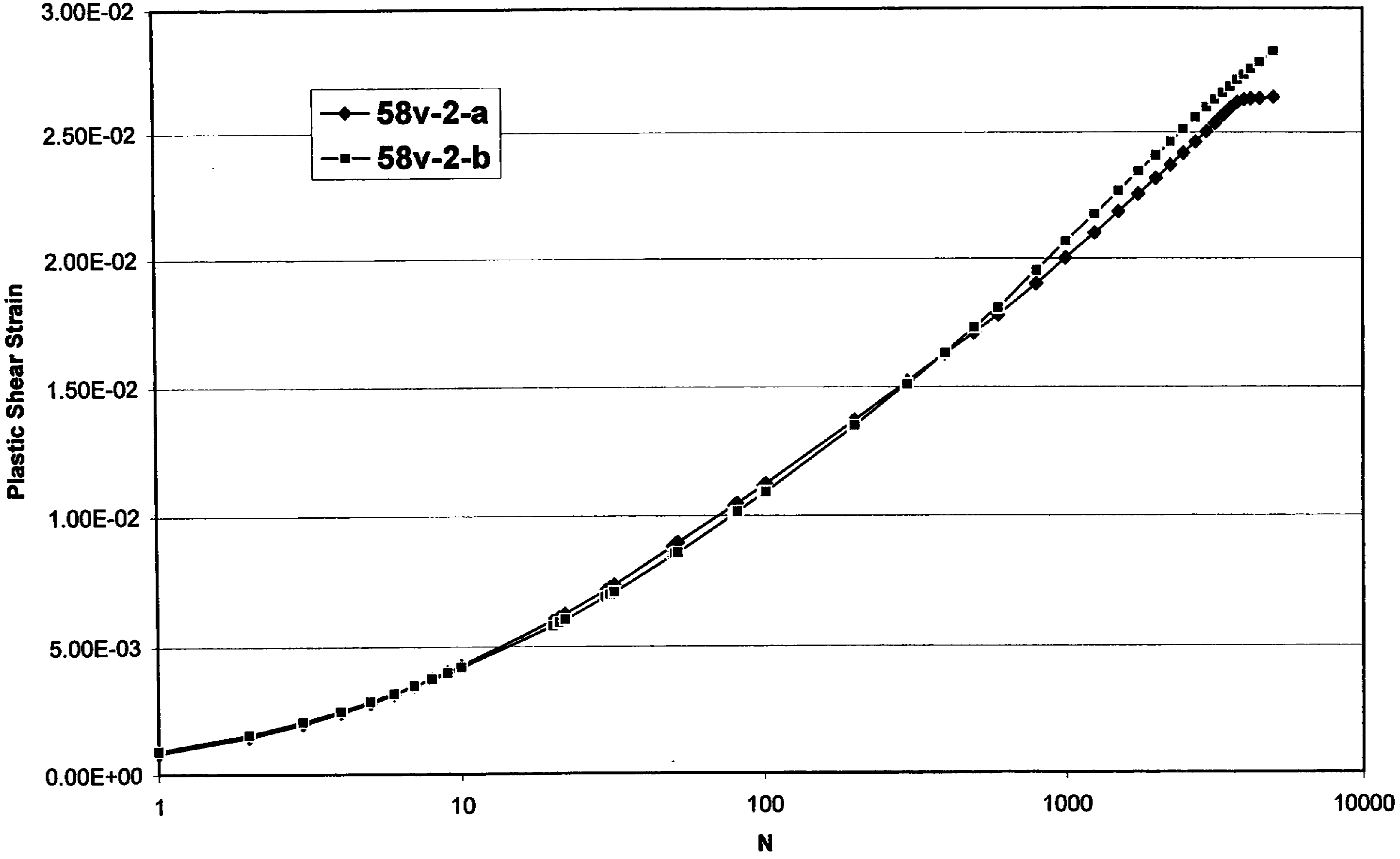


Replicate Testing
(58v-1-a & 58v-1-b)



Replicate Testing
(58v-2-a & 58v-2-b)



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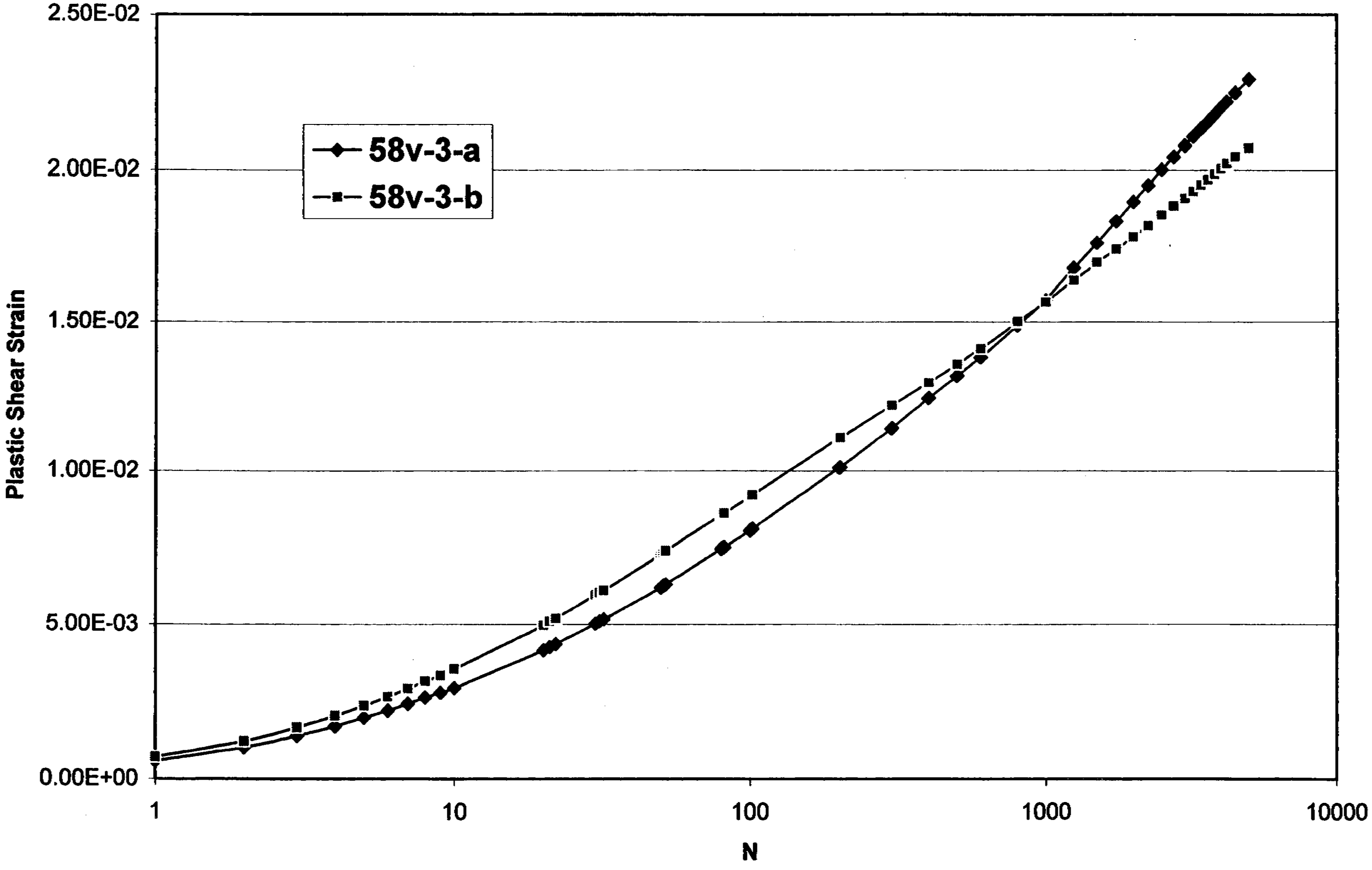
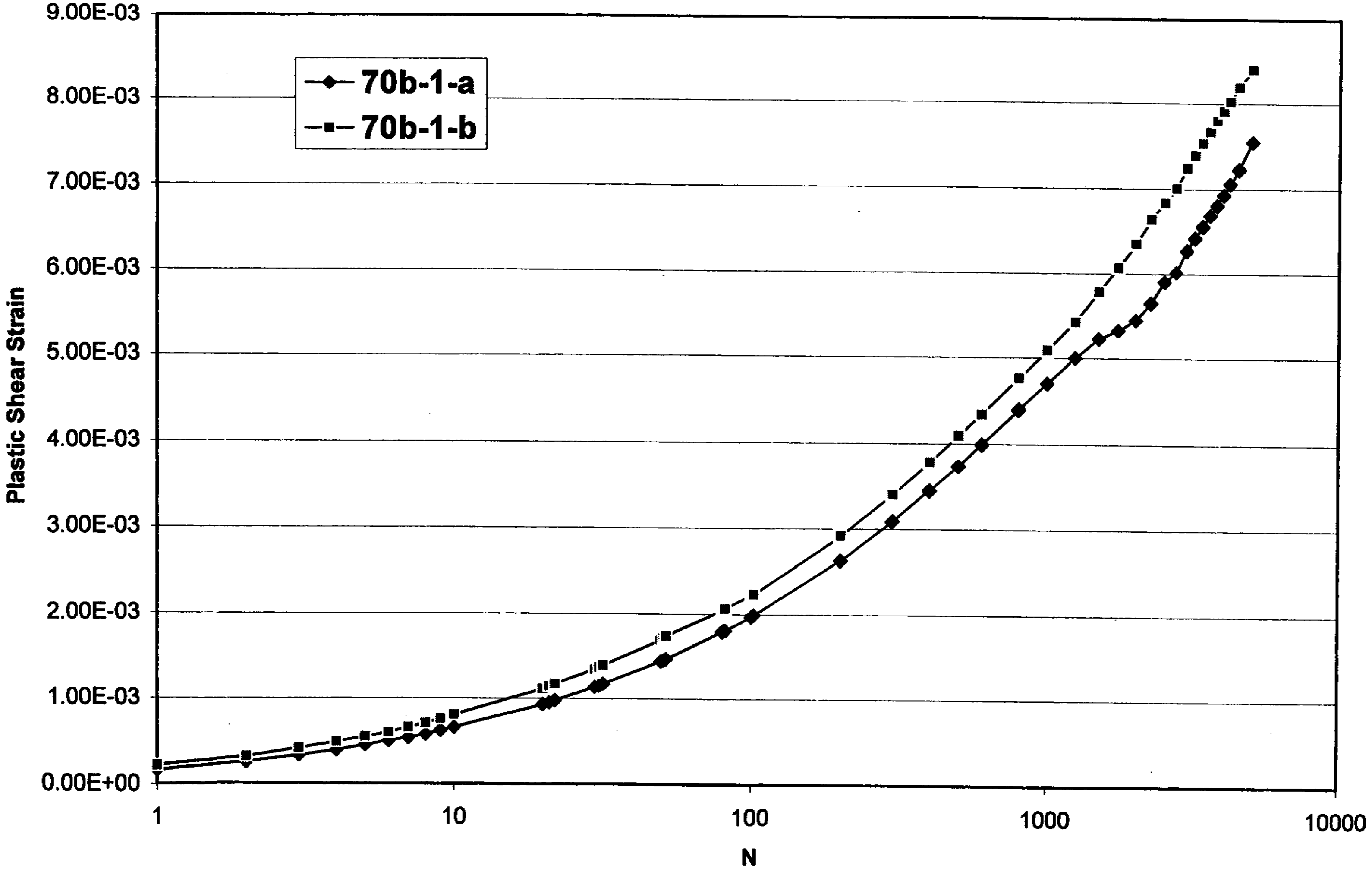
(58v-3-a & 58v-3-b)



Replicate Testing
(70b-1-a & 70b-1-b)



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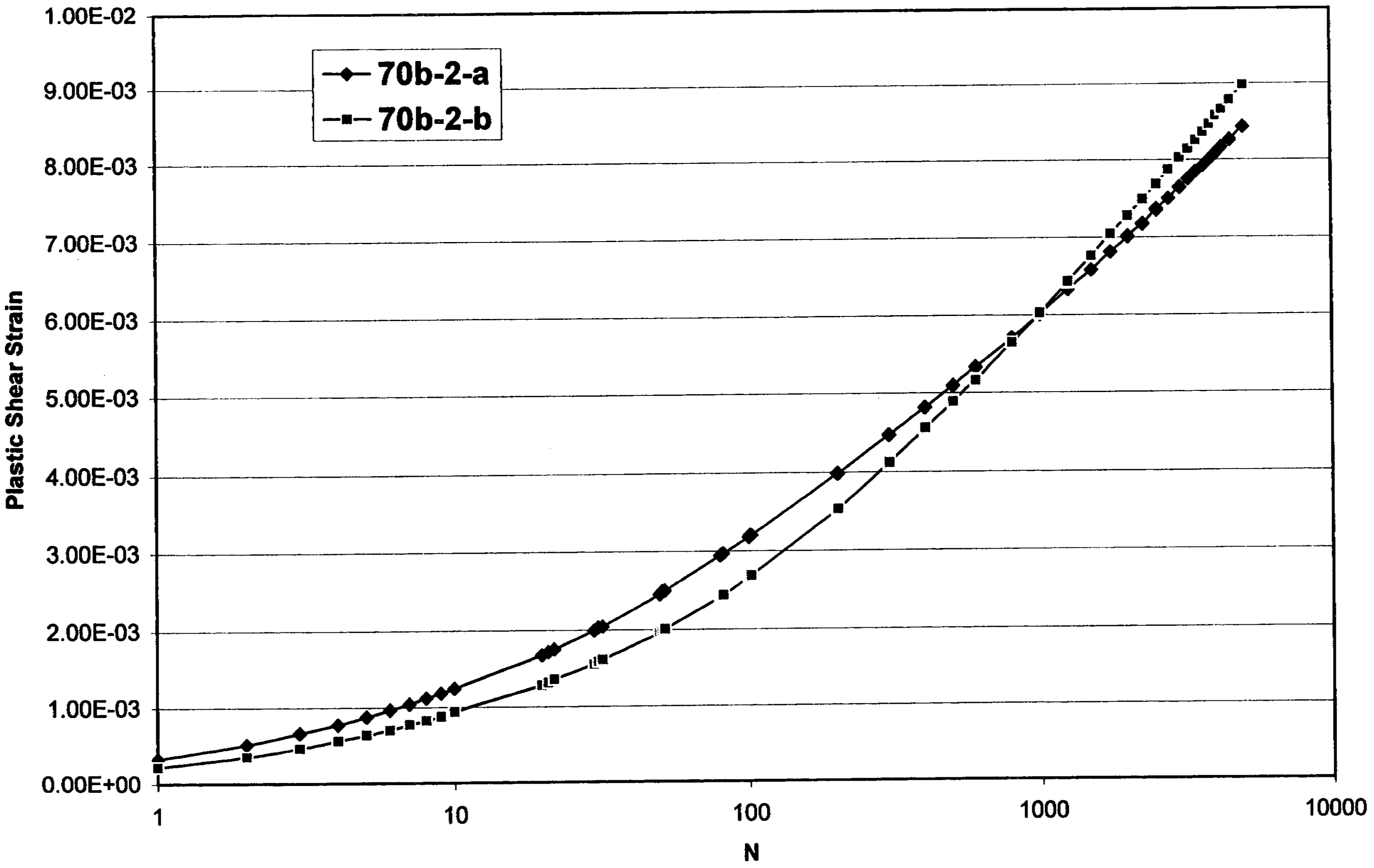
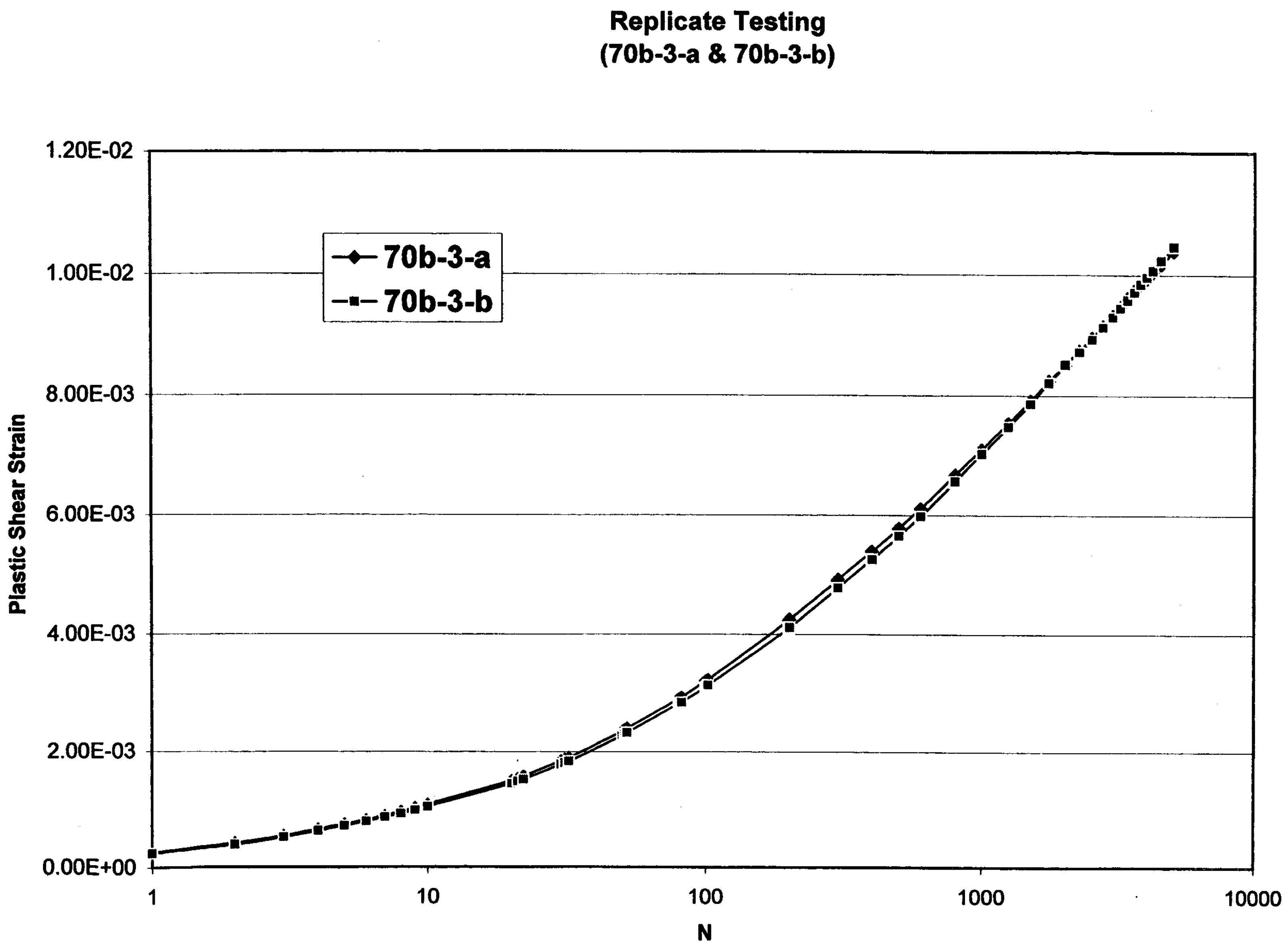
(70b-2-a & 70b-2-b)




Replicate Testing
(70b-3-a & 70b-3-b)
70b-3-a
70b-3-b
Plastic Shear Strain
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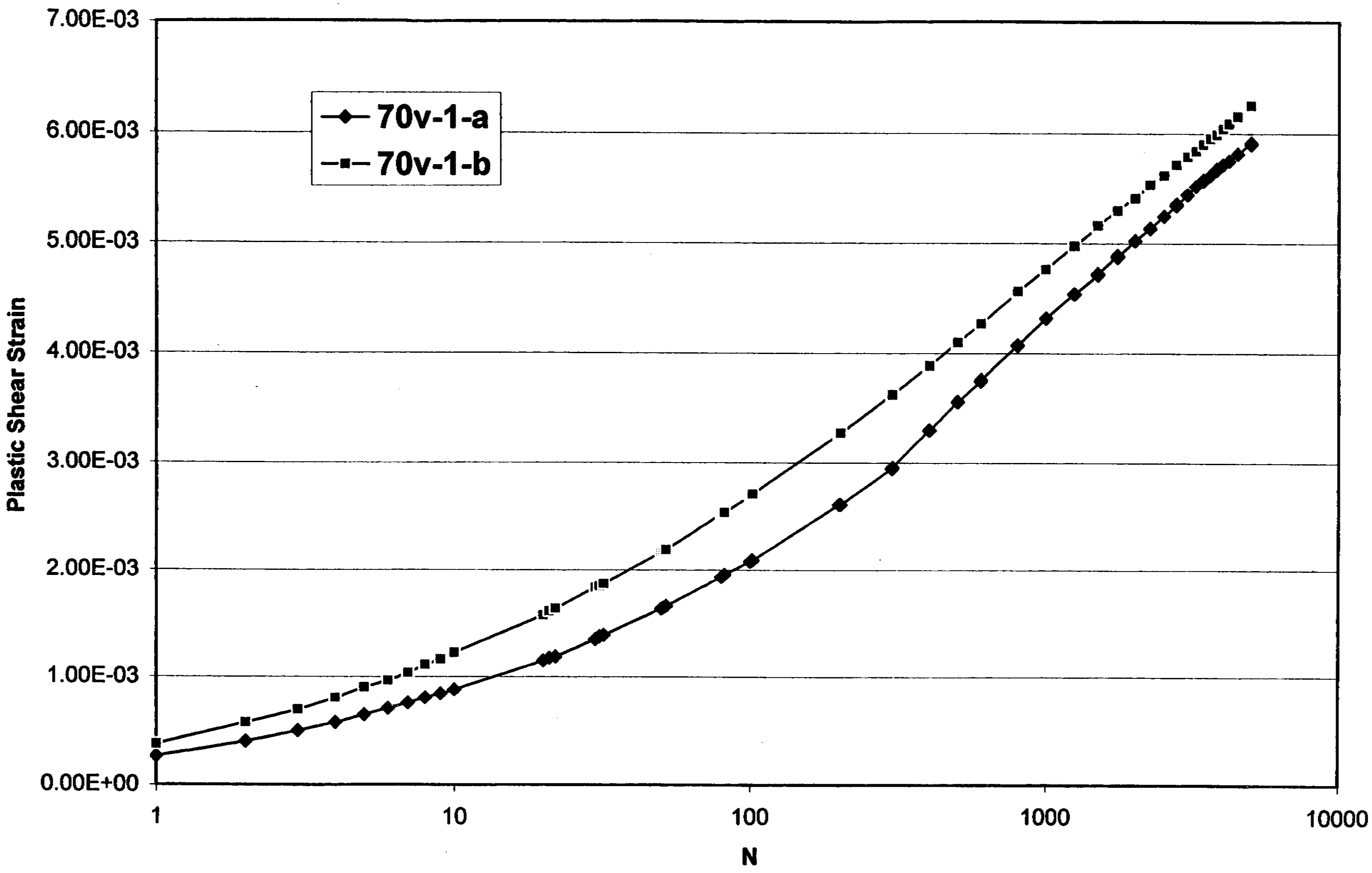
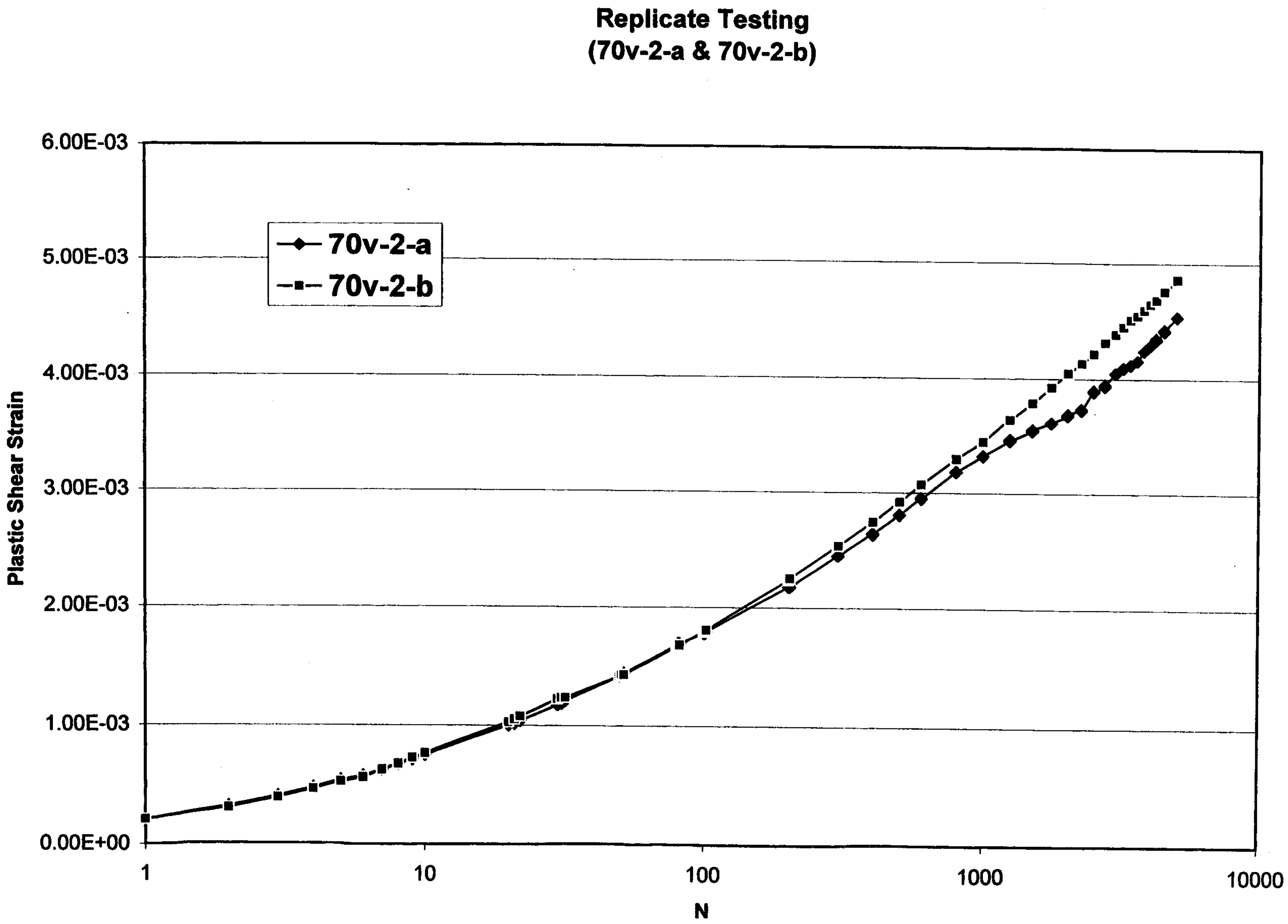
1.00E-02
8.00E-03
6.00E-03
4.00E-03
2.00E-03
0.00E+00
1
10
100
1000
10000
N

Replicate Testing
(70v-1-a & 70v-1-b)




Replicate Testing
(70v-2-a & 70v-2-b)
70v-2-a
70v-2-b
Plastic Shear Strain
6.00E-03
5.00E-03
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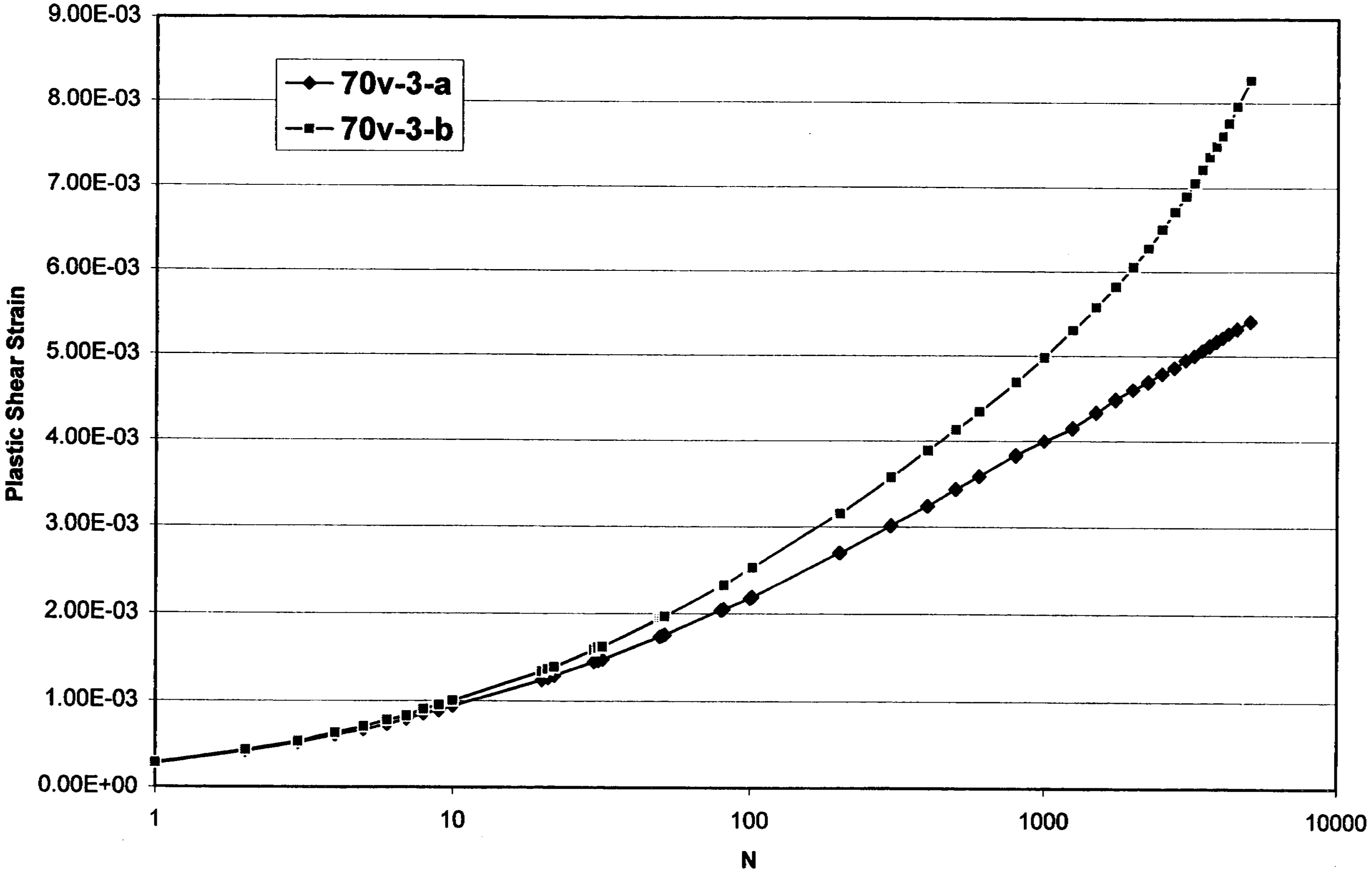
10
100
1000
10000
N



Replicate Testing
(70v-3-a & 70v-3-b)

Appendix D - Superpave Project Data (Provided by WSDOT Pavement Management Staff)

Contract No	SR	RRT[1]	RRQ[2]	BARM[3]	EARM[4]	BSRMP[5]	ESRMP[6]	Length (km)	Direction	Region	Mix Design Date	Construction Year	AGP Mix Type	Binder	Construction Type	Wearing Course Thickness (ft)	Design ESALs	Condition Data Available?	FWD Available?	Nearest NOAA Weather Station	Comments
5157	2			3.62	4.37	3.62	4.37	1.21	I	NW	7/97 - 4/98	1998	Class B	PG 58-22	Overlay	0.15	5,500,000	yes	no	Everett	
5157	2			3.63	3.83	3.63	3.83	0.32	D							0.15	5,500,000	yes	no		
5157	2			4.40	6.37	4.40	6.37	3.17	I							0.15	5,500,000	yes	no		
5157	2			6.53	11.36	6.53	11.41	7.77	I							0.15	5,500,000	yes	no		
5157	2			11.38	11.63	11.43	11.68	0.40	I							0.15	5,500,000	yes	no		
5157	2			11.65	12.97	11.70	13.02	2.12	I							0.15	5,500,000	yes	no		
5157	2			14.86	15.32	14.91	15.37	0.74	I							0.15	5,500,000	yes	no		
5157	2			15.35	16.09	15.40	16.14	1.19	I							0.15	5,500,000	yes	no		
4936	2			38.61	38.92	38.66	38.97	0.50	I	NW	8/96 - 3/97	1997	Class B	AR4000W	Overlay	0.20	1,300,000	yes	no	Startup	
4936	2			38.94	39.66	38.99	39.71	1.16	I					&		0.20	1,300,000	yes	no		
4936	2			40.04	40.68	40.09	40.73	1.03	I					PG 58-22		0.20	1,300,000	yes	no		
4936	2			40.69	40.94	40.74	40.99	0.40	I							0.20	1,300,000	yes	no		
4936	2			40.95	41.36	41.00	41.41	0.66	I							0.20	1,300,000	yes	no		
4936	2			41.37	42.66	41.42	42.71	2.08	I							0.20	1,300,000	yes	no		
4936	2			42.67	43.38	42.72	43.43	1.14	I							0.15	1,300,000	yes	no		
5367	2			255.25	256.23	263.44	264.42	1.58	I	E	5/98 - 6/98	1998	Class A	AR4000W	Overlay	0.15	2,000,000	yes	yes	Davenport	
5367	2			256.23	257.87	264.42	266.06	2.64	I				Class 12.5 mm	PG58-34		0.15	2,000,000	yes	yes		
5367	2			257.96	259.02	266.15	267.21	1.71	I				Class 12.5 mm	PG58-34		0.15	2,000,000	yes	yes		
5367	2			259.03	259.17	267.22	267.36	0.23	I				Class 12.5 mm	PG58-34		0.15	2,000,000	yes	yes		
5367	2			259.18	262.71	267.37	270.90	5.68	I				Class 12.5 mm	PG58-34		0.15	2,000,000	yes	yes		
5367	2			262.73	262.83	270.92	271.02	0.16	I				Class 12.5 mm	PG58-34		0.15	2,000,000	yes	yes		
5147	5			0.27	1.05	0.27	1.05	1.26	I	SW	6/97 - 7/97	1997	Class 12.5 mm	PG 70-22	Overlay	0.15	25,000,000	yes	no	Vancouver 4 NNE	
5147	5			0.27	1.05	0.27	1.05	1.26	D							0.15	25,000,000	yes	no		
5147	5			1.09	1.27	1.09	1.27	0.29	I							0.15	25,000,000	yes	no		
5147	5			1.09	1.27	1.09	1.27	0.29	D							0.15	25,000,000	yes	no		
5147	5			1.30	3.01	1.30	3.01	2.75	I							0.15	25,000,000	yes	no		
5147	5			1.30	3.01	1.30	3.01	2.75	D							0.15	25,000,000	yes	no		
4362	5			99.15	101.30	99.08	101.23	3.46	I	O	Aug-94	1994	Class A	AR4000W	Overlay	0.15	20,000,000	yes	no	Olympia WSO AP	
4362	5			99.15	101.30	99.08	101.23	3.46	D							0.15	20,000,000	yes	no		
4250	5			115.04	115.49	114.97	116.77	2.90	I	O	8/93 - 5/94	1994	Class A	AR4000W	Overlay	0.15	20,000,000	yes	no	Olympia WSO AP	
4250	5			115.56	118.39	116.77	118.77	3.22	I					PBA-6		0.15	20,000,000	yes	no		
4250	5			116.86	118.39	116.77	118.77	3.22	D					PBA-6		0.15	20,000,000	yes	no		
4250	5			118.43	119.44	118.77	120.77	3.22	I					PBA-6GR		0.15	20,000,000	yes	no		
4250	5			118.43	119.44	118.77	120.77	3.22	D					PBA-6GR		0.15	20,000,000	yes	no		
4250	5			119.45	120.93	120.77	124.21	5.54	I					AR4000W		0.15	20,000,000	yes	no		
4250	5			120.96	124.25	120.77	124.21	5.54	D					AR4000W		0.15	20,000,000	yes	no		
4326	5			177.84	179.97	177.78	179.91	3.43	I	NW	3/94 - 5/96	1996	Class A	AR4000W	Overlay	0.15	12,000,000	yes	no	Seattle Jackson Park	
4326	5			177.84	179.97	177.78	179.91	3.43	I							0.08	12,000,000	yes	no		
4326	5			177.84	178.31	177.78	178.25	0.76	D							0.08	12,000,000	yes	no		
4326	5			177.84	178.31	177.78	178.25	0.76	D							0.15	12,000,000	yes	no		
4326	5			180.02	180.13	179.96	180.07	0.18	I							0.15	12,000,000	yes	no		
4326	5			180.02	180.13	179.96	180.07	0.18	I							0.08	12,000,000	yes	no		
4326	5			180.16	180.77	180.10	180.71	0.98	I							0.15	12,000,000	yes	no		
4326	5			180.16	180.77	180.10	180.71	0.98	I							0.08	12,000,000	yes	no		
4326	5			180.81	181.57	180.75	181.51	1.22	I							0.08	12,000,000	yes	no		
4326	5			180.81	181.57	180.75	181.51	1.22	I							0.15	12,000,000	yes	no		
4326	5			180.81	181.57	180.75	181.51	1.22	D							0.15	12,000,000	yes	no		
4326	5			180.81	181.57	180.75	181.51	1.22	D							0.08	12,000,000	yes	no		
4676	8			0.00	11.54	0.00	11.54	18.57	I	O	07/01/95	1995	Class A	AR4000W	Overlay	0.15	2,400,000	yes	yes	Elma	
4676	8			0.00	11.54	0.00	11.54	18.57	D							0.15	2,400,000	yes	no		
5157	9			11.89	12.21	11.89	12.21	0.51	I	NW	7/97 - 4/98	1998	Class B	PG 58-22	Overlay	0.12	2,500,000	yes	yes	Everett	
5157	9			12.25	12.50	12.25	12.50	0.40	I							0.12	2,500,000	yes	yes		
5077	12			36.42	38.42	36.72	38.72	3.22	I	O	05/09/97	1997	Class A	PG 58-22	Overlay	0.15	3,500,000	yes	no	Oakville	
5077	12			38.44	38.89	38.74	39.19	0.72	I							0.15	3,500,000	yes	no		
5077	12			38.92	39.33	39.22	39.63	0.66	I							0.15	3,500,000	yes	no		

Appendix D - Superpave Project Data (Provided by WSDOT Pavement Management Staff)

Contract No.	SR	RRT[1]	RRQ[2]	BARM[3]	EARM[4]	BSRMP[5]	ESRMP[6]	Length (km)	Direction	Region	Mix Design Date	Construction Year	ACP Mix Type	Binder	Construction Type	Wearing Course Thickness (ft)	Design ESAL[9]	Condition Data Available?	FWD Available?	Nearest NOAA Weather Station	Comments
5077	12			39.71	41.37	40.01	41.67	2.67	I							0.15	3,500,000	yes	no		
5077	12			41.68	42.68	41.98	42.98	1.61	I							0.15	3,500,000	yes	no		
4692	12			185.08	189.05	185.46	189.38	6.39	I	SC	7/95 - 8/95	1995	Class A	AR4000W & F	Overlay	0.15	700,000	yes	no	Yakima WSO AP	
5307	12			308.55	311.15	311.37	313.97	4.18	I	SC	04/03/98	1998	Class 19 mm	PG 64-28	Overlay	0.35	6,100,000	yes	yes	Kennewick	
5307	12			311.19	311.34	314.01	314.16	0.24	I							0.35	6,100,000	yes	yes		
5307	12			311.38	311.45	314.20	314.27	0.11	I							0.35	6,100,000	yes	yes		
5364	14			3.92	7.94	3.91	7.93	6.47	D	SW	05/13/98	1998	Class 12.5 mm	PG 58-22	Overlay	0.25	9,000,000	yes	no	Vancouver 4 NNE	
5364	14			3.92	7.94	3.91	7.93	6.47	D							0.15	9,000,000	yes	no		
5364	14			3.94	7.94	3.93	7.93	6.44	I							0.25	9,000,000	yes	no		
5364	14			3.94	7.94	3.93	7.93	6.44	I							0.15	9,000,000	yes	no		
5084	14			27.62	28.93	27.87	29.18	2.11	I	SW	03/01/97	1998	Class A	PG 58-22	Overlay	0.15	2,700,000	yes	yes	Skamania Fish Hatchery	
5124	17			0.24	1.28	7.67	8.71	1.67	I	SC	02/06/98	1998	Class 12.5 mm	PG 64-28	Overlay	0.30	5,000,000	yes	yes	Connell 12 SE	
5124	17			1.31	1.66	8.74	9.09	0.56	I							0.30	5,000,000	yes	yes		
5124	17			1.78	2.50	9.21	9.99	1.16	I							0.30	5,000,000	yes	yes		
5290	17			20.74	24.96	28.23	32.45	6.79	I	NC	?	1998	Class 12.5 mm	PG 64-28	Overlay	0.25	5,700,000	yes	yes	Connell 1 W	
5290	17			24.96	25.58	32.45	33.07	1.00	I							0.33	5,700,000	yes	yes		
5290	17			25.58	25.95	33.07	33.44	0.60	I							0.25	5,700,000	yes	yes		
5290	17			25.95	26.61	33.44	34.10	1.06	I							0.33	5,700,000	yes	yes		
5290	17			26.61	26.75	34.10	34.24	0.23	I							0.15	5,700,000	yes	yes		
5290	17			26.75	26.81	34.24	34.30	0.10	I							0.25	5,700,000	yes	yes		
5290	17			26.81	26.95	34.30	34.44	0.23	I							0.15	5,700,000	yes	yes		
5290	17			26.95	28.00	34.44	35.49	1.69	I							0.25	5,700,000	yes	yes		
5290	17			28.00	28.54	35.49	36.03	0.87	I							0.33	5,700,000	yes	yes		
5290	17			28.54	29.34	36.03	36.83	1.29	I							0.25	5,700,000	yes	yes		
5290	17			29.34	29.46	36.83	36.95	0.19	I							0.15	5,700,000	yes	yes		
5290	17			29.46	30.37	36.95	37.86	1.46	I							0.25	5,700,000	yes	yes		
5290	17			30.37	30.80	37.86	38.29	0.69	I							0.15	5,700,000	yes	yes		
5290	17			30.80	31.83	38.29	39.32	1.66	I							0.33	5,700,000	yes	yes		
5290	17			31.83	32.25	39.32	39.74	0.68	I							0.25	5,700,000	yes	yes		
5290	17			32.25	32.37	39.74	39.86	0.19	I							0.33	5,700,000	yes	yes		
5290	17			32.37	32.75	39.86	40.24	0.61	I							0.15	5,700,000	yes	yes		
5290	17			32.75	34.70	40.24	42.19	3.14	I							0.25	5,700,000	yes	yes		
5290	17			34.70	35.34	42.19	42.83	1.03	I							0.33	5,700,000	yes	yes		
5290	17			35.38	35.51	42.87	43.00	0.21	I							0.33	5,700,000	yes	yes		
5168	82			0.06	0.61	0.06	0.61	0.89	D	SC	6/97 - 7/97	1997	Class A	PG 64-28	Overlay	0.15	7,000,000	yes	no	Ellensburg	
4818	82			24.14	25.16	24.14	25.16	1.64	I	SC	05/02/96	1996	Class A	PG 64-28	Overlay	0.20	6,500,000	yes	yes	Ellensburg	
4818	82			24.14	25.15	24.14	25.15	1.63	D							0.20	6,500,000	yes	yes		
4818	82			25.18	26.21	25.18	26.21	1.66	D							0.20	6,500,000	yes	yes		
4818	82			25.19	26.22	25.19	26.22	1.66	I							0.20	6,500,000	yes	yes		
4818	82			26.23	28.99	26.23	29.02	4.44	D							0.20	6,500,000	yes	yes		
4818	82			26.24	28.99	26.24	29.02	4.43	I							0.20	6,500,000	yes	yes		
4818	82			29.01	30.09	29.04	30.12	1.74	I							0.20	6,500,000	yes	yes		
4818	82			29.01	30.09	29.04	30.12	1.74	D							0.20	6,500,000	yes	yes		
5010	97			67.51	67.69	67.65	67.83	0.29	I	SC	04/02/97	1997	Oregon B	PG76-26	Overlay	0.15	3,000,000	yes	no	Wapato	Intersection Design
5010	97			67.51	67.76	67.65	67.90	0.40	D				with Class A	AR4000W on		0.21	3,000,000	yes	no		
5010	97			67.69	67.73	67.83	67.87	0.06	I					lower lifts		0.30	3,000,000	yes	no		
5010	97			67.73	67.77	67.87	67.91	0.06	I							0.15	3,000,000	yes	no		
4673	97			69.18	74.10	69.32	74.24	7.92	I	SC	06/07/95	1995	HIP &	AR4000W	Overlay	0.18	3,200,000	yes	yes	Wapato	0.18 ft HIP with
4673	97			69.18	74.10	69.32	74.24	7.92	D				Class D			0.18	3,200,000	yes	yes		0.08 ft Class D
5377	97			200.14	202.39	214.98	217.23	3.62	I	NC	07/06/98	1998	Class A Mod	PG 58-34	Overlay	0.25	2,700,000	yes	yes	Chelan	
5377	97			202.40	204.16	217.24	219.00	2.83	I							0.25	2,700,000	yes	yes		
5192	99			0.06	1.05	0.06	1.05	1.59	I	O	06/04/98	1998	Class 12.5 mm	PG 64-22	Overlay	0.15	7,000,000	yes	no	Tacoma No 1	
5192	99			1.06	2.50	1.06	6.15	2.32	I							0.15	7,000,000	yes	no		
5295	99			28.83	30.42	32.58	34.17	2.56	I	NW	04/29/98	1998	Class 12.5 mm	PG 70-22	Overlay	0.15	7,000,000	yes	no	Seattle-Tac WSCMO AP	
5295	99			28.83	30.42	32.58	34.17	2.56	D							0.15	7,000,000	yes	no		

Appendix D - Superpave Project Data (Provided by WSDOT Pavement Management Staff)

Contract No	SR	RRT¹	RRQ²	BARM³	EARM⁴	BSRMP⁵	ESRMP⁶	Length (km)	Direction	Region	Mix Design Date	Construction Year	ACP Mix Type	Binder	Construction Type	Wearing Course Thickness (ft)	Design ESAL⁸	Condition Data Available?	FWD Available?	Nearest NOAA Weather Station	Comments
5295	99			30.98	31.07	34.73	34.82	0.14	I							0.15	7,000,000	yes	no		
5295	99			30.98	31.07	34.73	34.82	0.14	D							0.15	7,000,000	yes	no		
5295	99			31.09	31.71	34.84	35.46	1.00	I							0.15	7,000,000	yes	no		
5295	99			31.09	31.10	34.84	34.85	0.02	D							0.15	7,000,000	yes	no		
5295	99			31.10	31.71	34.85	35.46	0.98	D							0.15	7,000,000	yes	no		
5295	99			31.73	31.94	35.48	35.69	0.34	I							0.15	7,000,000	yes	no		
5295	99			31.73	31.94	35.48	35.69	0.34	D							0.15	7,000,000	yes	no		
5295	99			31.95	32.54	35.70	36.29	0.95	I							0.15	7,000,000	yes	no		
5295	99			31.95	32.54	35.70	36.29	0.95	D							0.15	7,000,000	yes	no		
5295	99			32.56	33.14	36.31	36.89	0.93	I							0.15	7,000,000	yes	no		
5295	99			32.56	33.14	36.31	36.89	0.93	D							0.15	7,000,000	yes	no		
5295	99			33.14	33.18	36.89	36.93	0.06	I							0.25	7,000,000	yes	no		
5295	99			33.14	33.18	36.89	36.93	0.06	D							0.25	7,000,000	yes	no		
5295	99			33.18	33.56	36.93	37.31	0.61	I							0.15	7,000,000	yes	no		
5295	99			33.18	33.56	36.93	37.31	0.61	D							0.15	7,000,000	yes	no		
5295	99			33.56	33.62	37.31	37.37	0.10	I							0.25	7,000,000	yes	no		
5295	99			33.56	33.62	37.31	37.37	0.10	D							0.25	7,000,000	yes	no		
5295	99			33.62	33.68	37.37	37.43	0.10	I							0.15	7,000,000	yes	no		
5295	99			33.62	33.68	37.37	37.43	0.10	D							0.15	7,000,000	yes	no		
5295	99			33.73	34.05	37.48	37.80	0.51	I							0.15	7,000,000	yes	no		
5295	99			33.73	34.05	37.48	37.80	0.51	D							0.15	7,000,000	yes	no		
5295	99			34.05	34.15	37.80	37.90	0.16	I							0.11	7,000,000	yes	no		
5295	99			34.05	34.15	37.80	37.90	0.16	D							0.11	7,000,000	yes	no		
5295	99			34.15	34.60	37.90	38.35	0.72	I							0.15	7,000,000	yes	no		
5295	99			34.15	34.60	37.90	38.35	0.72	D							0.15	7,000,000	yes	no		
5295	99			34.60	34.68	38.35	38.43	0.13	I							0.15	7,000,000	yes	no		
5295	99			34.60	34.68	38.35	38.43	0.13	D							0.15	7,000,000	yes	no		
5295	99			34.68	34.72	38.43	38.47	0.06	I							0.25	7,000,000	yes	no		
5295	99			34.68	34.72	38.43	38.47	0.06	D							0.25	7,000,000	yes	no		
5295	99			34.72	35.20	38.47	38.95	0.77	I							0.15	7,000,000	yes	no		
5295	99			34.72	34.78	38.47	38.53	0.10	D							0.15	7,000,000	yes	no		
5295	99			34.78	36.69	38.53	40.44	3.07	D							0.15	7,000,000	yes	no		
5295	99			35.20	36.69	38.95	40.44	2.40	I							0.15	7,000,000	yes	no		
5295	99			36.69	36.73	40.44	40.48	0.06	I							0.25	7,000,000	yes	no		
5295	99			36.69	36.73	40.44	40.48	0.06	D							0.25	7,000,000	yes	no		
5295	99			36.73	37.05	40.48	40.80	0.51	I							0.15	7,000,000	yes	no		
5295	99			36.73	37.05	40.48	40.80	0.51	D							0.15	7,000,000	yes	no		
5252	101			3.84	4.52	3.84	4.52	1.09	I	SW	4/45/98	1998	Class A Mod	PG 58-22	Reconst	0.35	230,000	yes	no	Long Beach Exp Station	
5252	101			4.94	5.15	4.94	5.15	0.34	I							0.35	230,000	yes	no		
5184	101			20.42	24.02	20.42	24.02	5.79	I	SW	6/97 - 7/97	1997	Class 12.5 mm	PG 58-22	Overlay	0.15	600,000	yes	yes	Naselle 2 ENE	
4927	101			359.89	360.48	361.52	362.11	0.95	D	O	07/15/96	1996	Class A	AR4000W	Overlay	0.15	5,200,000	yes	yes	Shelton	
4927	101			360.50	361.20	362.13	362.83	1.13	D							0.15	5,200,000	yes	yes		
4927	101			361.26	363.19	362.89	364.82	3.11	D							0.15	5,200,000	yes	yes		
5160	125			0.00	0.83	0.00	0.83	1.34	I	SC	7/96 - 9/97	1998	Class E	AR4000W	Overlay	0.20	4,000,000	yes	yes	Walla Walla WSO CI	
5160	125			0.00	0.83	0.00	0.83	1.34	D							0.20	4,000,000	yes	yes		
5160	125			0.86	1.53	0.86	1.53	1.08	I							0.20	4,000,000	yes	yes		
5160	125			0.86	1.53	0.86	1.53	1.08	D							0.20	4,000,000	yes	yes		
5160	125			1.55	4.48	1.55	4.48	4.72	I							0.20	4,000,000	yes	yes		
5160	125			1.55	4.48	1.55	4.48	4.72	D							0.20	4,000,000	yes	yes		
5058	182	CD	01483	0.00	0.91	0.00	0.91	1.46	I	SC	04/10/97	1998	Class A	PG 64-28	Overlay	0.15	1,200,000	yes	no	Richland	
5058	182	CI	01393	0.00	1.00	0.00	1.00	1.61	I							0.15	6,500,000	yes	no		
5058	182	CI	01175	0.22	1.26	0.22	1.26	1.67	I							0.15	1,200,000	yes	no		
5058	182			12.31	12.68	12.31	12.68	0.60	I							0.15	17,000,000	yes	yes		
5058	182			12.33	12.68	12.33	12.68	0.56	D							0.15	17,000,000	yes	yes		
5058	182			12.71	13.76	12.71	13.76	1.69	I							0.15	17,000,000	yes	yes		

Appendix D - Superpave Project Data (Provided by WSDOT Pavement Management Staff)

Contract No	SR	RRT^1	RRQ^2	BARM^3	EARM^4	BSRMP^5	ESRMP^6	Length (km)	Direction	Region	Mix Design Date	Construction Year	ACP Mix Type	Binder	Construction Type	Wearing Course Thickness (ft)	Design ESAL^7	Condition Data Available?	FWD Available?	Nearest NOAA Weather Station	Comments
5058	182			12.71	13.76	12.71	13.76	1.69	D							0.15	17,000,000	yes	yes		
5058	182			13.79	13.83	13.79	13.83	0.06	I							0.20	21,000,000	yes	yes		
5058	182			13.79	13.83	13.79	13.83	0.06	D							0.20	21,000,000	yes	yes		
5058	182			13.92	15.19	13.92	15.19	2.04	I							0.15	11,000,000	yes	yes		
5058	182			13.93	15.19	13.93	15.19	2.03	D							0.15	11,000,000	yes	yes		
5240	240			28.58	28.60	28.58	28.60	0.03	I	SC	09/25/97	1997	Class 12.5 mm	PG 64-28	Reconst	0.45	980,000	yes	yes	Richland	
5240	240			28.60	28.86	28.60	30.63	0.42	I						Overlay	0.20	980,000	yes	yes		
5240	240			28.86	28.95	30.63	30.72	0.14	I							0.20	980,000	yes	yes		
5240	240			28.86	28.95	30.63	30.72	0.14	D							0.20	980,000	yes	yes		
5132	291			0.03	0.50	0.03	0.50	0.76	I	E	06/02/97	1997	Class 12.5 mm	PG 70-34	Overlay	0.15	1,900,000	yes	yes	Wellpinit	
5132	291			0.06	0.13	0.06	0.13	0.11	D							0.15	1,900,000	yes	yes		
5132	291			0.50	0.54	0.50	0.54	0.06	I							0.30	1,900,000	yes	yes		
5132	291			0.54	0.66	0.54	0.66	0.19	I							0.15	1,900,000	yes	yes		
5132	291			0.66	0.70	0.66	0.70	0.06	I							0.30	1,900,000	yes	yes		
5132	291			0.70	1.06	0.70	1.06	0.58	I							0.15	1,900,000	yes	yes		
5132	291			1.06	1.10	1.06	1.10	0.06	I							0.30	1,900,000	yes	yes		
5132	291			1.19	1.22	1.19	1.22	0.05	I							0.30	1,900,000	yes	yes		
5132	291			1.22	5.24	1.22	5.24	6.47	I							0.15	1,900,000	yes	yes		
4694	291			5.24	6.77	5.24	6.77	2.46	I	E	04/10/96	1996	Class B	PG58-34	Overlay	0.15	250,000	yes	yes	Wellpinit	
4694	291			7.59	7.91	7.59	7.91	0.51	I							0.15	250,000	yes	yes		
4694	291			7.91	8.49	7.91	8.49	0.93	I							0.35	250,000	yes	yes		
4694	291			8.49	8.78	8.49	8.78	0.47	I							0.15	250,000	yes	yes		
5058	395			26.89	27.30	20.13	20.54	0.66	I	SC	04/10/97	1997	Class A	PG 64-28	Overlay	0.15	9,500,000	yes	no	Pasco	
5058	395			26.89	27.30	20.13	20.54	0.66	D							0.15	9,500,000	yes	no		
5058	395			29.54	30.23	22.78	23.47	1.11	I							0.15	9,500,000	yes	no		
5058	395			29.54	30.27	22.78	23.51	1.17	D							0.15	9,500,000	yes	no		
5058	395			30.23	30.31	23.47	23.55	0.13	I							0.20	9,500,000	yes	no		
5058	395			30.27	30.35	23.51	23.59	0.13	D							0.20	9,500,000	yes	no		
5058	395			30.31	30.39	23.55	23.63	0.13	I							0.15	9,500,000	yes	no		
5058	395			30.35	30.45	23.59	23.69	0.16	D							0.15	9,500,000	yes	no		
5338	395			67.80	78.89	61.24	72.33	17.85	D	E	4/98 - 6/98	1998	Class A	AR4000W	Overlay	0.15	6,500,000	yes	yes	Lind 3 NE	
5338	395			78.89	88.18	72.33	81.62	14.95	D				Class 12.5 mm	PG64-28		0.15	6,500,000	yes	yes		
4625	395			212.60	213.79	207.81	209.00	1.92	I	E	9/95 - 8/96	1996	Class F	AR4000W	Overlay	0.45	1,700,000	yes	yes	Chewelah	
4625	395			213.79	214.44	209.00	209.65	1.05	I							0.50	1,700,000	yes	yes		
4625	395			214.44	215.34	209.65	210.55	1.45	I							0.45	1,700,000	yes	yes		
4625	395			215.34	217.46	210.55	212.67	3.41	I							0.15	1,700,000	yes	yes		
5058	397			11.03	11.23	11.03	11.23	0.32	I	SC	04/10/97	1997	Class A	PG 64-28	Overlay	0.15	6,000,000	yes	no	Pasco	
4712	401			1.00	3.29	1.00	3.29	3.69	I	SW	08/02/95		Class A	PG 58-22	Overlay	0.15	400,000	yes	yes	Naselle 2 ENE	
4712	401			3.29	3.58	3.29	3.58	0.47	I						Reconst	0.35	400,000	yes	yes		
4712	401			3.58	11.00	3.58	11.00	11.94	I						Overlay	0.15	400,000	yes	yes		
4692	410			107.34	107.44	116.27	116.37	0.16	I	SC	07/21/95	1995	Class B	PG 58-22	Overlay	0.15	800,000	yes	no	Naches 10 NW	
4201	504			44.96	45.00	44.99	45.03	0.06	I	SW	6/94 - 3/95	1995	Class A	AR4000W	New Const	0.35	250,000	yes	no	Spud Mountain	
4201	504			45.09	45.62	45.12	45.65	0.85	I							0.35	250,000	yes	no		
4201	504			45.65	47.87	45.68	47.90	3.57	I							0.35	250,000	yes	no		
4201	504			47.97	49.15	48.00	49.18	1.90	I							0.35	250,000	yes	no		
4201	504			49.17	51.78	49.20	51.81	4.20	I							0.35	250,000	yes	no		
4414	509	AR		1.72	3.02	1.72	3.02	2.09	I	O	9/94 - 3/95	1995	Class E	AR4000W	New Const	0.80	180,000	yes	no	Seattle-Tac WSCMO AP	
4414	509	AR		1.72	3.02	1.72	3.02	2.09	D					PBA-6GR		0.80	180,000	yes	no		
4414	509	AR		3.03	3.82	3.03	3.82	1.27	I							0.80	180,000	yes	no		
4414	509	AR		3.03	3.82	3.03	3.82	1.27	D							0.80	180,000	yes	no		
4414	509	AR		3.82	4.06	3.82	4.06	0.39	I						Overlay	0.25	180,000	yes	no		
5415	291			8.78	8.87	8.78	8.87	0.14	I	E	06/29/98	1998	Class A	AR4000W	Inlay	0.15	750,000	yes	yes	Wellpinit	
5415	291			8.87	9.17	8.87	9.17	0.48	I					PG 58-34	Overlay	0.15	750,000	yes	yes		
5415	291			9.17	9.24	9.17	9.24	0.11	I						Inlay	0.15	750,000	yes	yes		
5415	291			9.24	9.64	9.24	9.64	0.64	I						Overlay	0.15	750,000	yes	yes		

Appendix D - Superpave Project Data (Provided by WSDOT Pavement Management Staff)

Contract No.	SR	RRT[1]	RRQ[2]	BARM[3]	EARM[4]	BSRMP[5]	ESRMP[6]	Length (km)	Direction	Region	Mix Design Date	Construction Year	ACP Mix Type	Binder	Construction Type	Wearing Course Thickness (ft)	Design ESAL[8]	Condition Data Available?	FWD Available?	Nearest NOAA Weather Station	Comments
5415	291			9.64	9.90	9.64	9.90	0.42	I						Overlay	0.15	750,000	yes	yes		
5415	291			9.90	10.04	9.90	10.04	0.23	I						Overlay	0.15	750,000	yes	yes		
5415	291			10.06	10.36	10.06	10.36	0.48	I						Overlay	0.15	750,000	yes	yes		
5415	291			10.36	11.07	10.36	11.07	1.14	I						Overlay	0.15	750,000	yes	yes		
5415	291			11.07	11.17	11.07	11.17	0.16	I						Overlay	0.15	750,000	yes	yes		
5424	395			235.68	237.07	230.91	232.30	2.24	I	E	07/10/98	1998	Class B	PG 58-34	?	?	2,450,000	yes	yes	Cheney	
5424	395			237.07	237.09	232.30	232.32	0.03	I						?	?	2,450,000	yes	yes		
5424	395			237.09	237.83	232.32	233.06	1.19	I						?	?	2,450,000	yes	yes		
5424	395			237.83	238.37	233.06	233.60	0.87	I						?	?	2,450,000	yes	yes		
5424	395			238.37	238.55	233.60	233.78	0.29	I						?	?	2,450,000	yes	yes		
5424	395			238.55	239.21	233.78	234.44	1.06	I						?	?	2,450,000	yes	yes		
5424	395			239.21	239.86	234.44	235.09	1.05	I						?	?	2,450,000	yes	yes		
5424	395			239.86	239.92	235.09	235.15	0.10	I						?	?	2,450,000	yes	yes		
5424	395			239.92	240.28	235.15	235.51	0.58	I						?	?	2,450,000	yes	yes		
5424	395			240.28	242.62	235.51	237.85	3.77	I						?	?	2,450,000	yes	yes		
5396	24			5.32	6.15	5.37	6.20	1.34	I	SC	06/15/98	1998	Class A	PG 64-28	Overlay	0.30	900,000	yes	yes	Moxee City 10E	
5396	24			6.15	8.76	6.20	8.81	4.20	I				Class A w/ rap		Overlay	0.30	900,000	yes	yes		
5396	24			8.76	8.78	8.81	8.83	0.03	I						Overlay	0.12	900,000	yes	yes		
5396	24			8.78	8.91	8.83	8.96	0.21	I						Overlay	0.30	900,000	yes	yes		
5396	24			8.91	8.97	8.96	9.02	0.10	I						Overlay	0.30	900,000	yes	yes		
5396	24			8.97	9.93	9.02	9.98	1.54	I						Overlay	0.30	900,000	yes	yes		
5396	24			9.93	12.02	9.98	12.07	3.36	I						Overlay	0.30	900,000	yes	yes		
5396	24			12.02	15.61	12.07	15.66	5.78	I						Overlay	0.30	900,000	yes	yes		
5373	82			36.28	38.40	36.31	38.43	3.41	I	SC	06/22/98	1998	Class 19.0 mm	PG 70-28	Inlay	0.20	12,000,000	yes	yes	Yakima WB AP	
5373	82			38.40	38.46	38.43	38.49	0.10	I				Class A		Inlay	0.20	12,000,000	yes	yes		
5373	82			38.46	38.59	38.49	38.62	0.21	I				Class A w/ rap		Inlay	0.20	12,000,000	yes	yes		
5373	82			38.59	38.78	38.62	38.81	0.31	I						Inlay	0.20	12,000,000	yes	yes		
5373	82			38.78	38.83	38.81	38.86	0.08	I						Inlay	0.20	12,000,000	yes	yes		
5373	82			36.28	38.39	36.31	38.42	3.40	D						Inlay	0.20	12,000,000	yes	yes		
5373	82			38.39	38.45	38.42	38.48	0.10	D						Inlay	0.20	12,000,000	yes	yes		
5373	82			38.45	38.46	38.48	38.49	0.02	D						Inlay	0.20	12,000,000	yes	yes		
5373	82			38.46	38.58	38.49	38.61	0.19	D						Inlay	0.20	12,000,000	yes	yes		
5373	82			38.58	38.72	38.61	38.75	0.23	D						Inlay	0.20	12,000,000	yes	yes		
5408	240			34.78	34.87	36.61	36.70	0.14	I	SC	07/07/98	1998	Class 12.5 mm	PG 64-28	Overlay	0.30	6,000,000	yes	yes	Richland	
5408	240			34.87	35.76	36.70	37.59	1.43	I						Overlay	0.30	6,000,000	yes	yes		
5408	240			35.76	35.91	37.59	37.74	0.24	I						Overlay	0.30	6,000,000	yes	yes		
5408	240			35.91	35.95	37.74	37.78	0.06	I						Inlay	0.08	6,000,000	yes	yes		
5408	240			35.95	38.35	37.78	40.18	3.86	I						Overlay	0.20	6,000,000	yes	yes		
5408	240			38.35	38.90	40.18	40.73	0.89	I						Overlay	0.14	6,000,000	yes	yes		
5408	240			38.90	40.83	40.73	42.66	3.11	I						Overlay	0.20	6,000,000	yes	yes		
5408	240			40.83	40.92	42.66	42.75	0.14	I						Inlay	0.20	6,000,000	yes	yes		
5408	240			40.92	40.99	42.75	42.82	0.11	I						Overlay	0.20	6,000,000	yes	yes		
5408	240			40.99	41.11	42.82	42.94	0.19	I						Overlay	0.20	6,000,000	yes	yes		
5408	240			41.11	41.34	42.94	43.17	0.37	I						Inlay	0.20	6,000,000	yes	yes		
5381	512			3.61	4.35	3.61	4.35	1.19	I	O	06/16/98	1998	Class 12.5 mm	PG 58-22	Overlay	0.15	13,500,000	yes	yes	Puyallup 2 W Exp Stn	
5381	512			3.61	4.35	3.61	4.35	1.19	D							0.15	13,500,000	yes	yes		
5381	512			4.38	5.69	4.38	5.69	2.11	I							0.15	13,500,000	yes	yes		
5381	512			4.38	5.69	4.38	5.69	2.11	D							0.15	13,500,000	yes	yes		
5307	730			0.00	1.40	0.00	1.40	2.25	I	SC	04/03/98	1998	Class 19.0 mm	PG 64-28	Overlay	0.20	5,400,000	yes	yes	Kennewick	
5307	730			1.41	2.12	1.41	2.12	1.14	I							0.20	5,400,000	yes	yes		
5307	730			2.12	5.88	2.12	5.88	6.05	I							0.30	5,400,000	yes	yes		
5307	730	SP	WALU	0.00	0.06	5.82	5.88	0.10	I							0.30	5,400,000	yes	no		
5659	395			88.18	88.50	81.62	81.94	0.51	D	E	08/05/99	1999	Class 12.5 mm	PG 70-28	Overlay	0.15	15,500,000	yes	no	Lind 3 NE	
5659	395			88.50	88.53	81.94	81.97	0.05	D						Overlay	0.15	15,500,000	yes	no		
5659	395			88.53	88.84	81.97	82.28	0.50	D						Overlay	0.15	15,500,000	yes	no		

Appendix D - Superpave Project Data (Provided by WSDOT Pavement Management Staff)

Contract No.	SR	RRT[1]	RRQ[2]	BARM[3]	EARM[4]	BSRMP[5]	ESRMP[6]	Length (km)	Direction	Region	Mix Design Date	Construction Year	ACP Mix Type	Binder	Construction Type	Wearing Course Thickness (ft)	Design ESALs	Condition Data Available?	FWD Available?	Nearest NOAA Weather Station	Comments
5659	395			88.84	89.28	82.28	82.72	0.71	D						Overlay	0.15	15,500,000	yes	no		
5659	395			89.28	89.78	82.72	83.22	0.80	D						Overlay	0.15	15,500,000	yes	no		
5659	395			89.78	92.09	83.22	85.53	3.72	D						Overlay	0.15	15,500,000	yes	no		
5659	395			92.09	94.01	85.53	87.45	3.09	D						Overlay	0.15	15,500,000	yes	no		
5659	395			94.01	94.10	87.45	87.54	0.14	D						Overlay	0.15	15,500,000	yes	no		
5659	395			94.10	94.12	87.54	87.56	0.03	D						Overlay	0.15	15,500,000	yes	no		
5659	395			94.12	94.22	87.56	87.66	0.16	D						Overlay	0.15	15,500,000	yes	no		
5659	395			94.22	101.13	87.66	94.57	11.12	D						Overlay	0.15	15,500,000	yes	no		
5659	395			101.13	101.39	94.57	94.83	0.42	D						Overlay	0.15	15,500,000	yes	no		
5544	2			306.83	307.26	315.04	315.47	0.69	I	E	08/13/99	1999	Class 12.5 mm	PG 64-34	Inlay	0.17	2,000,000	yes	no	Deer Park 2 E	
5544	2			307.26	311.02	315.47	319.23	6.05	I						Inlay	0.17	2,000,000	yes	no		
5544	2			311.02	313.08	319.23	321.29	3.32	I						Inlay	0.17	2,000,000	yes	no		
5544	2			313.08	313.38	321.29	321.66	0.48	I						Inlay	0.17	2,000,000	yes	no		
5544	2			313.38	313.47	321.66	321.75	0.14	I						Inlay	0.17	2,000,000	yes	no		
5544	2			313.47	313.55	321.75	321.83	0.13	I						Inlay	0.17	2,000,000	yes	no		
5544	2			307.26	311.02	315.47	319.23	6.05	D						Inlay	0.17	2,000,000	yes	no		
5544	2			311.02	313.08	319.23	321.29	3.32	D						Inlay	0.17	2,000,000	yes	no		
5544	2			313.08	313.38	321.29	321.66	0.48	D						Inlay	0.17	2,000,000	yes	no		
5636	20			363.25	370.30	363.60	370.65	11.35	I	E		1999	Class 19.0 mm	PG 58-34	Overlay	0.20	7,080,000	yes	yes	Colville AP	
5636	20			370.30	370.31	370.65	370.66	0.02	I						Inlay	0.20	7,080,000	yes	yes		
5636	20			370.31	370.50	370.66	370.85	0.31	I						Overlay	0.20	7,080,000	yes	yes		
5636	20			370.50	372.49	370.85	372.84	3.20	I						Overlay	0.20	7,080,000	yes	yes		
5497	2			242.64	242.70	250.83	250.89	0.10	I	E	04/01/99	1999	Class 12.5 mm	PG 58-34	Overlay	0.15	2,000,000	yes	yes	Davenport	
5497	2			242.70	242.84	250.89	251.03	0.23	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			242.84	243.06	251.03	251.25	0.35	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			243.06	243.16	251.25	251.35	0.16	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			243.16	243.36	251.35	251.55	0.32	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			243.36	243.48	251.55	251.67	0.19	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			243.48	243.62	251.67	251.81	0.23	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			243.62	243.67	251.81	251.86	0.08	I						Inlay	0.15	2,000,000	yes	yes		
5497	2			243.67	243.73	251.86	251.92	0.10	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			243.73	246.64	251.92	254.83	4.68	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			246.64	246.82	254.83	255.01	0.29	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			246.82	246.90	255.01	255.09	0.13	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			246.90	247.82	255.09	256.01	1.48	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			247.82	247.90	256.01	256.09	0.13	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			247.90	248.62	256.09	256.81	1.16	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			248.62	248.72	256.81	256.91	0.16	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			248.72	250.06	256.91	258.25	2.16	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			250.06	250.13	258.25	258.32	0.11	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			250.13	250.69	258.32	258.88	0.90	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			250.69	250.84	258.88	259.03	0.24	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			250.84	251.75	259.03	259.94	1.46	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			251.75	252.10	259.94	260.29	0.56	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			252.10	255.08	260.29	263.27	4.80	I						Overlay	0.15	2,000,000	yes	yes		
5497	2			255.08	255.25	263.27	263.44	0.27	I						Overlay	0.15	2,000,000	yes	yes		
5606	195			8.53	8.92	8.60	9.44	0.63	I	E	June	1999	Class A	PG 64-28	Overlay	0.15	4,000,000	yes	yes	Colfax 1 NW	
5606	195			8.92	9.75	9.44	9.47	1.34	I						Inlay	0.15	4,000,000	yes	yes		
5606	195			9.75	9.78	9.47	10.89	0.05	I						Overlay	0.15	4,000,000	yes	yes		
5606	195			9.78	11.20	10.89	11.10	2.29	I						Overlay	0.15	4,000,000	yes	yes		
5606	195			11.20	11.41	11.10	14.94	0.34	I						Overlay	0.15	4,000,000	yes	yes		
5606	195			11.41	15.25	14.94	15.42	6.18	I						Overlay	0.15	4,000,000	yes	yes		
5606	195			15.25	15.73	15.42	19.79	0.77	I						Overlay	0.15	4,000,000	yes	yes		
5606	195			15.73	20.09	19.79	19.96	7.02	I						Overlay	0.15	4,000,000	yes	yes		
5606	195			20.09	20.26	19.96	22.89	0.27	I						Overlay	0.15	4,000,000	yes	yes		

Appendix D - Superpave Project Data (Provided by WSDOT Pavement Management Staff)

Contract No.	SR	RRT^1	RRQ^2	BARM^3	EARM^4	BSRMP^5	ESRMP^6	Length (km)	Direction	Region	Mix Design Date	Construction Year	ACP Mix Type	Binder	Construction Type	Wearing Course Thickness (ft)	Design ESAL^9	Condition Data Available?	FWD Available?	Nearest NOAA Weather Station	Comments
5606	195			20.26	23.25	22.89	25.85	4.81	I						Overlay	0.15	4,000,000	yes	yes		
5606	195			23.25	24.00	25.85	26.10	1.21	I						Inlay	0.17	4,000,000	yes	yes		
5606	195			24.00	24.25	26.10	27.09	0.40	I						Overlay	0.15	4,000,000	yes	yes		
5606	195			24.25	25.24	27.09	28.75	1.59	I						Inlay	0.17	4,000,000	yes	yes		
5606	195			25.24	26.90	28.75	29.10	2.67	I						Inlay	0.15	4,000,000	yes	yes		
5627	17			35.51	37.73	43.00	45.22	3.57	I	NC	07/08/99	1999	Class 19.0 mm	PG 64-28	Overlay	0.16	3,700,000	yes	yes	Moses Lake 3 E	
5627	17			37.73	40.42	45.22	47.91	4.33	I						Overlay	0.16	3,700,000	yes	yes		
5627	17			40.42	40.60	47.91	48.09	0.29	I						Overlay	0.16	3,700,000	yes	yes		
5627	17			40.60	40.61	48.09	48.10	0.02	I						Inlay	0.16	3,700,000	yes	yes		
5627	17			40.61	40.79	48.10	48.28	0.29	I						Overlay	0.16	3,700,000	yes	yes		
5627	17			40.79	41.15	48.28	48.64	0.58	I						Overlay	0.16	3,700,000	yes	yes		
5627	17			41.15	41.54	48.64	49.03	0.63	I						Overlay	0.16	3,700,000	yes	yes		
5627	17			41.54	42.73	49.03	50.22	1.92	I						Overlay	0.16	3,700,000	yes	yes		
5627	17			42.73	42.91	50.22	50.40	0.29	I						Overlay	0.16	3,700,000	yes	yes		
5654	18			21.53	21.67	21.03	21.17	0.23	I	NW	07/28/99	1999	Class 12.5 mm	PG 64-22	Overlay	0.15	15,000,000	yes	no	Landsburg	
5654	18			21.67	22.36	21.17	21.86	1.11	I						Overlay	0.15	15,000,000	yes	no		
5654	18			22.36	22.64	21.86	22.14	0.45	I						Overlay	0.15	15,000,000	yes	no		
5654	18			22.64	22.86	22.14	22.36	0.35	I						Overlay	0.15	15,000,000	yes	no		
5654	18			22.86	23.34	22.36	22.84	0.77	I						Overlay	0.15	15,000,000	yes	no		
5654	18			23.34	23.98	22.84	23.48	1.03	I						Overlay	0.15	15,000,000	yes	no		
5654	18			23.98	24.07	23.48	23.57	0.14	I						Overlay	0.15	15,000,000	yes	no		
5654	18			24.07	24.19	23.57	23.69	0.19	I						Overlay	0.15	15,000,000	yes	no		
5654	18			24.19	24.47	23.69	23.97	0.45	I						Overlay	0.15	15,000,000	yes	no		
5654	18			24.47	25.56	23.97	25.06	1.75	I						Overlay	0.15	15,000,000	yes	no		
5654	18			25.56	26.17	25.06	25.67	0.98	I						Overlay	0.15	15,000,000	yes	no		
5654	18			26.17	26.37	25.67	25.87	0.32	I						Overlay	0.15	15,000,000	yes	no		
5654	18			26.37	26.80	25.87	26.30	0.69	I						Overlay	0.15	15,000,000	yes	no		
5645	99			17.93	18.09	21.58	21.74	0.26	I	NW	08/05/99	1999	Class 12.5 mm	PG 64-22	Overlay	0.15	2,000,000	yes	no	WB AP	
5645	99			18.09	18.27	21.74	21.92	0.29	I						Overlay	0.15	2,000,000	yes	no		
5645	99			18.27	18.34	21.92	21.99	0.11	I						Overlay	0.15	2,000,000	yes	no		
5645	99			18.34	18.65	21.99	22.30	0.50	I						Overlay	0.15	2,000,000	yes	no		
5645	99			18.65	18.92	22.30	22.57	0.43	I						Overlay	0.15	2,000,000	yes	no		
5645	99			18.92	19.11	22.57	22.76	0.31	I						Overlay	0.15	2,000,000	yes	no		
5645	99			19.11	19.24	22.76	22.89	0.21	I						Overlay	0.15	2,000,000	yes	no		
5645	99			19.24	19.32	22.89	22.978	0.13	I						Overlay	0.15	2,000,000	yes	no		
5645	99			19.38	19.50	23.02	23.14	0.19	I						Overlay	0.15	2,000,000	yes	no		
5645	99			19.50	19.61	23.14	23.25	0.18	I						Overlay	0.15	2,000,000	yes	no		
5645	99			19.61	19.71	23.25	23.35	0.16	I						Overlay	0.15	2,000,000	yes	no		
5645	99			19.71	19.84	23.35	23.48	0.21	I						Overlay	0.15	2,000,000	yes	no		
5645	99			19.84	20.00	23.48	23.64	0.26	I						Overlay	0.15	2,000,000	yes	no		
5645	99			20.00	20.08	23.64	23.72	0.13	I						Overlay	0.15	2,000,000	yes	no		
5645	99			20.08	20.38	23.72	24.02	0.48	I						Overlay	0.15	2,000,000	yes	no		
5645	99			20.38	20.67	24.02	24.31	0.47	I						Overlay	0.15	2,000,000	yes	no		
5645	99			20.67	21.03	24.31	24.67	0.58	I						Overlay	0.15	2,000,000	yes	no		
5645	99			21.03	21.22	24.67	24.86	0.31	I						Overlay	0.15	2,000,000	yes	no		
5645	99			21.22	21.75	24.86	25.39	0.85	I						Overlay	0.15	2,000,000	yes	no		
5645	99			21.75	21.77	25.39	25.41	0.03	I						Overlay	0.15	2,000,000	yes	no		
5645	99			21.77	21.93	25.41	24.57	0.26	I						Overlay	0.15	2,000,000	yes	no		
5645	99			21.93	22.19	24.57	24.83	0.42	I						Overlay	0.15	2,000,000	yes	no		
5645	99			22.19	22.40	24.83	26.04	0.34	I						Overlay	0.15	2,000,000	yes	no		
5645	99			19.33	19.36	22.97	23.00	0.05	D						Overlay	0.15	2,000,000	yes	no		
5645	99			19.36	19.50	23.00	23.14	0.23	D						Overlay	0.15	2,000,000	yes	no		
5645	99			19.50	19.60	23.14	23.24	0.16	D						Overlay	0.15	2,000,000	yes	no		
5645	99			19.60	19.71	23.24	23.35	0.18	D						Overlay	0.15	2,000,000	yes	no		
5645	99			19.71	20.38	23.35	24.02	1.08	D						Overlay	0.15	2,000,000	yes	no		

Appendix D - Superpave Project Data (Provided by WSDOT Pavement Management Staff)

Contract No	SR	RRT^1	RRQ^2	BARM^3	EARM^4	BSRMP^5	ESRMP^6	Length (km)	Direction	Region	Mix Design Data	Construction Year	ACP Mix Type	Binder	Construction Type	Wearing Course Thickness (ft)	Design ESAL^9	Condition Data Available?	FWD Available?	Nearest NOAA Weather Station	Comments
5645	99			20.38	20.76	24.02	24.40	0.61	D						Overlay	0.15	2,000,000	yes	no		
5645	99			20.76	21.00	24.40	24.64	0.39	D						Overlay	0.15	2,000,000	yes	no		
5645	99			21.00	21.09	24.64	24.73	0.14	D						Overlay	0.15	2,000,000	yes	no		
5645	99			21.09	21.23	24.73	24.87	0.23	D						Overlay	0.15	2,000,000	yes	no		
5645	99			21.23	21.35	24.87	24.99	0.19	D						Overlay	0.15	2,000,000	yes	no		
5645	99			21.35	21.42	24.99	25.06	0.11	D						Overlay	0.15	2,000,000	yes	no		
5645	99			21.42	21.75	25.06	25.39	0.53	D						Overlay	0.15	2,000,000	yes	no		
5645	99			21.75	21.77	25.39	25.41	0.03	D						Overlay	0.15	2,000,000	yes	no		
5645	99			21.77	21.93	25.41	25.57	0.26	D						Overlay	0.15	2,000,000	yes	no		
5645	99			21.93	22.34	25.57	25.98	0.66	D						Overlay	0.15	2,000,000	yes	no		
5645	99			22.34	22.40	25.98	26.04	0.10	D						Overlay	0.15	2,000,000	yes	no		
5645	99			22.40	22.48	26.04	26.12	0.13	D						Overlay	0.15	2,000,000	yes	no		
5626	524			3.48	3.56	3.30	3.44	0.13	I	NW		1999	SMA	PG 64-22	Inlay	0.15	2,500,000	yes	yes	Jackson Park	
5626	524			3.56	3.72	3.44	3.60	0.26	I						Inlay	0.15	2,500,000	yes	yes		
5626	524			3.72	3.92	3.60	3.80	0.32	I						Inlay	0.15	2,500,000	yes	yes		
5626	524			3.92	4.01	3.80	3.89	0.14	I						Inlay	0.15	2,500,000	yes	yes		
5626	524			4.01	4.29	3.89	4.17	0.45	I						Inlay	0.15	2,500,000	yes	yes		
5626	524			4.29	4.46	4.17	4.34	0.27	I						Inlay	0.15	2,500,000	yes	yes		
5626	524			4.46	4.73	4.34	4.61	0.43	I						Inlay	0.15	2,500,000	yes	yes		
5626	524			4.73	4.82	4.61	4.70	0.14	I						Inlay	0.15	2,500,000	yes	yes		
5626	524			4.82	5.00	4.70	4.90	0.29	I						Inlay	0.15	2,500,000	yes	yes		
5626	524			3.48	3.56	3.30	3.44	0.13	D						Inlay	0.15	2,500,000	yes	yes		
5626	524			3.56	3.72	3.44	3.60	0.26	D						Inlay	0.15	2,500,000	yes	yes		
5626	524			3.72	3.92	3.60	3.80	0.32	D						Inlay	0.15	2,500,000	yes	yes		
5626	524			3.92	4.01	3.80	3.89	0.14	D						Inlay	0.15	2,500,000	yes	yes		
5626	524			4.01	4.29	3.89	4.17	0.45	D						Inlay	0.15	2,500,000	yes	yes		
5626	524			4.29	4.46	4.17	4.34	0.27	D						Inlay	0.15	2,500,000	yes	yes		
5626	524			4.46	4.73	4.34	4.61	0.43	D						Inlay	0.15	2,500,000	yes	yes		
5626	524			4.73	4.82	4.61	4.70	0.14	D						Inlay	0.15	2,500,000	yes	yes		
5626	524			4.82	5.00	4.70	4.90	0.29	D						Inlay	0.15	2,500,000	yes	yes		
5666	12			31.52	32.20	31.82	32.50	1.09	I	O		1999	Class 12.5 mm	PG 58-22	Overlay	0.13	2,800,000	yes	no	Oakville	
5666	12			32.20	33.27	32.50	33.57	1.72	I						Overlay	0.13	2,800,000	yes	no		
5666	12			33.27	33.95	33.57	34.25	1.09	I						Overlay	0.13	2,800,000	yes	no		
5666	12			33.98	34.20	34.28	34.50	0.35	I						Overlay	0.13	2,800,000	yes	no		
5666	12			34.20	34.67	34.50	34.97	0.76	I						Overlay	0.13	2,800,000	yes	no		
5666	12			34.67	34.73	34.97	35.03	0.10	I						Overlay	0.13	2,800,000	yes	no		
5666	12			34.73	34.89	35.03	35.19	0.26	I						Overlay	0.13	2,800,000	yes	no		
5666	12			34.89	35.06	35.19	35.36	0.27	I						Overlay	0.13	2,800,000	yes	no		
5666	12			35.06	35.27	35.36	35.57	0.34	I						Overlay	0.13	2,800,000	yes	no		
5666	12			35.27	36.42	35.57	36.72	1.85	I						Overlay	0.13	2,800,000	yes	no		
5666	12			36.42	37.29	36.72	37.59	1.40	I						Overlay	0.13	2,800,000	yes	no		
5666	12			37.32	37.94	37.62	38.24	1.00	I						Overlay	0.13	2,800,000	yes	no		
5666	12			37.94	38.32	38.24	38.62	0.61	I						Overlay	0.13	2,800,000	yes	no		
5666	12			38.32	38.42	38.62	38.72	0.16	I						Overlay	0.13	2,800,000	yes	no		
5666	12			38.44	38.54	38.74	38.84	0.16	I						Overlay	0.13	2,800,000	yes	no		
5666	12			38.54	38.82	38.84	39.12	0.45	I						Overlay	0.13	2,800,000	yes	no		
5666	12			38.82	38.89	39.12	39.19	0.11	I						Overlay	0.13	2,800,000	yes	no		
5666	12			38.92	39.00	39.22	39.30	0.13	I						Overlay	0.13	2,800,000	yes	no		
5666	12			39.00	39.33	39.30	39.63	0.53	I						Overlay	0.13	2,800,000	yes	no		
5666	12			39.33	39.56	39.63	39.86	0.37	I						Overlay	0.13	2,800,000	yes	no		
5666	12			39.56	39.57	39.86	39.87	0.02	I						Inlay	0.13	2,800,000	yes	no		
5666	12			39.57	39.71	39.87	40.01	0.23	I						Overlay	0.13	2,800,000	yes	no		
5663	82			30.75	30.79	30.78	30.82	0.06	I	SC		1999	Class 19.0 mm	PG 70-28	Inlay	0.20	19,300,000	yes	no	Yakima WB AP	
5663	82			30.79	30.81	30.82	30.84	0.03	I						Inlay	0.20	19,300,000	yes	no		
5663	82			30.81	30.87	30.84	30.90	0.10	I						Inlay	0.20	19,300,000	yes	no		

Appendix D - Superpave Project Data (Provided by WSDOT Pavement Management Staff)

Contract No.	SR	RRT[1]	RRQ[2]	BARM[3]	EARM[4]	BSRMP[5]	ESRMP[6]	Length (km)	Direction	Region	Mix Design Date	Construction Year	ACP Mix Type	Binder	Construction Type	Wearing Course Thickness (ft)	Design ESAL[7]	Condition Data Available?	FWD Available?	Nearest NOAA Weather Station	Comments
5663	82			30.87	30.93	30.90	30.96	0.10	I						Inlay	0.20	19,300,000	yes	no		
5663	82			30.93	31.00	30.96	31.03	0.11	I						Inlay	0.20	19,300,000	yes	no		
5663	82			31.00	31.10	31.03	31.13	0.16	I						Inlay	0.20	19,300,000	yes	no		
5663	82			31.10	31.17	31.13	31.20	0.11	I						Inlay	0.20	19,300,000	yes	no		
5663	82			31.17	31.96	31.20	31.99	1.27	I						Inlay	0.20	19,300,000	yes	no		
5663	82			31.96	31.99	31.99	32.02	0.05	I						Inlay	0.20	19,300,000	yes	no		
5663	82			31.99	32.44	32.02	32.47	0.72	I						Inlay	0.20	19,300,000	yes	no		
5663	82			32.44	32.48	32.47	32.51	0.06	I						Inlay	0.20	19,300,000	yes	no		
5663	82			32.48	33.80	32.51	33.83	2.12	I						Inlay	0.20	19,300,000	yes	no		
5663	82			33.80	33.81	33.83	33.84	0.02	I						Inlay	0.20	19,300,000	yes	no		
5663	82			33.81	34.85	33.84	34.88	1.67	I						Inlay	0.20	19,300,000	yes	no		
5663	82			34.85	36.26	34.88	36.29	2.27	I						Inlay	0.20	19,300,000	yes	no		
5663	82			36.26	36.28	36.29	36.31	0.03	I						Inlay	0.20	19,300,000	yes	no		
5663	82			30.75	30.81	30.78	30.84	0.10	D						Inlay	0.20	19,300,000	yes	no		
5663	82			30.81	30.87	30.84	30.90	0.10	D						Inlay	0.20	19,300,000	yes	no		
5663	82			30.87	30.93	30.90	30.96	0.10	D						Inlay	0.20	19,300,000	yes	no		
5663	82			30.93	31.09	30.96	31.12	0.26	D						Inlay	0.20	19,300,000	yes	no		
5663	82			31.09	31.96	31.12	31.99	1.40	D						Inlay	0.20	19,300,000	yes	no		
5663	82			31.96	31.99	31.99	32.02	0.05	D						Inlay	0.20	19,300,000	yes	no		
5663	82			31.99	32.44	32.02	32.47	0.72	D						Inlay	0.20	19,300,000	yes	no		
5663	82			32.44	32.48	32.47	32.51	0.06	D						Inlay	0.20	19,300,000	yes	no		
5663	82			32.48	33.11	32.51	33.14	1.01	D						Inlay	0.20	19,300,000	yes	no		
5663	82			33.11	33.80	33.14	33.83	1.11	D						Inlay	0.20	19,300,000	yes	no		
5663	82			33.80	33.81	33.83	33.84	0.02	D						Inlay	0.20	19,300,000	yes	no		
5663	82			33.81	33.95	33.84	33.98	0.23	D						Inlay	0.20	19,300,000	yes	no		
5663	82			33.95	36.26	33.98	36.29	3.72	D						Inlay	0.20	19,300,000	yes	no		
5663	82			36.26	36.28	36.29	36.31	0.03	D						Inlay	0.20	19,300,000	yes	no		
5581	82			82.11	82.31	82.14	82.34	0.32	I	SC	06/16/99	1999	Class 19.0 mm	PG 70-28	Overlay	0.20	11,000,000	yes	yes	Prosser	
5581	82			82.31	84.16	82.34	84.19	2.98	I						Overlay	0.20	11,000,000	yes	yes		
5581	82			84.16	89.94	84.19	89.97	9.30	I						Overlay	0.20	11,000,000	yes	yes		
5581	82			89.94	90.14	89.97	90.17	0.32	I						Overlay	0.20	11,000,000	yes	yes		
5581	82			84.32	90.00	84.35	90.03	9.14	D						Recon	0.74	11,000,000	yes	yes		
5581	82			90.00	90.14	90.03	90.17	0.23	D						Recon	0.74	11,000,000	yes	yes		
5677	12			118.43	118.85	118.73	119.14	0.68	I	SW		1999	Class 12.5 mm	PG 64-28	Overlay	0.15	2,000,000	yes	yes	Alpha	
5677	12			118.85	119.46	119.14	119.75	0.98	I						Overlay	0.15	2,000,000	yes	yes		
5677	12			119.46	120.24	119.75	120.53	1.26	I						Overlay	0.15	2,000,000	yes	yes		
5677	12			120.24	120.25	120.53	120.54	0.02	I						Inlay	0.15	2,000,000	yes	yes		
5677	12			120.25	121.51	120.54	121.80	2.03	I						Overlay	0.15	2,000,000	yes	yes		
5677	12			121.51	121.53	121.80	121.82	0.03	I						Inlay	0.15	2,000,000	yes	yes		
5677	12			121.53	122.30	121.82	122.59	1.24	I						Overlay	0.15	2,000,000	yes	yes		
5677	12			122.30	122.47	122.59	122.76	0.27	I						Overlay	0.15	2,000,000	yes	yes		
5677	12			122.47	122.57	122.76	122.86	0.16	I						Inlay	0.15	2,000,000	yes	yes		
5677	12			122.57	122.68	122.86	122.97	0.18	I						Overlay	0.15	2,000,000	yes	yes		
5677	12			122.68	122.80	122.97	123.09	0.19	I						Overlay	0.15	2,000,000	yes	yes		
5677	12			122.80	122.82	123.09	123.11	0.03	I						Inlay	0.15	2,000,000	yes	yes		
5677	12			122.82	123.23	123.11	123.52	0.66	I						Overlay	0.15	2,000,000	yes	yes		
5677	12			123.23	123.26	123.52	123.55	0.05	I						Inlay	0.15	2,000,000	yes	yes		
5677	12			123.26	123.41	123.55	123.70	0.24	I						Overlay	0.15	2,000,000	yes	yes		
5677	12			123.41	124.07	123.70	124.36	1.06	I						Overlay	0.15	2,000,000	yes	yes		
5677	12			124.07	127.57	124.36	127.86	5.63	I						Overlay	0.15	2,000,000	yes	yes		
5677	12			127.57	127.59	127.86	127.88	0.03	I						Inlay	0.15	2,000,000	yes	yes		
5677	12			127.59	127.88	127.88	128.17	0.47	I						Overlay	0.15	2,000,000	yes	yes		
5677	12			127.88	127.96	128.17	128.25	0.13	I						Overlay	0.15	2,000,000	yes	yes		
5677	12			127.96	127.99	128.25	128.28	0.05	I						Inlay	0.15	2,000,000	yes	yes		
5677	12			127.99	128.07	128.28	128.36	0.13	I						Overlay	0.15	2,000,000	yes	yes		

Appendix D - Superpave Project Data (Provided by WSDOT Pavement Management Staff)

Contract No.	SR	RRT[1]	RRQ[2]	BARM[3]	EARM[4]	BSRMP[5]	ESRMP[6]	Length (km)	Direction	Region	Mix Design Date	Construction Year	ACP Mix Type	Binder	Construction Type	Wearing Course Thickness (ft)	Design ESAL[9]	Condition Data Available?	FWD Available?	Nearest NOAA Weather Station	Comments
5677	12			128.07	128.67	128.36	128.96	0.97	I						Overlay	0.15	2,000,000	yes	yes		
5677	12			128.67	128.68	128.96	128.97	0.02	I						Inlay	0.15	2,000,000	yes	yes		
5677	12			128.68	128.83	128.97	129.12	0.24	I						Overlay	0.15	2,000,000	yes	yes		
5677	12			128.83	129.45	129.12	129.74	1.00	I						Overlay	0.15	2,000,000	yes	yes		
5677	12			129.45	130.48	129.74	130.77	1.66	I						Overlay	0.15	2,000,000	yes	yes		
5677	12			130.48	130.85	130.77	131.14	0.60	I						Inlay	0.15	2,000,000	yes	yes		
5677	12			130.85	131.06	131.14	131.35	0.34	I						Inlay	0.15	2,000,000	yes	yes		
5677	12			131.06	133.13	131.35	133.42	3.33	I						Overlay	0.15	2,000,000	yes	yes		
5677	12			133.15	133.75	133.44	134.04	0.97	I						Overlay	0.15	2,000,000	yes	yes		
5677	12			133.75	134.87	134.04	135.16	1.80	I						Overlay	0.15	2,000,000	no	yes		

1. ID = Database identification number
2. RRT = Related Roadway Type - Indicates a classification of a roadway associated with a mainline route (mainline, alternate route, collector-distributor, couplet, spur, etc.).
3. RRQ = Related Roadway Qualifier - name which uniquely describes the related roadway type.
4. BARM = Beginning accumulated route mile - excludes all equations.
5. EARM = Ending accumulated route mile - excludes all equations.
6. BSRMP = Beginning state route milepost
7. ESRMP = Ending state route milepost
8. CONTR-CONSTR-END-DT = Contract Construction End Date - date which the contract was officially closed.
9. FYI - Prior to 1995 ESAL's were calculated using a 10 year life, 1995 to present, ESAL's are based on a 15 year life. Keep in mind that projects are designed 2 - 3 years in advance of construction.

Appendix E - Superpave Project Data (Extracted from WSPMS)

Contract No	SR	BSRMP[a]	ESRMP[b]	No of Segments	Length (mi)	Direction	Rut (mm)	PSC	IRI (cm/km)	Region	Mix Design Date	Construction Year
5157	2	3.62	4.50	9	0.88	I	1	99	97	NW	7/97 - 4/98	1998
5157	2	3.62	3.83	2	0.21	D	3	84	102			
5157	2	4.50	6.00	15	1.50	I	2	100	81			
5157	2	6.00	6.45	5	0.45	I	1	100	92			
5157	2	6.45	7.90	15	1.45	I	1	100	89			
5157	2	7.90	14.27	63	6.32	I	1	100	86			
5157	2	14.27	16.12	20	1.85	I	5	100	128			
4936	2	37.89	40.73	28	2.84	I	3	100	135	NW	8/96 - 3/97	1997
4936	2	40.73	46.05	52	5.16	I	3	99	133			
5367	2	263.45	263.97	6	0.52	I	2	96	83	E	5/98 - 6/98	1998
5367	2	263.97	266.15	23	2.18	I	2	92	73			
5367	2	266.15	266.86	7	0.71	I	2	83	74			
5367	2	266.86	268.80	19	1.94	I	1	84	78			
5367	2	268.80	271.02	23	2.22	I	2	98	85			
5147	5	0.27	1.52	12	1.25	I	1	100	84	SW	6/97 - 7/97	1997
5147	5	1.52	3.07	16	1.55	I	2	99	91			
5147	5	0.27	0.80	5	0.53	D	1	99	88			
5147	5	0.80	1.30	5	0.50	D	2	99	108			
5147	5	1.30	2.30	10	1.00	D	2	100	111			
5147	5	2.30	3.07	8	0.77	D	1	99	100			
4362	5	87.96	100.52	125	12.56	I	8	100	81	O	Aug-94	1994
4362	5	100.52	101.23	8	0.71	I	3	100	77			
4362	5	97.21	100.52	34	3.31	D	12	88	83			
4362	5	100.52	101.23	8	0.71	D	2	99	63			
4250	5	114.97	115.42	4	0.45	I	4	100	131	O	8/93 - 5/94	1994
4250	5	115.42	115.77	3	0.27	I	2	96	140			
4250	5	115.77	118.33	26	2.55	I	2	99	93			
4250	5	118.33	124.21	59	5.88	I	3	96	89			
4250	5	116.72	117.88	12	1.15	D	2	100	77			
4250	5	117.88	118.33	5	0.45	D	1	100	80			
4250	5	118.33	124.21	59	5.88	D	1	100	80			
4326	5	177.75	181.07	32	3.20	I	3	100	96	NW	3/94 - 5/96	1996
4326	5	177.75	181.07	33	3.29	D	4	94	119			
4676	8	0.00	1.57	16	1.57	I	3	99	102	O	07/01	1995
4676	8	1.57	2.32	9	0.75	I	2	100	80			
4676	8	2.32	10.54	82	8.22	I	2	100	86			

▨

Shade indicates that the beginning or ending mile-post is more than 1.00 off from the original stated milepost

░

Shade indicates indicates a jump in the mileposts.

Appendix E - Superpave Project Data (Extracted from WSPMS)

Contract No	SR	BSRMP	ESRMP	No. of Segments	Length (mi)	Direction	Rut (mm)	PSC	IRI (cm/km)	Region	Mix Design Date	Construction Year
4676	8	0.00	1.57	16	1.57	D	3	100	97			
4676	8	1.57	2.32	9	0.75	D	2	100	77			
4676	8	2.32	8.27	60	5.95	D	2	100	89			
4676	8	8.27	8.77	6	0.50	D	2	36	97			
4676	8	8.77	10.54	18	1.77	D	2	100	81			
5157	9	10.87	12.04	13	1.17	I	5	55	178	NW	7/97 - 4/98	1998
5157	9	12.04	12.46	5	0.42	I	1	94	110			
5077	12	35.36	37.58	23	2.22	I	9	100	136	O	05/09	1997
5077	12	37.58	38.84	13	1.26	I	4	100	101			
5077	12	38.84	42.97	41	4.13	I	3	83	105			
4692	12	185.46	189.80	44	4.39	I	3	98	99	SC	7/95 - 8/95	1995
5307	12	311.37	314.29	29	2.92	I	3	98	92	SC	04/03	1998
5364	14	3.90	5.98	21	2.08	I	1	100	84	SW	05/13	1998
5364	14	5.98	7.93	20	1.95	I	1	100	80			
5364	14	3.90	5.98	21	2.08	D	1	100	77			
5364	14	5.98	7.93	20	1.95	D	2	100	75			
5084	14	27.87	43.93	163	16.17	I	1	100	116	SW	03/01	1998
5124	17	7.67	8.82	14	1.34	I	2	98	94	SC	02/06	1998
5124	17	8.82	9.99	11	1.11	I	1	94	96			
5290	17	21.80	35.60	137	13.80	I	3	100	83	NC	?	1998
5290	17	35.60	43.00	74	7.40	I	2	100	79			
5168	82	0.00	3.23	32	3.23	D	4	97	73	SC	6/97 - 7/97	1997
4818	82	23.89	30.12	63	6.20	I	4	93	76	SC	05/02	1996
4818	82	23.89	30.18	62	6.26	D	3	98	75			
5010	97	64.56	69.00	45	4.44	I	7	92	110	SC	04/02	1997
5010	97	63.83	69.00	52	5.17	I	12	87	86			
4673	97	69.00	69.19	2	0.19	I	8	93	160	SC	06/07	1995
4673	97	69.19	70.15	11	0.96	I	7	94	99			
4673	97	70.15	70.91	9	0.76	I	11	80	89			
4673	97	70.91	74.24	34	3.33	I	12	92	103			
4673	97	69.00	74.24	53	5.24	D	5	93	81			
5377	97	214.98	216.30	13	1.32	I	2	98	100	NC	07/06	1998
5377	97	216.30	219.00	27	2.70	I	2	99	103			
5192	99	0.00	0.22	2	0.16	I	3	100	298	O	06/04	1998
5192	99	0.22	0.65	5	0.43	I	2	98	123			
5192	99	0.65	5.27	9	0.97	I	1	100	111			

Appendix E - Superpave Project Data (Extracted from WSPMS)

Contract No	SR	BSRMP[a]	ESRMP[a]	No. of Segments	Length (mi)	Direction	Rut (mm)	PSC	IRI (cm/km)	Region	Mix Design Date	Construction Year
5192	99	5.27	6.15	8	0.88	I	1	100	104			
5295	99	32.58	33.56	10	0.98	I	1	100	146	NW	04/29	1998
5295	99	33.56	34.17	8	0.61	I	1	100	115			
5295	99	34.17	34.82	7	0.65	I	9	100	200			
5295	99	34.82	40.80	61	5.98	I	1	98	135			
5295	99	32.58	33.94	13	1.32	D	1	99	109			
5295	99	33.94	34.82	10	0.88	D	9	100	193			
5295	99	34.82	40.80	61	5.98	D	1	92	117			
5252	101	[illegible]	[illegible]	66	6.59	I	4	92	122	SW	4/45/98	1998
5184	101	[illegible]	[illegible]	114	11.47	I	2	95	143	SW	6/97 - 7/97	1997
4927	101	361.52	362.59	11	1.07	D	2	100	119	O	07/15	1996
4927	101	362.59	[illegible]	44	4.25	D	2	100	104			
5160	125	0.00	0.83	8	0.83	I	3	100	113	SC	7/96 - 9/97	1998
5160	125	0.83	0.86	1	0.03	I	3	100	197			
5160	125	0.86	1.53	7	0.67	I	3	100	125			
5160	125	1.53	1.55	1	0.02	I	3	100	182			
5160	125	1.55	1.63	2	0.08	I	3	100	166			
5160	125	1.63	3.47	19	1.84	I	5	100	109			
5160	125	3.47	4.50	11	1.02	I	4	100	138			
5160	125	0.00	0.83	8	0.83	D	4	100	127			
5160	125	0.83	0.86	1	0.03	D	3	70	187			
5160	125	0.86	1.53	6	0.63	D	3	100	115			
5160	125	1.53	1.55	1	0.02	D	3	100	142			
5160	125	1.55	1.63	2	0.08	D	3	100	125			
5160	125	1.63	3.47	19	1.84	D	3	100	99			
5160	125	3.47	4.50	11	1.02	D	4	99	111			
5058	182	0.00	0.84	9	0.84	I	1	100	97	SC	04/10	1998
5058	182	0.84	3.70	27	2.86	I	2	93	102			
5058	182	3.70	5.40	17	1.70	I	2	100	100			
5058	182	5.40	6.04	6	0.64	I	1	93	109			
5058	182	6.04	12.30	62	6.26	I	2	95	109			
5058	182	12.30	15.19	29	2.89	I	1	100	69			
5058	182	12.33	15.19	29	2.86	D	2	98	71			
5240	240	[illegible]	28.62	50	4.95	I	9	95	134	SC	09/25	1997
5240	240	28.62	32.02	15	1.39	I	4	99	90			
5240	240	30.63	32.02	15	1.39	D	3	96	89			

Appendix E - Superpave Project Data (Extracted from WSPMS)

Contract No.	SR	BSRMP³	ESRMP³	No. of Segments	Length (mi)	Direction	Rut (mm)	PSC	IRI (cm/km)	Region	Mix Design Date	Construction Year
5132	291	0.00	[illegible]	75	7.47	I	2	96	120	E	06/02	1997
5132	291	0.00	[illegible]	51	5.16	D	2	97	150			
4694	291	0.00	[illegible]	75	7.47	I	2	96	120	E	04/10	1996
4694	291	7.53	[illegible]	36	3.54	I	1	100	97			
5058	395	20.33	20.59	2	0.17	I	1	100	81	SC	04/10	1997
5058	395	22.72	23.63	8	0.85	I	1	98	117			
5058	395	20.33	20.59	2	0.17	D	2	89	98			
5058	395	22.72	23.69	9	0.91	D	2	59	89			
5338	395	61.24	81.64	204	20.40	D	3	94	70	E	4/98 - 6/98	1998
4625	395	207.80	212.67	49	4.87	I	3	97	98			
5058	397	10.60	11.23	6	0.63	I	2	96	87	SC	04/10	1997
4712	401	1.00	3.58	26	2.58	I	3	87	97	SW	08/02	
4712	401	3.58	4.70	12	1.12	I	3	81	110			
4712	401	4.70	10.13	55	5.43	I	2	98	103			
4712	401	10.13	11.41	14	1.28	I	2	64	93			
4692	410	116.27	116.37	1	0.10	I	2	100	124	SC	07/21	1995
4201	504	[illegible]	46.82	162	16.36	I	2	97	97	SW	6/94 - 3/95	1995
4201	504	46.82	51.81	49	4.89	I	2	100	114			
4414	509	1.64	3.20B	16	1.56	I	6	100	174	O	9/94 - 3/95	1995
4414	509	3.76B	3.20	25	2.63	I	5	97	163			
4414	509	3.20	[illegible]	25	2.50	I	6	50	194			
4414	509	1.64	3.20B	16	1.56	D	2	100	151			
4414	509	3.76B	[illegible]	17	1.88	D	1	100	151			
5415	291	[illegible]	11.07	36	3.54	I	1	100	97			
5424	395	230.17	232.32	23	2.15	I	4	75	128	E	07/10	1998
5424	395	232.32	233.06	8	0.74	I	5	93	102			
5424	395	233.06	234.44	15	1.38	I	5	84	129			
5424	395	234.44	[illegible]	48	4.74	I	5	92	112			
5396	24	5.24	9.02	37	3.73	I	2	98	68	SC	06/15	1998
5396	24	9.02	9.98	10	0.96	I	2	90	74			
5396	24	9.98	12.07	22	2.09	I	2	76	60			
5396	24	12.07	15.68	37	3.61	I	2	93	62			
5373	82	36.29	38.49	22	2.20	I	2	97	69	SC	06/22	1998
5373	82	38.49	38.81	5	0.32	I	2	100	84			
5373	82	36.29	38.49	22	2.20	D	1	100	71			
5373	82	38.49	38.75	3	0.26	D	1	100	86			

Appendix E - Superpave Project Data (Extracted from WSPMS)

Contract No.	SR	BSRMP[5]	ESRMP[6]	No. of Segments	Length (mi)	Direction[7]	Rut (mm)	PSC	IRI (cm/km)	Region	Mix Design Date	Construction Year
5408	240	36.05	43.17	70	6.99	I	1	95	76			
5381	512	3.61	5.69	21	2.08	I	2	98	71	O	06/16	1998
5381	512	3.61	5.69	21	2.08	D	2	100	68			
5307	730	0.00	6.08	61	6.08	I	2	100	84	SC	04/03	1998
5659	395	81.64	83.22	16	1.58	D	4	83	97	E	08/05	1999
5659	395	83.22	94.83	116	11.61	D	7	73	97			
5544	2	314.94	315.47	6	0.53	I	2	71	98	E	08/13	1999
5544	2	315.47	321.29	58	5.82	I	3	48	117			
5544	2	315.47	321.29	58	5.82	D	2	63	89			
5544	2	321.29	321.66	4	0.30	D	1	51	110			
5636	20	363.84	372.84	90	9.00	I	5	38	196			
5497	2	250.83	251.35	6	0.52	I	7	100	610			
5497	2	251.35	263.45	122	12.10	I	2	100	172			
5606	195	8.60	10.89	22	2.29	I	6	77	117	E	June	1999
5606	195	10.89	22.89	121	12.05	I	5	59	109			
5606	195	22.89	25.85	9	0.75	I	7	79	109			
5606	195	25.85	27.09	13	1.24	I	8	42	187			
5606	195	27.09	29.10	21	2.01	I	9	73	154			
5627	17	43.00	50.40	74	7.40	I	5	70	97			
5654	18	21.04	21.86	9	0.82	I	4	99	132	NW	07/28	1999
5654	18	21.86	22.84	11	0.98	I	4	69	159			
5654	18	22.84	23.57	8	0.73	I	3	77	131			
5654	18	23.57	25.06	16	1.49	I	5	66	154			
5654	18	25.06	26.90	18	1.74	I	9	92	143			
5645	99	20.43	22.97B	26	2.54	I	4	54	194	NW	08/05	1999
5645	99	22.97	24.02	11	1.00	I	7	53	153			
5645	99	24.02	26.03	21	2.01	I	6	88	133			
5645	99	22.97	24.40	14	1.40	D	8	65	102			
5645	99	24.40	26.12	17	1.72	D	14	85	127			
5626	524	3.26	5.29	20	1.94	I	5	89	291	NW		1999
5626	524	3.26	3.89	7	0.63	D	5	75	422			
5626	524	3.89	4.70	9	0.81	D	5	94	282			
5666	12	31.82	35.36	35	3.54	I	7	99	140	O		1999
5666	12	35.36	37.58	23	2.22	I	9	100	136			
5666	12	37.58	38.84	13	1.26	I	4	100	101			
5666	12	38.84	42.97	41	4.13	I	3	83	105			

Appendix E - Superpave Project Data (Extracted from WSPMS)

Contract No.	SR	BSRMP[6]	ESRMP[7]	No. of Segments	Length (mi)	Direction	Rut (mm)	PSC	IRI (cm/km)	Region	Mix Design Date	Construction Year
5663	82	30.78	30.82	1	0.01	I	2	100	188	SC		1999
5663	82	30.82	30.90	1	0.06	I	2	99	125			
5663	82	30.90	30.96	1	0.06	I	5	84	203			
5663	82	30.96	36.29	51	5.22	I	12	98	115			
5663	82	30.78	30.84	1	0.06	D	3	100	191			
5663	82	30.84	30.90	1	0.06	D	3	100	191			
5663	82	30.90	36.29	53	5.39	D	13	96	109			
5581	82	82.14	90.17	81	8.03	I	10	84	132	SC	06/16	1999
5581	82	84.35	90.15	57	5.67	D	11	96	153			
5677	12	118.73	120.54	19	1.81	I	11	87	121	SW		1999
5677	12	120.54	122.86	23	2.22	I	4	81	149			
5677	12	122.86	128.99	61	6.09	I	6	94	115			
5677	12	128.99	131.07	21	2.08	I	6	85	136			
5677	12	131.07	134.04	31	2.97	I	4	95	136			
5677	12	134.04	134.20	2	0.16	I	3	99	124			
5677	12	134.20	[illegible]	38	3.84	I	2	96	114			

1. ID = Database identification number
2. RRT = Related Roadway Type - indicates a classification of a roadway associated with a mainline route (mainline, alternate route, collector-distributor, couplet, spur, etc.).
3. RRQ = Related Roadway Qualifier - name which uniquely describes the related roadway type.
4. BARM = Beginning accumulated route mile - excludes all equations.
5. EARM = Ending accumulated route mile - excludes all equations.
6. BSRMP = Beginning state route milepost
7. ESRMP = Ending state route milepost
8. CONTR-CONSTR-END-DT = Contract Construction End Date - date which the contract was officially closed.
9. FYI - Prior to 1995 ESAL's were calculated using a 10 year life, 1995 to present, ESAL's are based on a 15 year life. Keep in mind that projects are designed 2 - 3 years in advance of construction.

Appendix E - Superpave Project Data (Extracted from WSPMS)

							DEFECT TYPE																				
							Alligator Cracking			Longitudinal Crack			Transverse Crack			Patching			Ravelling			Flushing			Rutting		
Contract	SR	BSRMP*	ESRMP*	Segments	Length (mi)	Direction	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
5157	2	3.62	4.50	9	0.88	I				1																	
5157	2	3.62	3.83	2	0.21	D				25	13																
5157	2	4.50	6.00	15	1.50	I																					
5157	2	6.00	6.45	5	0.45	I																					
5157	2	6.45	7.90	15	1.45	I																					
5157	2	7.90	14.27	63	6.32	I																					
5157	2	14.27	16.12	20	1.85	I																					
4936	2	37.89	40.73	28	2.84	I																					
4936	2	40.73	[illegible]	52	5.16	I																					
5367	2	263.45	263.97	6	0.52	I																					
5367	2	263.97	266.15	23	2.18	I																					
5367	2	266.15	266.86	7	0.71	I									2												
5367	2	266.86	268.80	19	1.94	I									1												
5367	2	268.80	271.02	23	2.22	I																					
5147	5	0.27	1.52	12	1.25	I																					
5147	5	1.52	3.07	16	1.55	I																					
5147	5	0.27	0.80	5	0.53	D																					
5147	5	0.80	1.30	5	0.50	D				1																	
5147	5	1.30	2.30	10	1.00	D																					
5147	5	2.30	3.07	8	0.77	D				1																	
4362	5	87.96	100.52	125	12.56	I																					
4362	5	100.52	101.23	8	0.71	I																					
4362	5	97.21	100.52	34	3.31	D				13																	
4362	5	100.52	101.23	8	0.71	D																					
4250	5	114.97	115.42	4	0.45	I																					
4250	5	115.42	115.77	3	0.27	I																					
4250	5	115.77	118.33	26	2.55	I																					
4250	5	118.33	124.21	59	5.88	I																					
4250	5	116.72	117.88	12	1.15	D																					
4250	5	117.88	118.33	5	0.45	D																					
4250	5	118.33	124.21	59	5.88	D																					
4326	5	177.75	181.07	32	3.20	I																					
4326	5	177.75	181.02	33	3.29	D					4																
4676	8	0.00	1.57	16	1.57	I				1																	
4676	8	1.57	2.32	9	0.75	I																					
4676	8	2.32	10.54	82	8.22	I																					
4676	8	0.00	1.57	16	1.57	D																					
4676	8	1.57	2.32	9	0.75	D																					
4676	8	2.32	8.27	60	5.95	D																					
4676	8	8.27	8.77	6	0.50	D				1								17									
4676	8	8.77	10.54	18	1.77	D																					

Appendix E - Superpave Project Data (Extracted from WSPMS)

							DEFECT TYPE																				
							Alligator Cracking			Longitudinal Crack			Transverse Crack			Patching			Ravelling			Flushing			Faulting		
Contract	SR	BSRMP[3]	ESRMP[4]	Segments	Length (mi)	Direction	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
5157	9	10.87	12.04	13	1.17	I				8			1			28											
5157	9	12.04	12.46	5	0.42	I										1											
5077	12	35.36	37.58	23	2.22	I																					
5077	12	37.58	38.84	13	1.26	I																					
5077	12	38.84	42.97	41	4.13	I					1						3										
4692	12	185.46	189.80	44	4.39	I																					
5307	12	311.37	314.29	29	2.92	I																					
5364	14	3.90	5.98	21	2.08	I																					
5364	14	5.98	7.93	20	1.95	I																					
5364	14	3.90	5.98	21	2.08	D																					
5364	14	5.98	7.93	20	1.95	D																					
5084	14	27.87	43.93	163	16.17	I																2	3				
5124	17	7.43	8.82	14	1.34	I				3																	
5124	17	8.82	9.99	11	1.11	I				10																	
5290	17	21.80	35.60	137	13.80	I																					
5290	17	35.60	43.00	74	7.40	I																					
5168	82	0.00	3.23	32	3.23	D																					
4818	82	23.89	30.12	63	6.20	I				1			1														
4818	82	23.89	30.18	62	6.26	D																					
5010	97	64.56	69.00	45	4.44	I				5			2														
5010	97	63.83	69.00	52	5.17	I				1			2				1						14				
4673	97	69.00	69.19	2	0.19	I							2									1					
4673	97	69.19	70.15	11	0.96	I				2			1														
4673	97	70.15	70.91	9	0.76	I				1			2				3										
4673	97	70.91	74.24	34	3.33	I				1			2														
4673	97	69.00	74.24	53	5.24	D							2														
5377	97	214.98	216.30	13	1.32	I																					
5377	97	216.30	219.00	27	2.70	I																	1				
5192	99	0.00	0.22	2	0.16	I																					
5192	99	0.22	0.65	5	0.43	I					1																
5192	99	0.65	5.27	9	0.97	I																					
5192	99	5.27	6.15	8	0.88	I																					
5295	99	32.58	33.56	10	0.98	I																					
5295	99	33.56	34.17	8	0.61	I																					
5295	99	34.17	34.82	7	0.65	I																					
5295	99	34.82	40.80	61	5.98	I																					
5295	99	32.58	33.94	13	1.32	D																					
5295	99	33.94	34.82	10	0.88	D																					
5295	99	34.82	40.80	61	5.98	D				5		1															
5252	101	20.61	27.20	66	6.59	I				1	1																
5184	101	14.74	26.21	114	11.47	I				8																	

Appendix E - Superpave Project Data (Extracted from WSPMS)

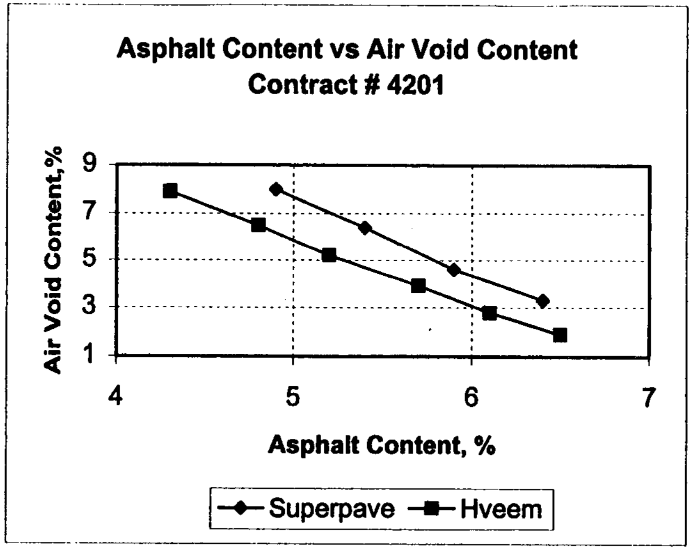
							DEFECT TYPE																				
							Alligator Cracking			Longitudinal Crack			Transverse Crack			Patching			Ravelling			Flushing			Faulting		
Contract	SR	BSRMP	ESRMP	Segments	Length (mi)	Direction	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
4927	101	361.52	362.59	11	1.07	D																					
4927	101	362.59	366.84	44	4.25	D																					
5160	125	0.00	0.83	8	0.83	I																					
5160	125	0.83	0.86	1	0.03	I																					
5160	125	0.86	1.53	7	0.67	I																					
5160	125	1.53	1.55	1	0.02	I																					
5160	125	1.55	1.63	2	0.08	I																					
5160	125	1.63	3.47	19	1.84	I																					
5160	125	3.47	4.50	11	1.02	I																					
5160	125	0.00	0.83	8	0.83	D																					
5160	125	0.83	0.86	1	0.03	D																				11	
5160	125	0.86	1.53	6	0.63	D																					
5160	125	1.53	1.55	1	0.02	D																					
5160	125	1.55	1.63	2	0.08	D																					
5160	125	1.63	3.47	19	1.84	D																					
5160	125	3.47	4.50	11	1.02	D																					
5058	182	0.00	0.84	9	0.84	I																					
5058	182	0.84	3.70	27	2.86	I																					
5058	182	3.70	5.40	17	1.70	I																					
5058	182	5.40	6.04	6	0.64	I																				1	
5058	182	6.04	12.30	62	6.26	I																					
5058	182	12.30	15.19	29	2.89	I																					
5058	182	12.33	15.19	29	2.86	D																					
5240	240	[illegible]	28.62	50	4.95	I				5	1		1														
5240	240	28.62	32.02	15	1.39	I				1												1	90				
5240	240	30.63	32.02	15	1.39	D				6																	
5132	291	0.00	[illegible]	75	7.47	I				1			1														
5132	291	0.00	[illegible]	51	5.16	D							1														
4694	291	0.00	[illegible]	75	7.47	I				1			1														
4694	291	7.53	11.07	36	3.54	I																					
5058	395	20.33	20.59	2	0.17	I																					
5058	395	22.72	23.63	8	0.85	I				1																	
5058	395	20.33	20.59	2	0.17	D				21	3																
5058	395	22.72	23.69	9	0.91	D										25						1					
5338	395	61.24	81.64	204	20.40	D																					
4625	395	207.80	212.67	49	4.87	I				3																	
5058	397	10.60	11.23	6	0.63	I							1														
4712	401	1.00	3.58	26	2.58	I												1									
4712	401	3.58	4.70	12	1.12	I												1									
4712	401	4.70	10.13	55	5.43	I																					
4712	401	10.13	11.41	14	1.28	I	1	3	1			20															

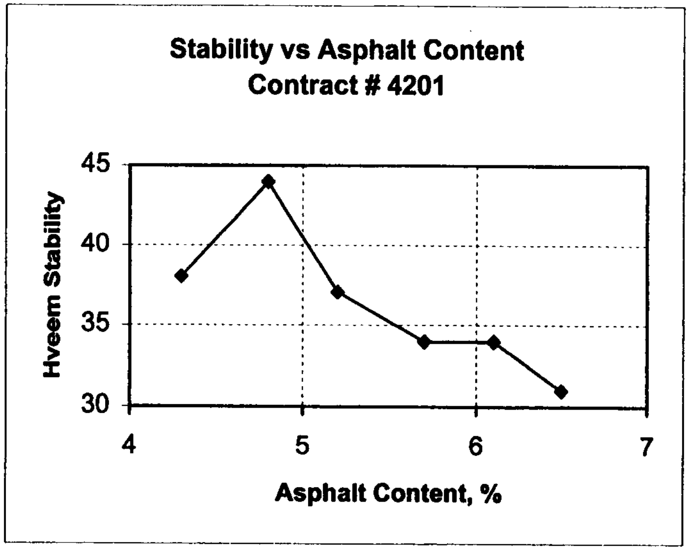
Appendix E - Superpave Project Data (Extracted from WSPMS)

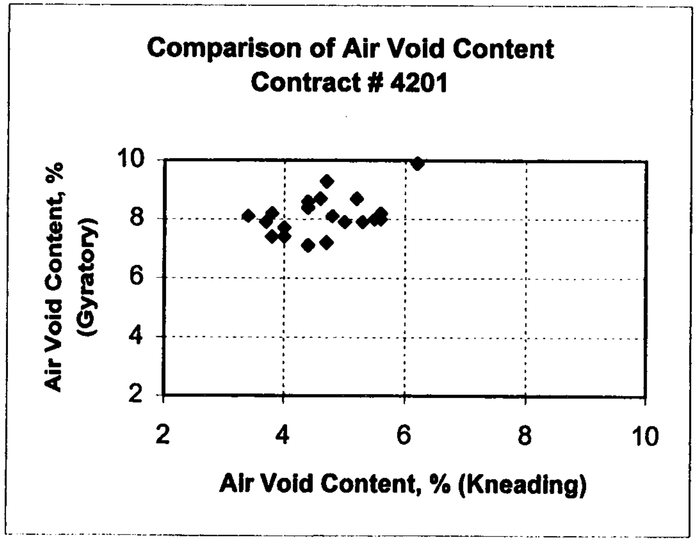
Contract	SR	BSRMP[1]	ESRMP[2]	Segments	Length (mi)	Direction	DEFECT TYPE																				
							Alligator Cracking			Longitudinal Crack			Transverse Crack			Patching			Ravelling			Flushing			Faulting		
							Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
4692	410	116.27	116.37	1	0.10	I																					
4201	504	29.92	46.82	162	16.36	I				1																	
4201	504	46.82	51.81	49	4.89	I																					
4414	509	1.64	3.20B	16	1.56	I																					
4414	509	3.76B	3.20	25	2.63	I																					
4414	509	3.20	5.70	25	2.50	I			1	2	12	38	1	1	2		7										
4414	509	1.64	3.20B	16	1.56	D																					
4414	509	3.76B	5.64B	17	1.88	D																					
5415	291	7.53	11.07	36	3.54	I																					
5424	395	230.17	232.32	23	2.15	I				4	16	7						1									
5424	395	232.32	233.06	8	0.74	I																					
5424	395	233.06	234.44	15	1.38	I								1	1												
5424	395	234.44	239.18	48	4.74	I				3			2														
5396	24	5.24	9.02	37	3.73	I				1																	
5396	24	9.02	9.98	10	0.96	I	1			12																	
5396	24	9.98	12.07	22	2.09	I	7			14																	
5396	24	12.07	15.68	37	3.61	I	1			1																	
5373	82	36.29	38.49	22	2.20	I					1																
5373	82	38.49	38.81	5	0.32	I																					
5373	82	36.29	38.49	22	2.20	D																					
5373	82	38.49	38.75	3	0.26	D																					
5408	240	36.05	43.17	70	6.99	I				7																	
5381	512	3.61	5.69	21	2.08	I				1																	
5381	512	3.61	5.69	21	2.08	D																					
5307	730	0.00	6.08	61	6.08	I																					
5659	395	81.64	83.22	16	1.58	D				23	14																
5659	395	83.22	94.83	116	11.61	D	1			18	24			2								1	35	4			
5544	2	314.94	315.47	6	0.53	I				46	7	21															
5544	2	315.47	321.29	58	5.82	I	5	1		67	74	21															
5544	2	315.47	321.29	58	5.82	D	1			64	48	11															
5544	2	321.29	321.66	4	0.30	D				119	89																
5636	20	363.84	372.84	90	9.00	I	2			26			1	1			27										
5497	2	250.83	251.35	6	0.52	I																					
5497	2	251.35	263.45	122	12.10	I																					
5606	195	8.60	10.89	22	2.29	I				5	6	11			1												
5606	195	10.89	22.89	121	12.05	I	5	1	2	9	18	18			1	1											
5606	195	22.89	25.85	9	0.75	I	1			45					1												
5606	195	25.85	27.09	13	1.24	I	15		8	8						3											
5606	195	27.09	29.10	21	2.01	I	1		1	12					1	9											
5627	17	43.00	50.40	74	7.40	I	5	2		13	3						2										
5654	18	21.04	21.86	9	0.82	I				1																	

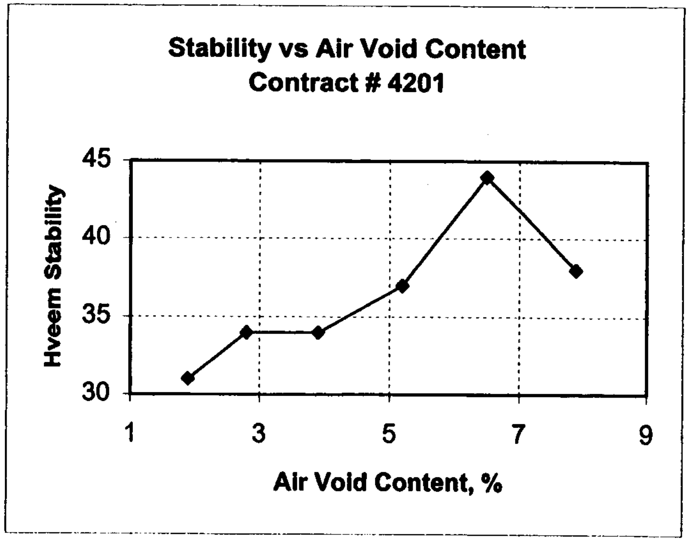
Appendix E - Superpave Project Data (Extracted from WSPMS)

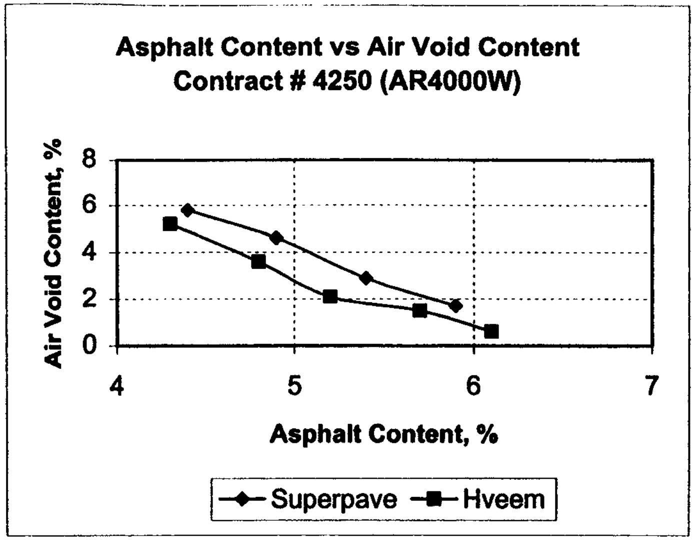
							DEFECT TYPE																				
							Alligator Cracking			Longitudinal Crack			Transverse Crack			Patching			Ravelling			Flushing			Faulting		
Contract	SR	BSRMP^{1}	ESRMP^{2}	Segments	Length (mi)	Direction	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
5654	18	21.86	22.84	11	0.98	I				19	5	18				8											
5654	18	22.84	23.57	8	0.73	I				11	8	17															
5654	18	23.57	25.06	16	1.49	I				31	39	18															
5654	18	25.06	26.90	18	1.74	I				11	2																
5645	99	20.43	22.97B	26	2.54	I	1	7	1	11	43	9		1													
5645	99	22.97	24.02	11	1.00	I	12			1	5	4				14	4										
5645	99	24.02	26.03	21	2.01	I	1			6	3						1										
5645	99	22.97	24.40	14	1.40	D	6	2	2			2															
5645	99	24.40	26.12	17	1.72	D						1				1	2										
5626	524	3.26	5.29	20	1.94	I				8	6	1															
5626	524	3.26	3.89	7	0.63	D	1	1			26	5															
5626	524	3.89	4.70	9	0.81	D				1	3																
5666	12	31.82	35.36	35	3.54	I																					
5666	12	35.36	37.58	23	2.22	I																					
5666	12	37.58	38.84	13	1.26	I																					
5666	12	38.84	42.97	41	4.13	I					1						3										
5663	82	30.78	30.82	1	0.01	I																					
5663	82	30.82	30.90	1	0.06	I				1																	
5663	82	30.90	30.96	1	0.06	I																			4	4	
5663	82	30.96	36.29	51	5.22	I																					
5663	82	30.78	30.84	1	0.06	D																					
5663	82	30.84	30.90	1	0.06	D																					
5663	82	30.90	36.29	53	5.39	D																					
5581	82	82.14	90.17	81	8.03	I	1			8	1	1					1					1					
5581	82	84.35	90.15	57	5.67	D				6																	
5677	12	118.73	120.54	19	1.81	I				18	1																
5677	12	120.54	122.86	23	2.22	I	2			49																	
5677	12	122.86	128.99	61	6.09	I				6																	
5677	12	128.99	131.07	21	2.08	I				4								1									
5677	12	131.07	134.04	31	2.97	I				7																	
5677	12	134.04	134.20	2	0.16	I				1																	
5677	12	134.20	138.09	38	3.84	I				6																	

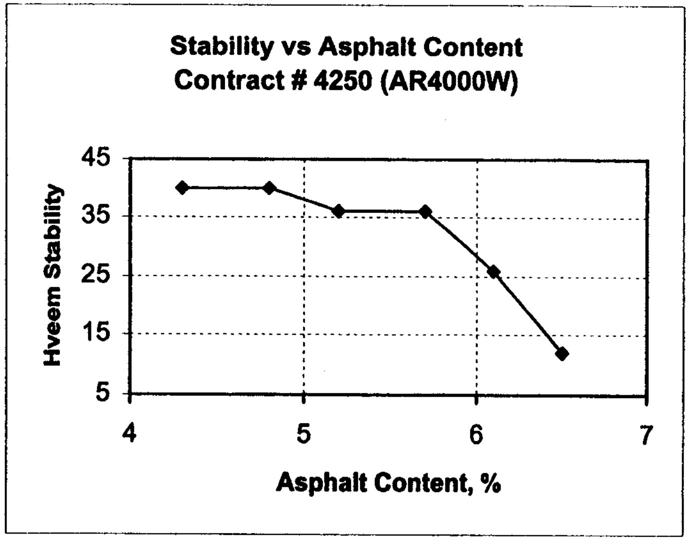

Asphalt Content vs Air Void Content
Contract # 4201

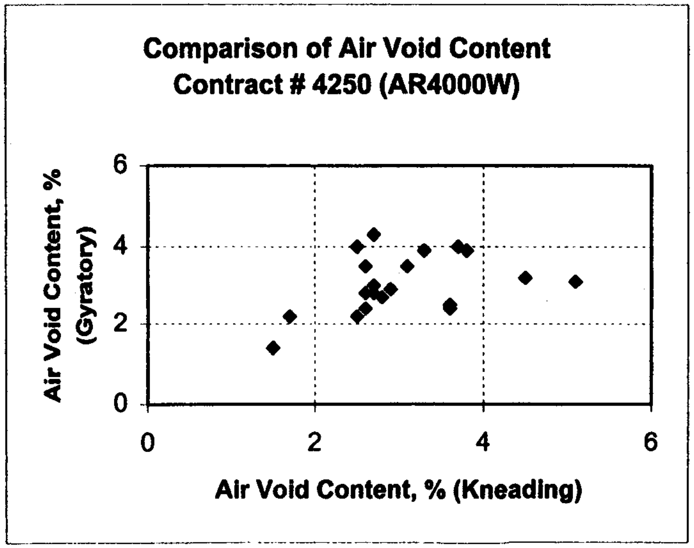

Stability vs Asphalt Content
Contract # 4201

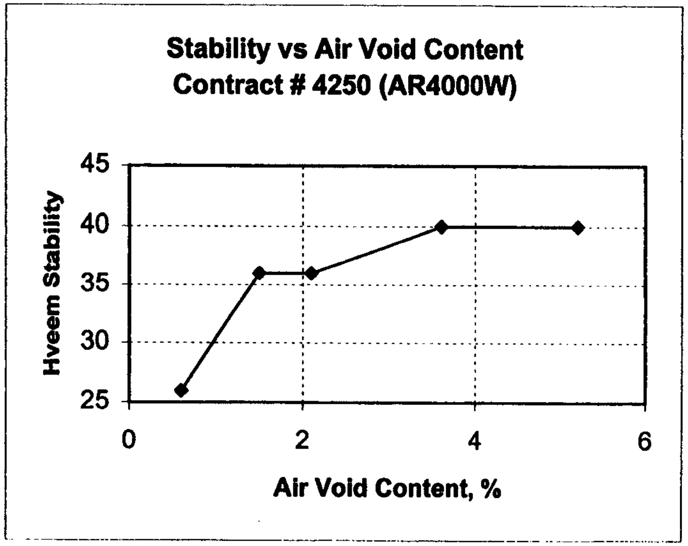

Comparison of Air Void Content
Contract # 4201


Stability vs Air Void Content
Contract # 4201

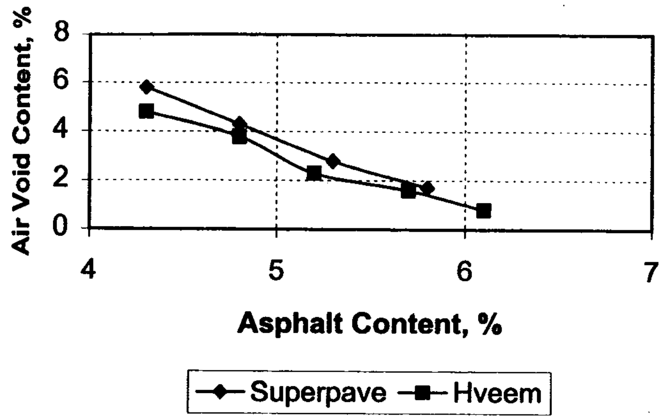

Asphalt Content vs Air Void Content
Contract # 4250 (AR4000W)


Stability vs Asphalt Content
Contract # 4250 (AR4000W)

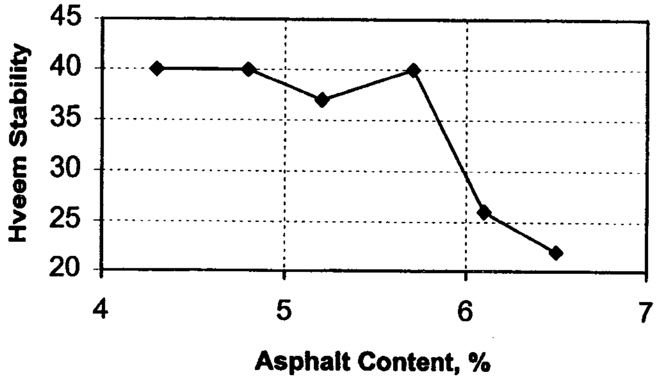

Comparison of Air Void Content
Contract # 4250 (AR4000W)


Stability vs Air Void Content
Contract # 4250 (AR4000W)

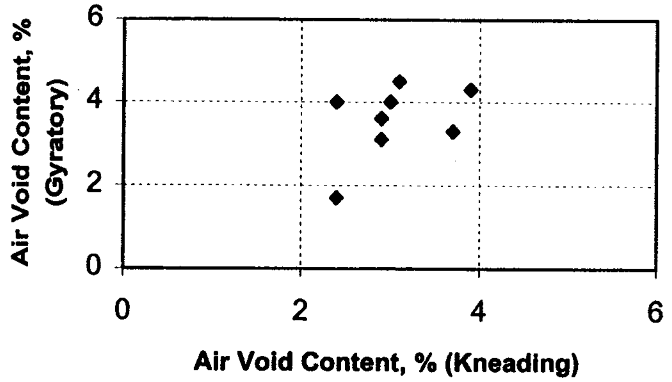
Asphalt Content vs Air Void Content
Contract # 4250 (PBA-6)



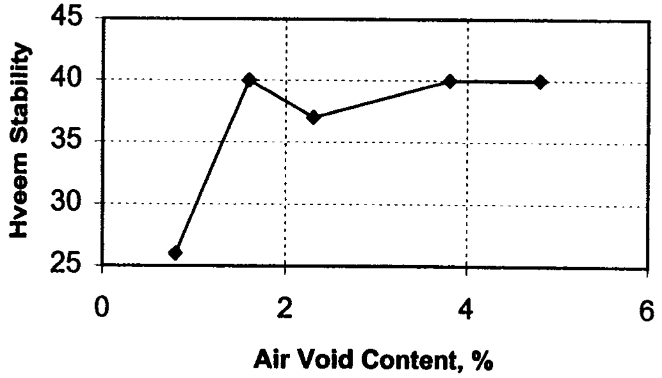
Stability vs Asphalt Content
Contract # 4250 (PBA-6)

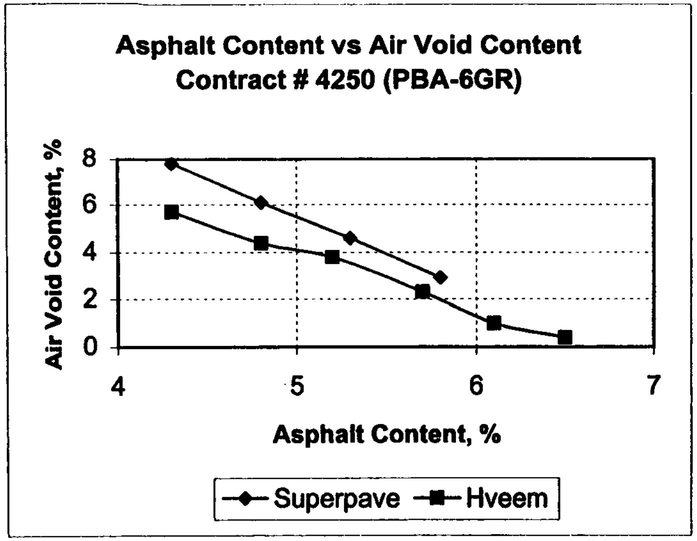


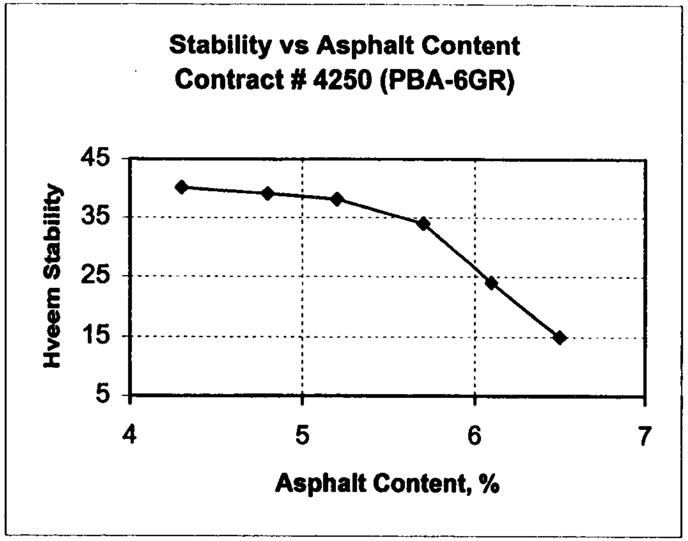
Comparison of Air Void Content
Contract # 4250 (PBA-6)



Stability vs Air Void Content
Contract # 4250 (PBA-6)




Asphalt Content vs Air Void Content
Contract # 4250 (PBA-6GR)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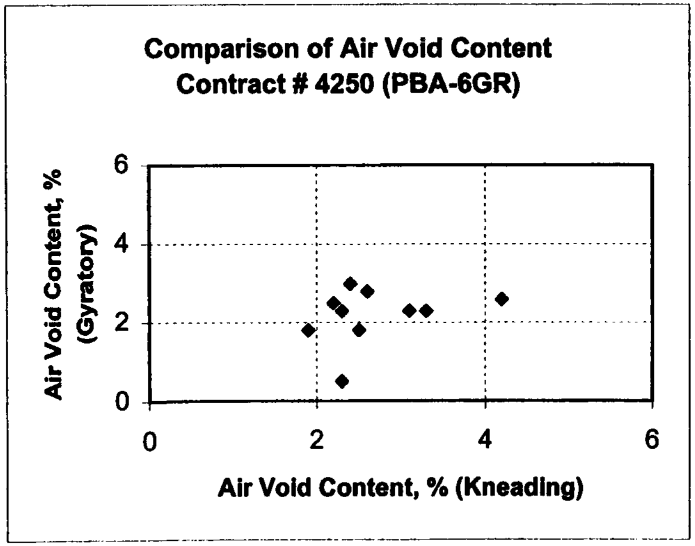
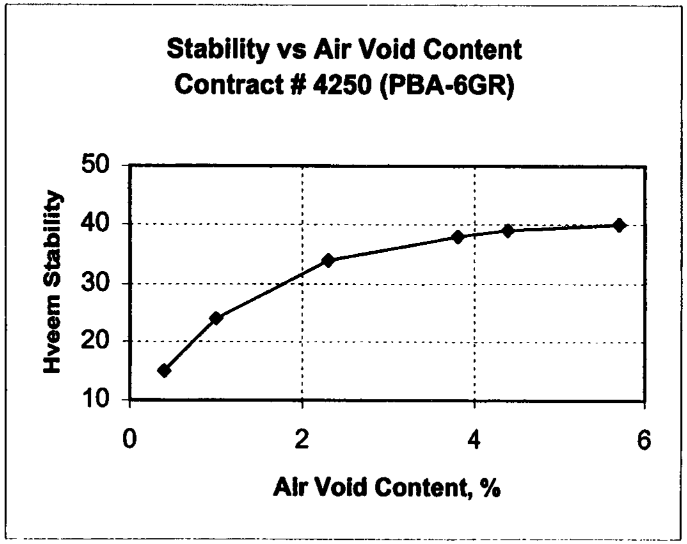
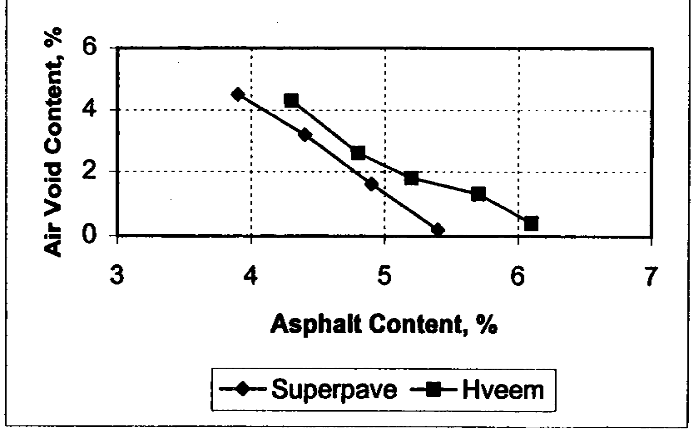
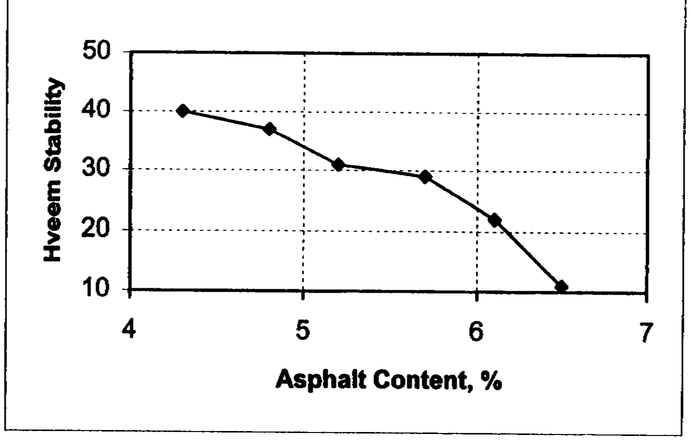
Contract # 4250 (PBA-6GR)


Comparison of Air Void Content
Contract # 4250 (PBA-6GR)

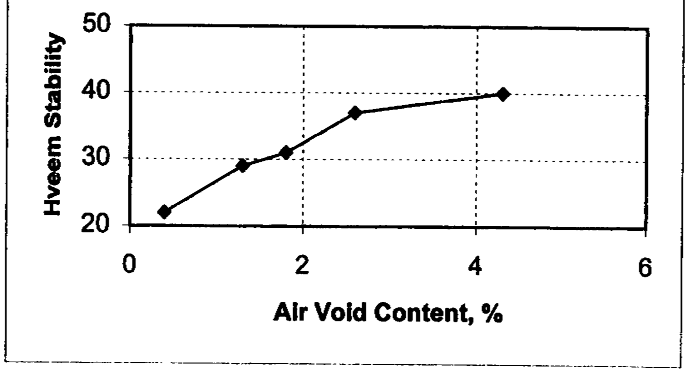

Stability vs Air Void Content
Contract # 4250 (PBA-6GR)



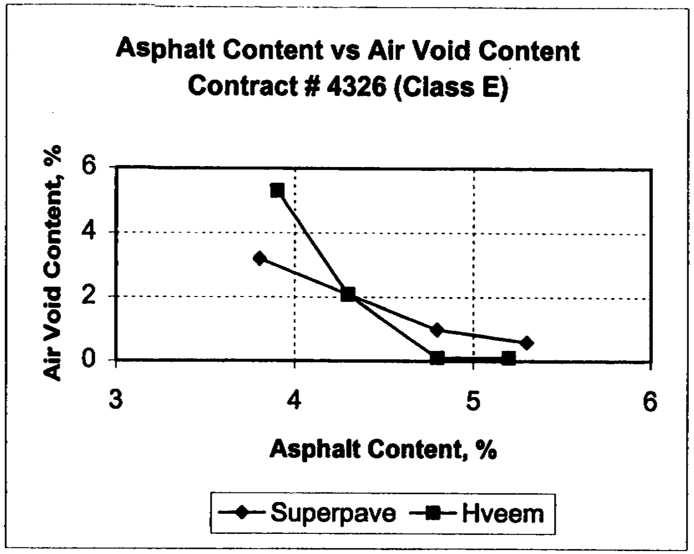
Asphalt Content vs Air Void Content
Contract # 4326 (Class A)

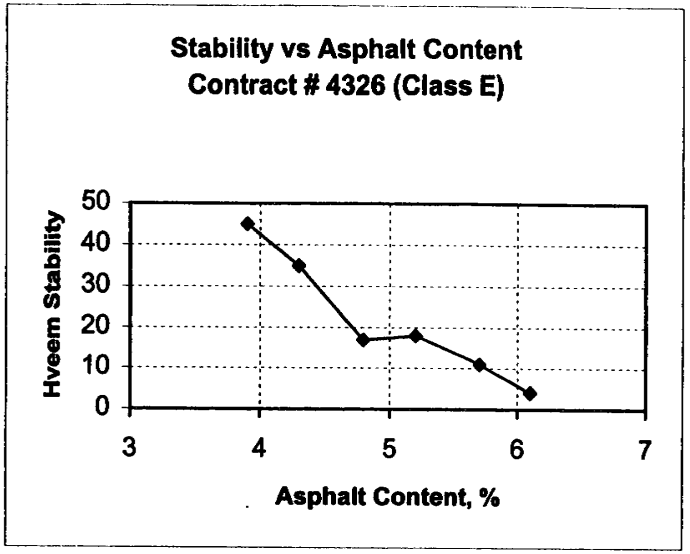


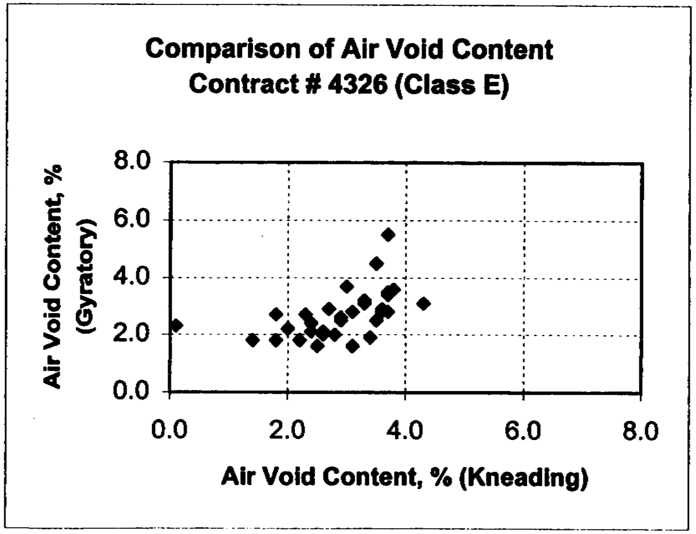
Stability vs Asphalt Content
Contract # 4326 (Class A)

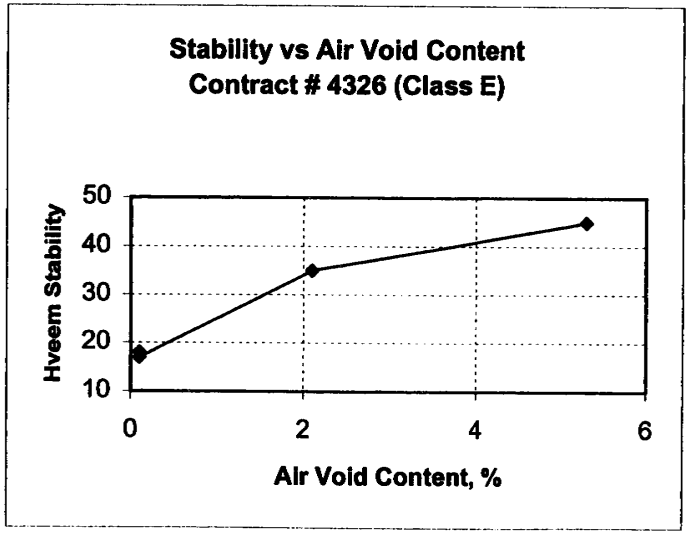


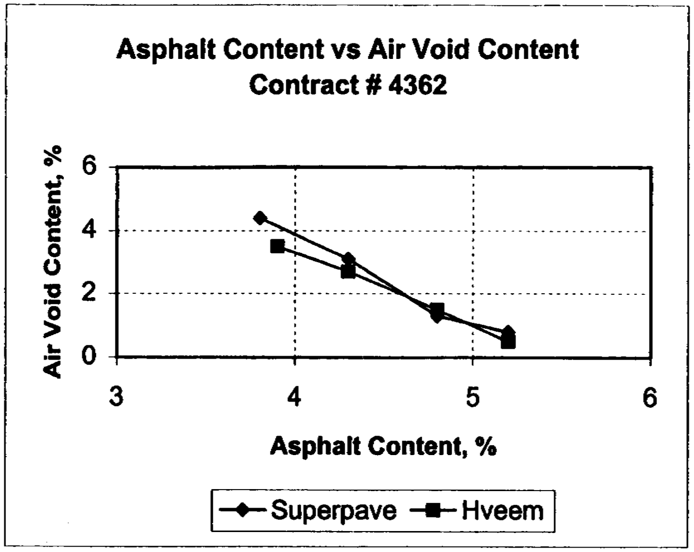
Stability vs Air Void Content
Contract # 4326 (Class A)

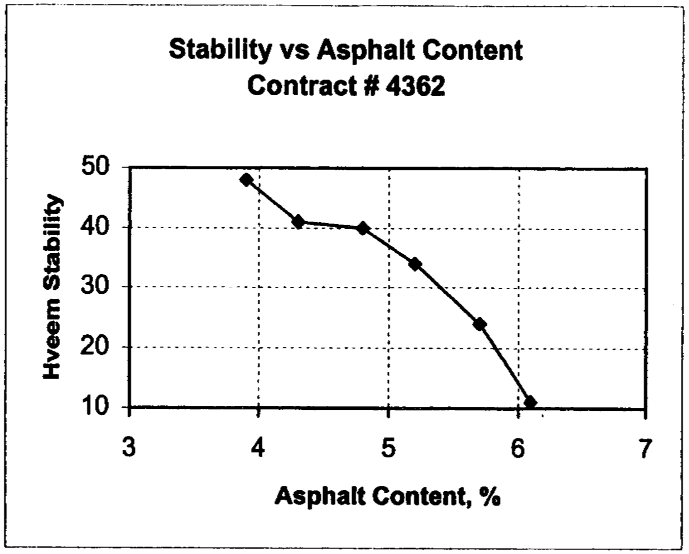

Asphalt Content vs Air Void Content
Contract # 4326 (Class E)
Air Void Content, %
6
4
2
0
3
4
5
6
Asphalt Content, %
Superpave
Hveem

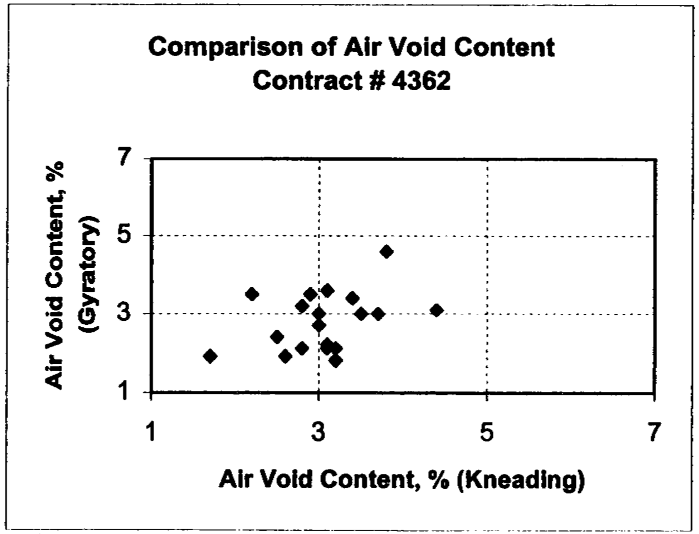

Stability vs Asphalt Content
Contract # 4326 (Class E)
Hveem Stability
50
40
30
20
10
0
3
4
5
6
7
Asphalt Content, %

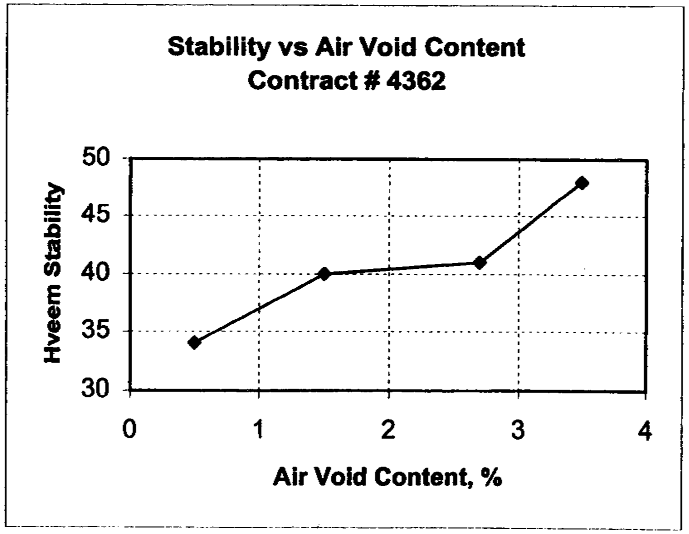

Comparison of Air Void Content
Contract # 4326 (Class E)
Air Void Content, % (Gyratory)
8.0
6.0
4.0
2.0
0.0
0.0
2.0
4.0
6.0
8.0
Air Void Content, % (Kneading)


Stability vs Air Void Content
Contract # 4326 (Class E)
Hveem Stability
50
40
30
20
10
0
2
4
6
Air Void Content, %

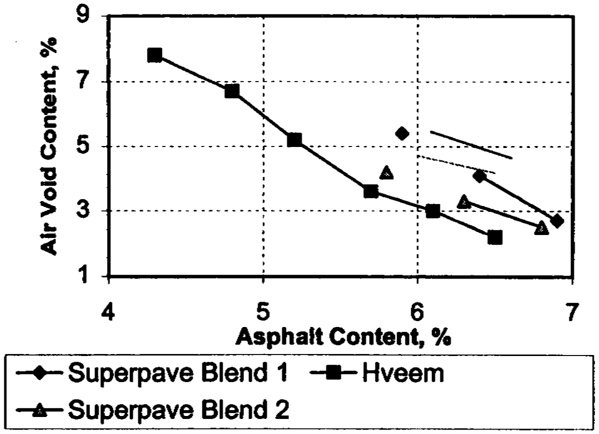

Asphalt Content vs Air Void Content
Contract # 4362


Stability vs Asphalt Content
Contract # 4362

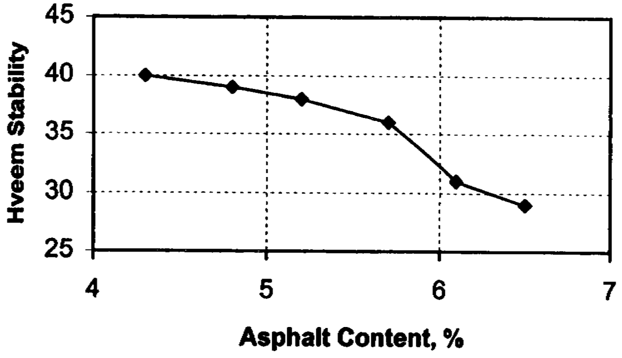

Comparison of Air Void Content
Contract # 4362


Stability vs Air Void Content
Contract # 4362

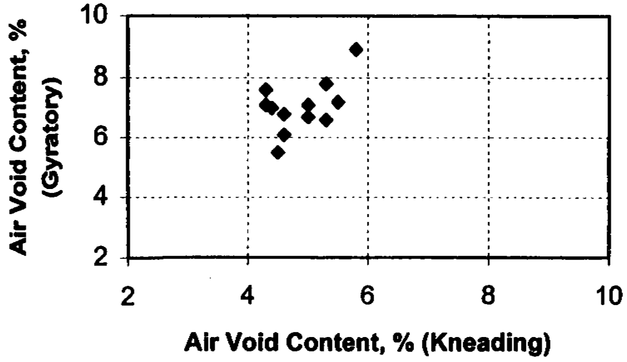
Asphalt Content vs Air Void Content Contract # 4692



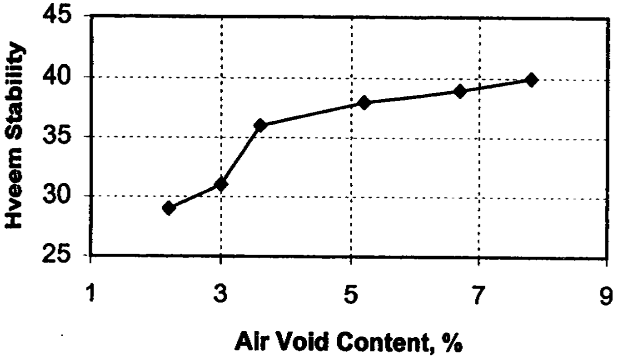
Stability vs Asphalt Content Contract # 4692

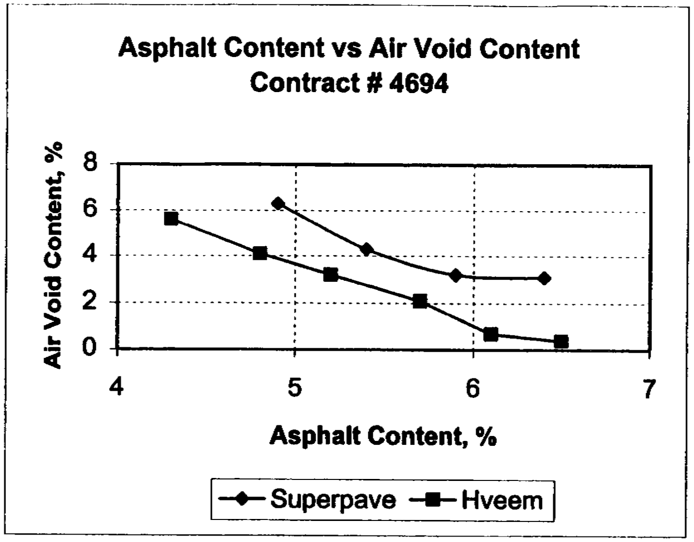


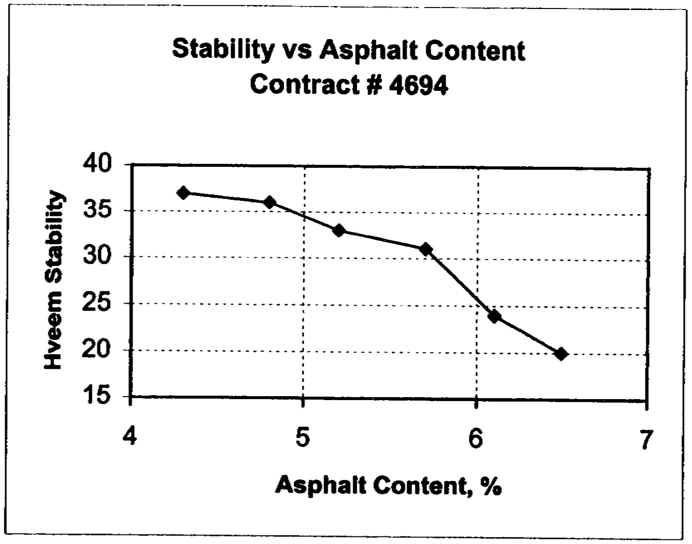
Comparison of Air Void Content Contract # 4692

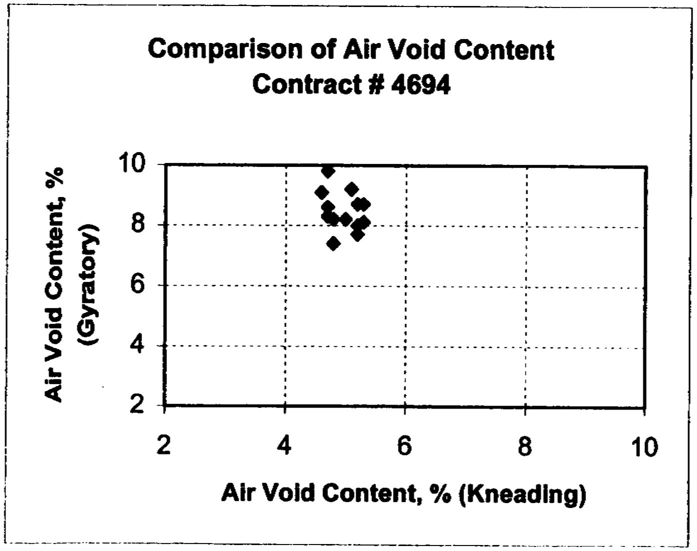


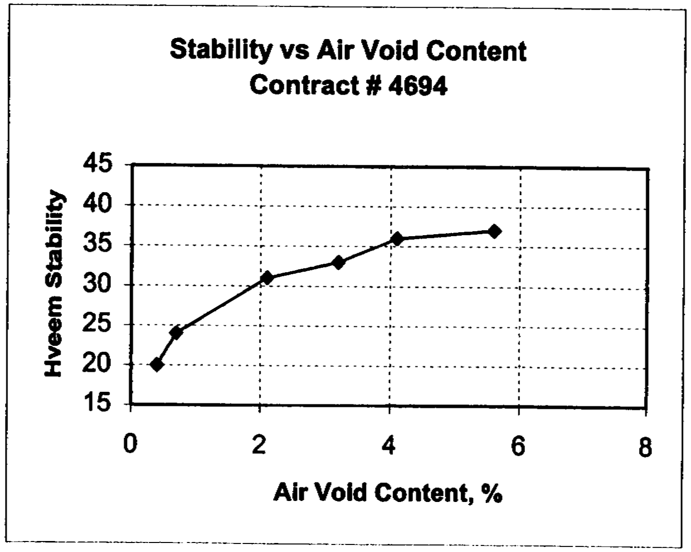
Stability vs Air Void Content Contract # 4692

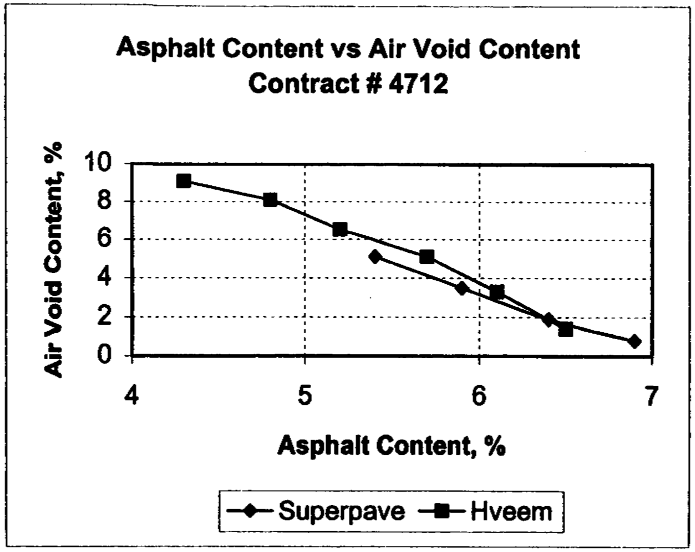


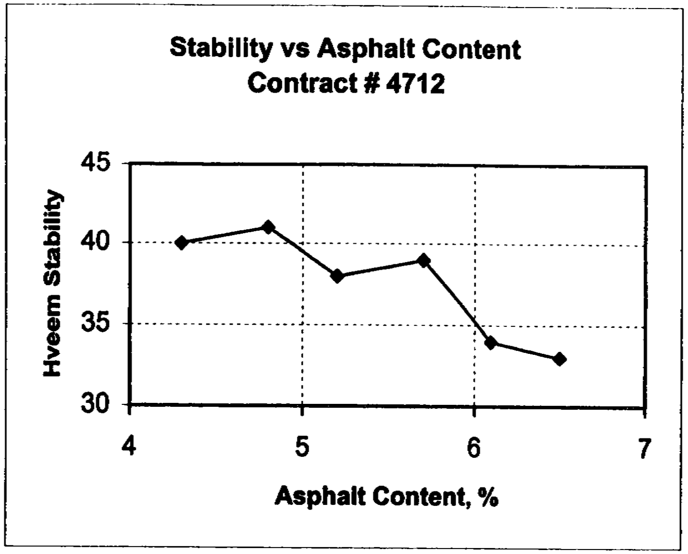

Asphalt Content vs Air Void Content
Contract # 4694

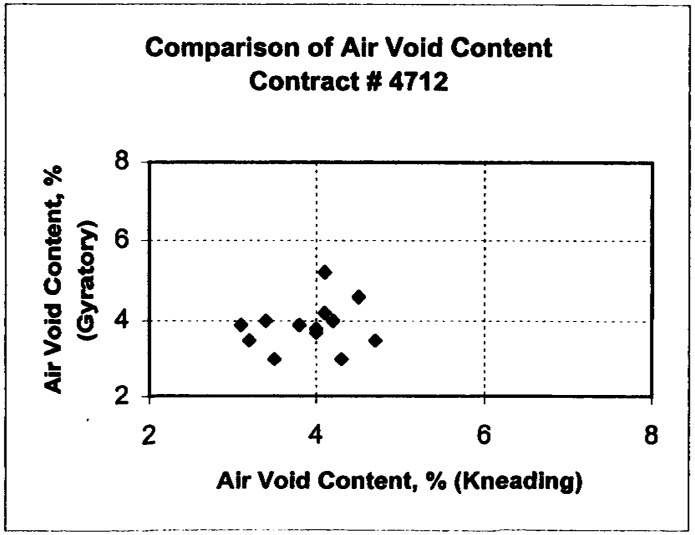

Stability vs Asphalt Content
Contract # 4694

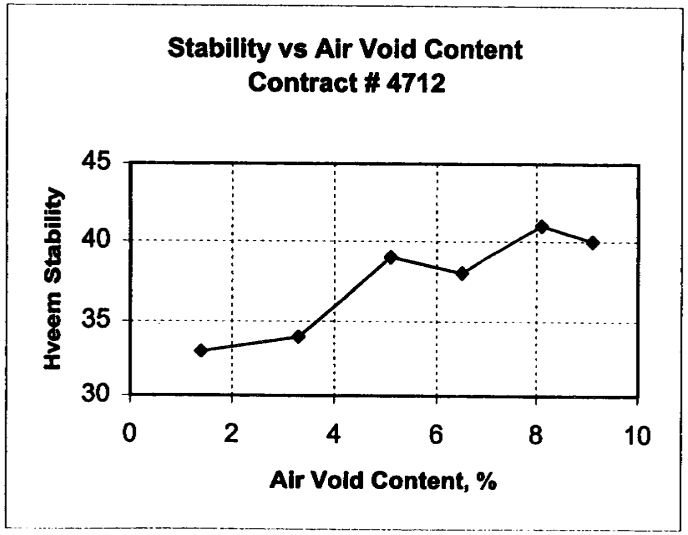

Comparison of Air Void Content
Contract # 4694

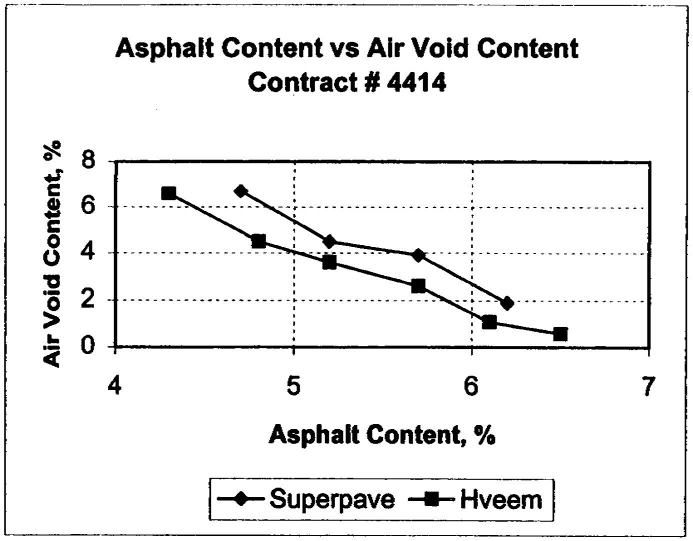

Stability vs Air Void Content
Contract # 4694

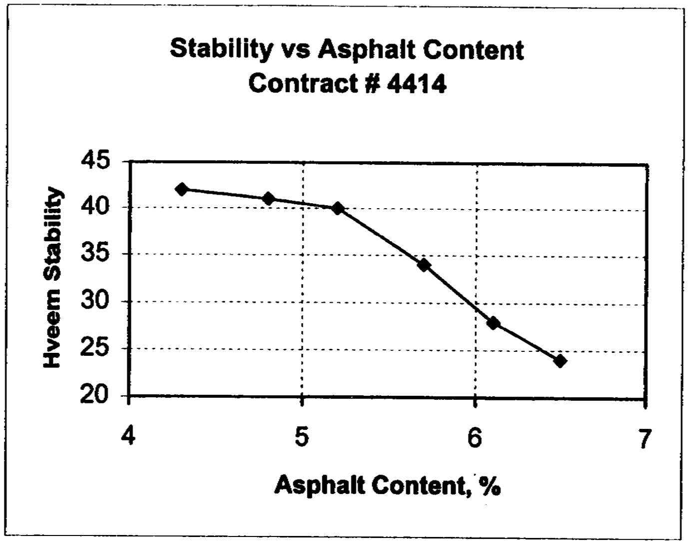

Asphalt Content vs Air Void Content
Contract # 4712

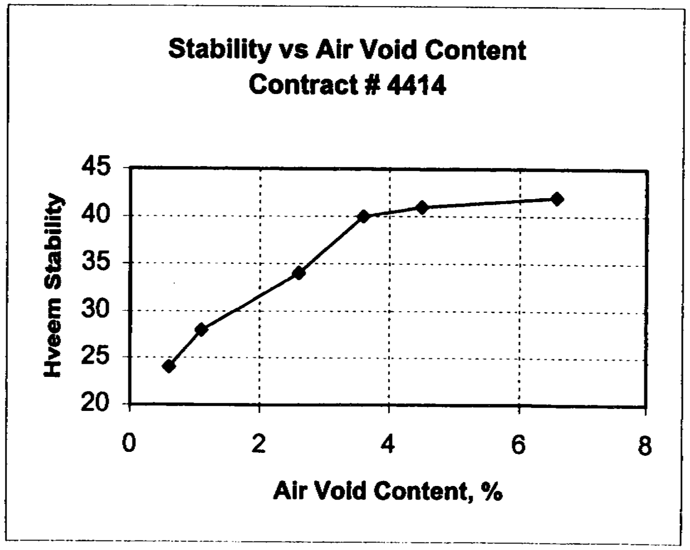

Stability vs Asphalt Content
Contract # 4712

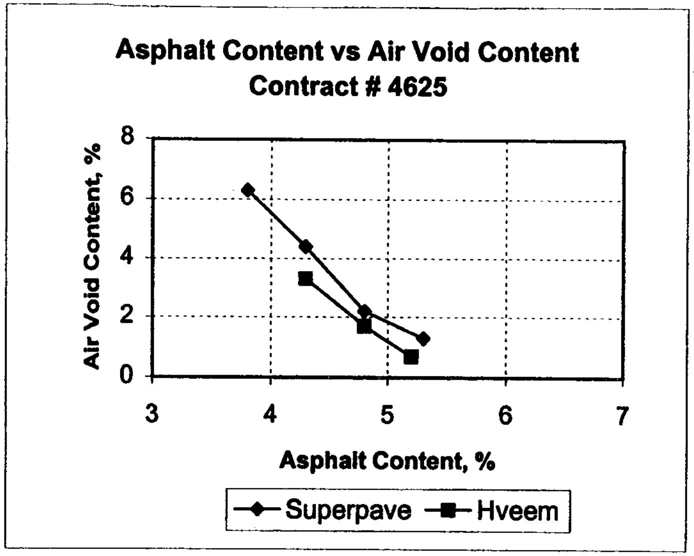

Comparison of Air Void Content
Contract # 4712

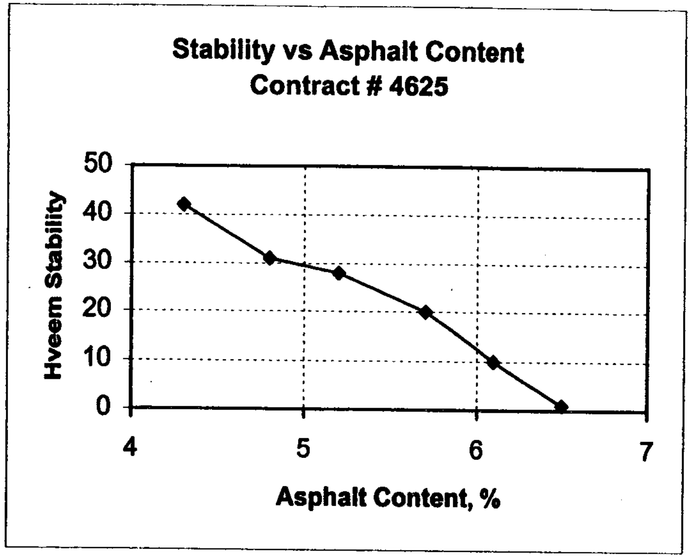

Stability vs Air Void Content
Contract # 4712

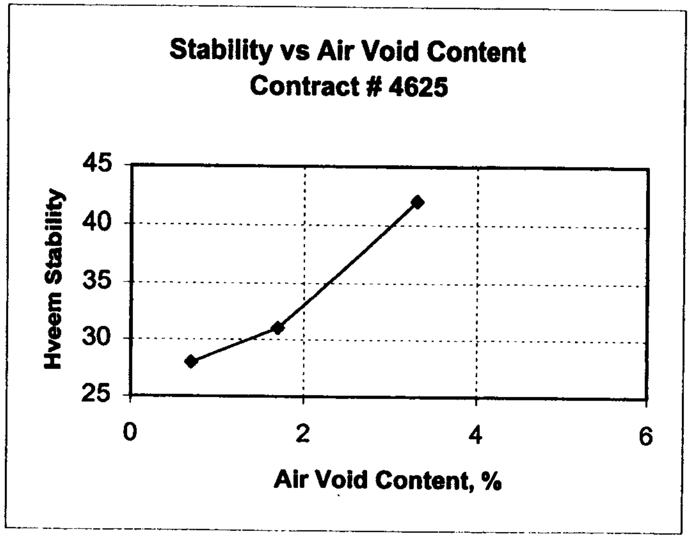

Asphalt Content vs Air Void Content
Contract # 4414

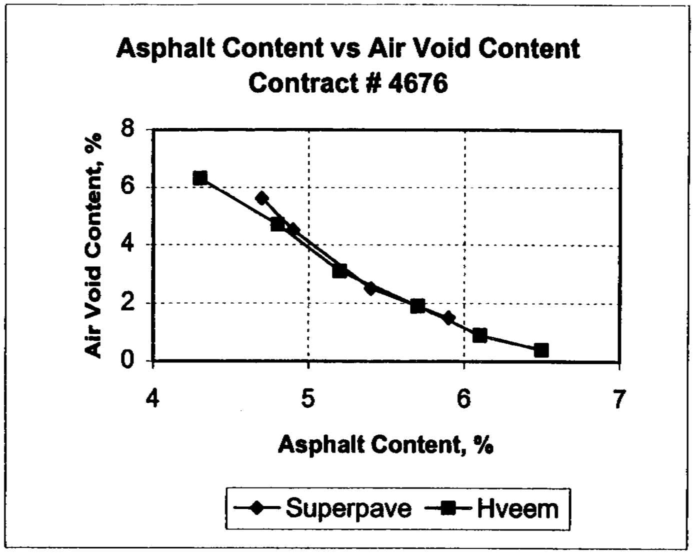

Stability vs Asphalt Content
Contract # 4414

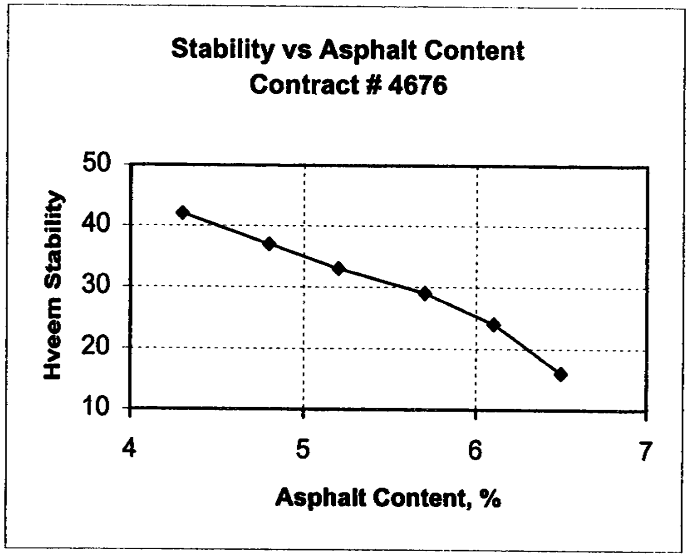

Stability vs Air Void Content
Contract # 4414


Asphalt Content vs Air Void Content
Contract # 4625


Stability vs Asphalt Content
Contract # 4625


Stability vs Air Void Content
Contract # 4625


Asphalt Content vs Air Void Content
Contract # 4676


Stability vs Asphalt Content
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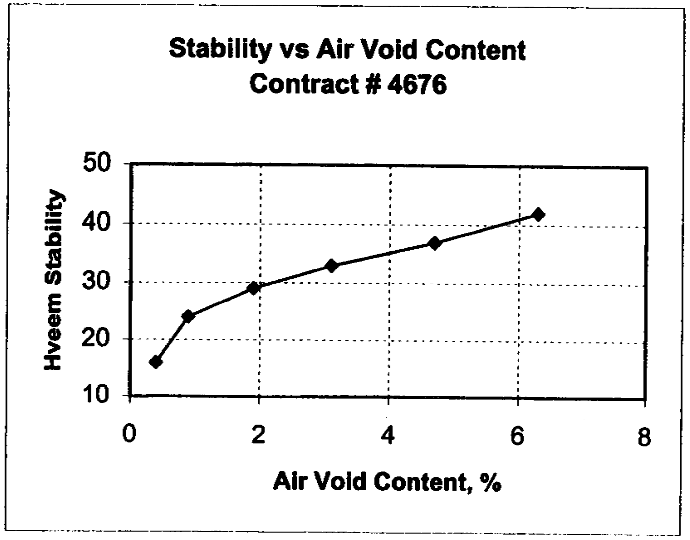
Stability vs Air Void Content
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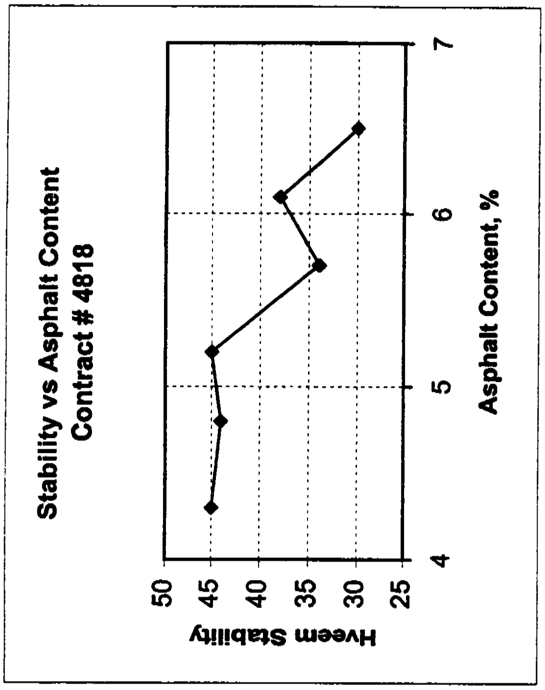
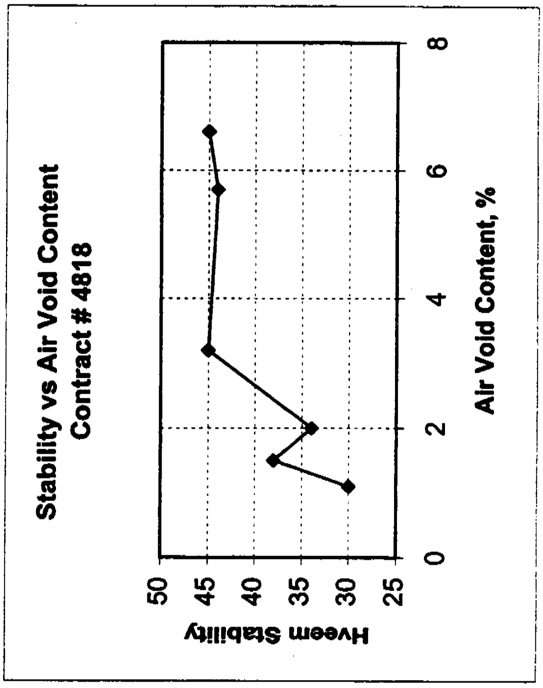


Stability vs Asphalt Content
Contract # 4818



Stability vs Air Void Content
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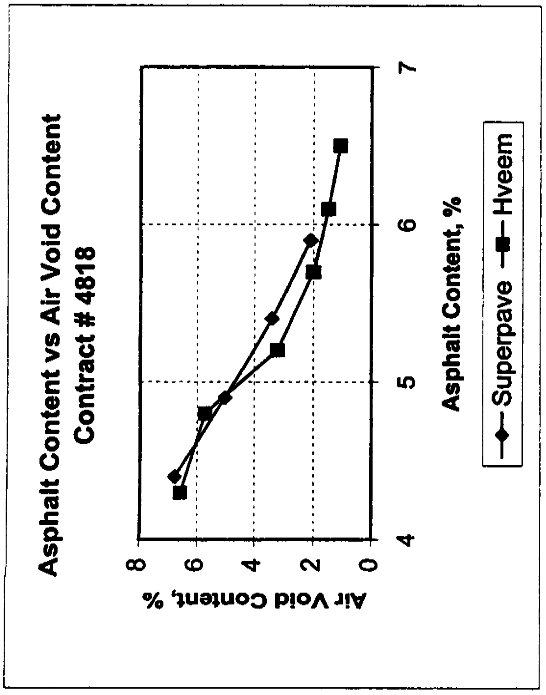
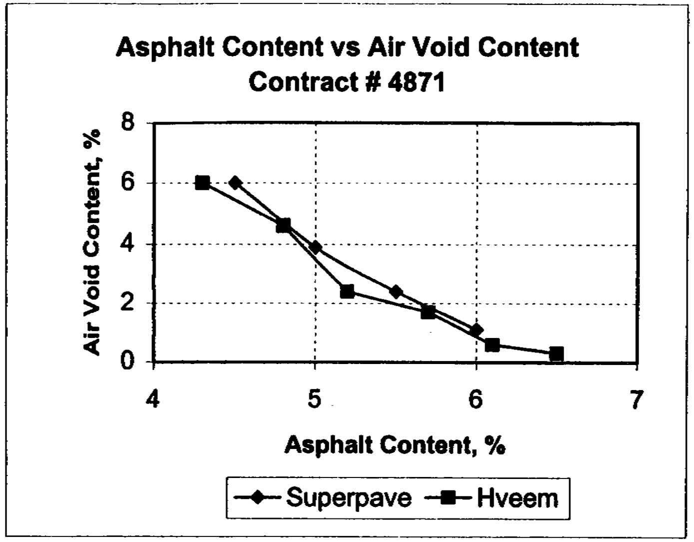
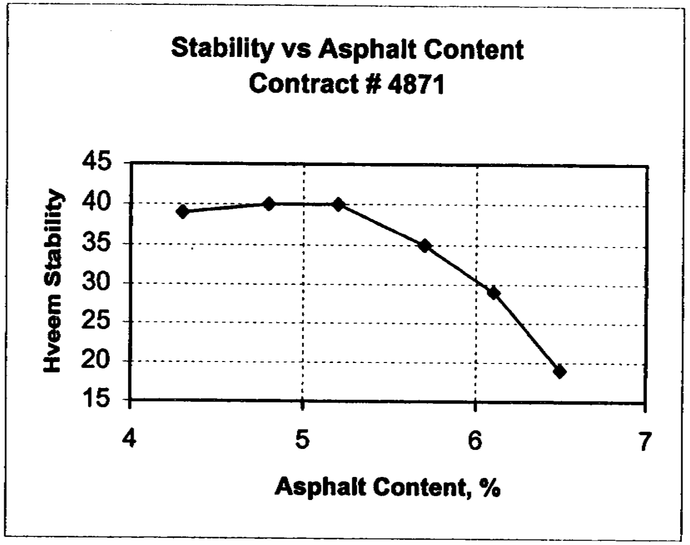


Asphalt Content vs Air Void Content
Contract # 4818



Asphalt Content vs Air Void Content
Contract # 4871



Stability vs Asphalt Content
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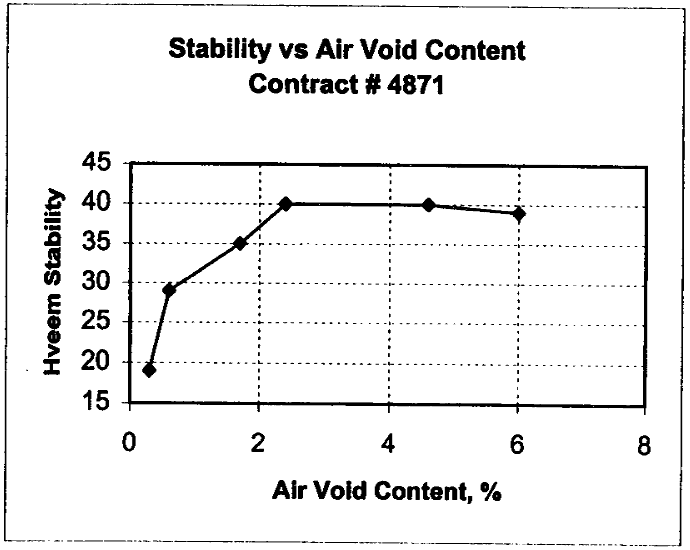
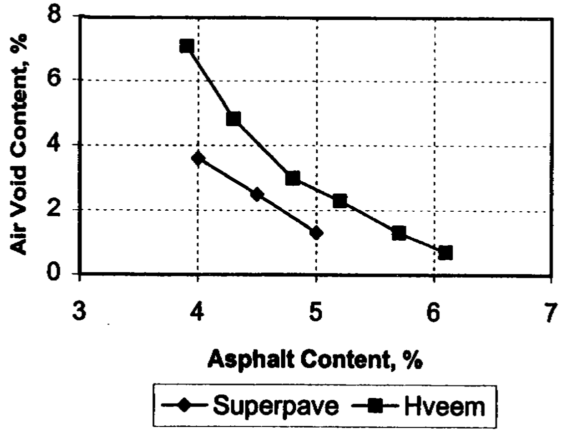
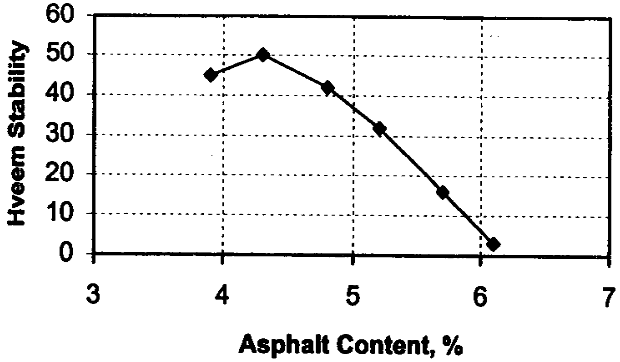


Stability vs Air Void Content
Contract # 4871

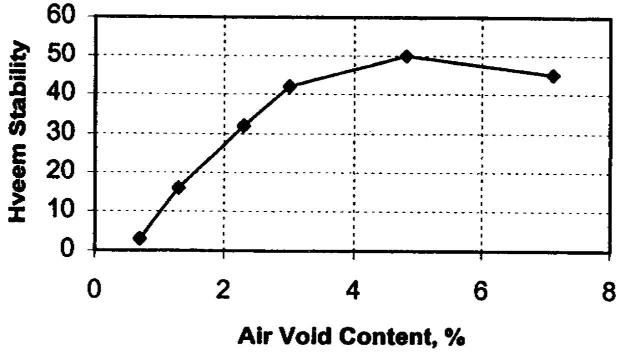
Asphalt Content vs Air Void Content
Contract # 5160

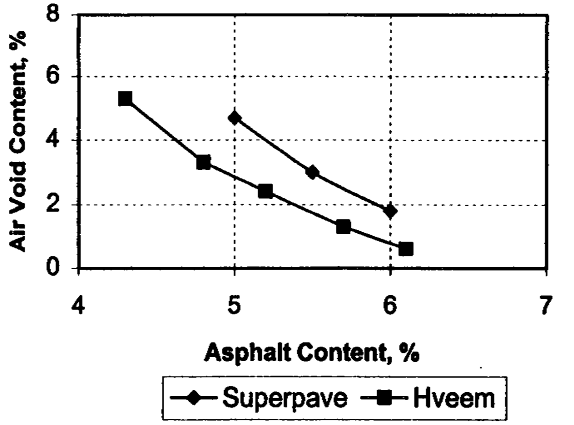


Stability vs Asphalt Content
Contract # 5160

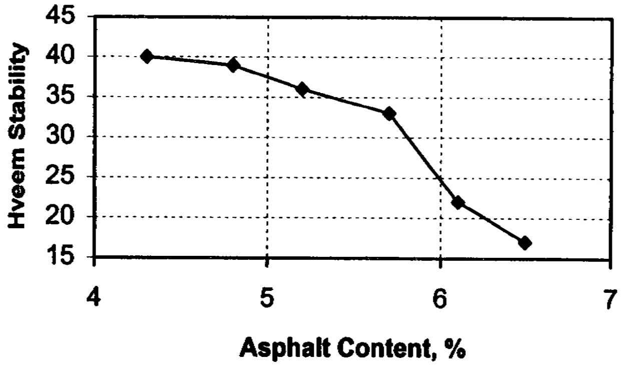


Stability vs Air Void Content
Contract # 5160

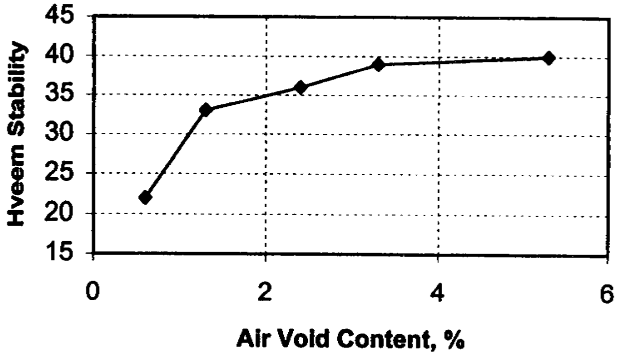




Asphalt Content vs Air Void Content
Contract # 5338



Stability vs Asphalt Content
Contract # 5338



Stability vs Air Void Content
Contract # 5338