WASHINGTON STATE DEPARTMENT OF TRANSPORTATION
December 2003

SUPERPAVE FACT SHEET

Superpave stands for SUperior PERforming asphalt PAVEment and is the result of a Strategic Highway Research Program (SHRP) initiative begun in 1988 to improve Hot Mix Asphalt (HMA). Superpave is a new way of specifying, testing and designing asphalt materials and has been in use by the WSDOT since the mid 1990's.

Superpave offers several advantages over the traditional Hveem HMA design process. Benefits include; longer pavement life with less rutting, fatigue cracking, and thermal cracking which results in reduced maintenance costs. The mix design can be tailored to local traffic and environmental conditions. Because of these benefits the WSDOT has decided to transition to the use of superpave beginning in 2004. Local agencies can use nonstatistical acceptance testing.

How does Superpave compare to the Hveem process?

Testing Element	Superpave	Hveem
Pavement Design Needed	Yes	Yes
Specifications Based on Traffic	Yes	No
Performance Grade (PG) Asphalt Binder Selection	Yes	Yes/No
Mix Design Required	Yes	Yes
Use of Reference Design	Yes	Yes
Contractor Mix Designs	Yes	No
State Verification of Design	Yes	Yes
Class A, B, E, etc Mix	No	Yes
Superpave 3/8-inch, 1/2-inch, 3/4-inch, 1-inch Mix	Yes	No
Sampling of HMA	Yes	Yes
Gradation Testing	Yes	Yes
Asphalt Content Testing	Yes	Yes
Field Compaction Density Testing	Yes	Yes
Gyratory Percent Voids Testing	**Yes***	No
Gyratory Voids in Mineral Aggregate (VMA)	**Yes***	No
Flat and Elongated Particles Testing	Yes	No
Fine Aggregate Angularity Testing	Yes	No
Sand Equivalent Testing	Yes	Yes
Fracture Testing	Yes	Yes
PG Asphalt Acceptance Tests	Yes	Yes
*** For statistical acceptance testing only.**		
Material Cost Increase Experienced	Slight/None	--

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION
Revised March 2004

SUPERPAVE TESTING PROTOCOLS

How do Superpave testing protocols compare to Hveem?

Testing Protocol	Superpave (Volumetric)	Superpave (Non-volumetric)	Hveem
Source Approval			
LA Abrasion Test	Yes	Yes	Yes
Aggregate Degradation	Yes	Yes	Yes
Bulk Specific Gravity Agg. (Gsb)	Yes	Yes	Yes
Mix Design			
Sand Equivalent	Yes	Yes	Yes
Fracture Testing	Yes	Yes	Yes
Fine Aggregate Angularity (FAA)	Yes	Yes	No
Flat and Elongated Particles	Yes	Yes	No
Bulk Specific Gravity Agg. (Gsb)	Yes	Yes	Yes
Bulk Specific Gravity Mix (Gmb)	Yes	Yes	Yes
Rice Density (Gmm)	Yes	Yes	Yes
Voids in Mineral Aggregate (VMA)	Yes	No	Yes
Voids in Mix (Va)	Yes	Yes	Yes
Voids Filled with Asphalt (VFA)	Yes	No	Yes
Moisture Sensitivity (Lottman)	Yes	Yes	Yes
Ignition Furnace Calibration	Yes	Yes	Yes
Hveem Stability	No	No	Yes
Cohesion Test	No	No	Yes
Acceptance Testing			
Ignition Furnace – Gradation	Yes	Yes	Yes
Ignition Furnace – Asphalt Content	Yes	Yes	Yes
Moisture Content	Yes	Yes	Yes
Gyratory Specific Gravity (Gmb)	Yes	No	No
Gyratory Density (Gmm)	Yes	No	No
Voids in Mineral Aggregate (VMA)	Yes	No	No
Voids in Mix (Va)	Yes	No	No
Sand Equivalent	Yes	Yes	Yes
Fracture Testing	Yes	Yes	Yes
Flat and Elongated Particles	Yes	Yes	No
Fine Aggregate Angularity (FAA)	Yes	Yes	No
PG Asphalt Acceptance Testing	Yes	Yes	Yes
Field Compaction Density	Yes	Yes	Yes

SUPERPAVE TESTING EQUIPMENT

How does Superpave testing equipment compare to Hveem?

Field Acceptance Testing Equipment	Superpave (Volumetric)	Superpave (Non-volumetric)	Hveem
Ignition Furnace	Yes	Yes	Yes
Aggregate Drying Oven	Yes	Yes	Yes
Moisture Content Oven	Yes	Yes	Yes
Gyratory Sample Oven	Yes	No	No
Sieves and Sieve Shaker	Yes	Yes	Yes
Sand Equivalent Test Equipment	Yes	Yes	Yes
Balance (16,000 gram)	Yes	No	No
Balance (< 16,000 gram)	No	Yes	Yes
Vacuum Pump	Yes	Yes	Yes
Rice Density (Gmm) Test Equipment	Yes	Yes	Yes
Fine Aggregate Angularity (FAA) Equip.	Yes	Yes	No
Flat and Elongated Particles Equip.	Yes	Yes	No
Gyratory Compactor	Yes	No	No
Water Bath (Gmb use)	Yes	No	No
Nuclear Density Gauge	Yes	Yes	Yes
Miscellaneous Equipment	Yes	Yes	Yes

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS LABORATORY

TECH NOTES

JULY 2004

SUPERPAVE PERFORMANCE AND COST COMPARISON

Introduction

WSDOT placed its first Superpave test section in 1996 and has placed an increasing number of projects each year, with volumetric acceptance planned for 2007. There has been over 2.1 million tons placed through the year 2002 on approximately 1090 lane-miles. In 1997, Superpave only accounted for 2 percent of the tonnage placed while almost half the tonnage placed in 2002 was Superpave. Figure 1 shows the location of each Superpave project that has been placed through 2002.

The performance and cost comparison presented here is for wearing course mixes, therefore the ½ and ¾ inch Superpave mixes are compared to Hveem-designed HMA classes A, B, E, and F.

Performance Background

A comparison of the Pavement Structural Condition (PSC), International Roughness Index (IRI), and rut depths between Superpave and Hveem-designed HMA was performed using data from the 2002 Washington State Pavement Management System (WSPMS). The PSC is a measure of pavement distress (includes longitudinal, alligator, and transverse cracking and patching) and ranges from 100 (no distress) to 0 (extensive distress). IRI is a measure of road roughness and ranges from 0 inches/mile (perfectly smooth) to values in excess of 320 inches/mile (very rough). The rut depths are measured in the wheelpaths and can range from 0 inches to values in excess of ½ inch. WSDOT programs rehabilitation projects for roadways that exhibit a PSC between 40 and 60, an IRI measurement of 220 inches/mile or higher, and/or rut depths that exceed 3/8 inch.

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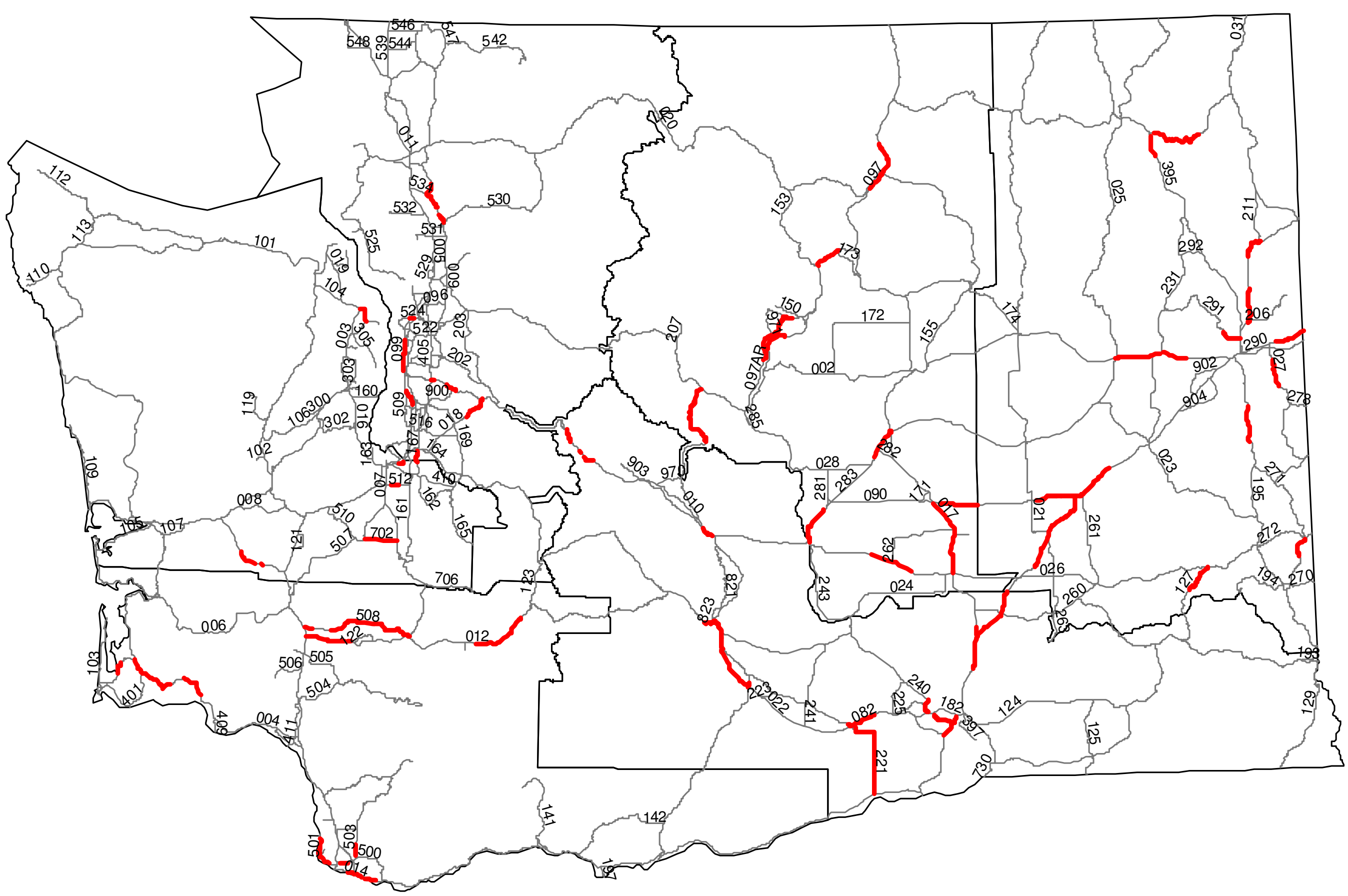

Figure 1. Superpave projects by type and year.

Each Superpave project was compared to the previous overlay or construction that was done at the same location (State Route and milepost) to limit variables such as environment and traffic levels. The PSC, IRI, and rut depths were retrieved from the WSPMS for both projects at the same age.

The Superpave projects range in age from one to six years old (placed from 1996 to 2001),of which approximately 70 percent are age 3 or less. The Hveem-designed projects were constructed anywhere from 1967 to 1998 (approximately 68 percent of these projects were placed prior to 1990). For the comparison, the Superpave and Hveem-designed projects were broken into similar sections, which consist of the same year or class of mix and a similar lift thickness. All Superpave projects utilized a PG binder, while almost all the Hveem-designed mixes (94 percent) used AR4000W. Since lift thickness can affect the PSC, IRI, and rut depths, comparisons where only made when the lift thicknesses for both projects were within 0.10 feet of each other.

Pavement Condition Performance

The Superpave PSC ranged from 47 to 100 while the Hveem-designed mixes ranged from 22 to 100 (Figure 2). The majority of the Superpave sections have a higher PSC than its comparable Hveem-designed section. After a maximum of six years performance:

- 48 percent of Superpave sections have a higher PSC
- 29 percent of the comparable sections had the same PSC
- 23 percent of the Superpave sections have a lower PSC

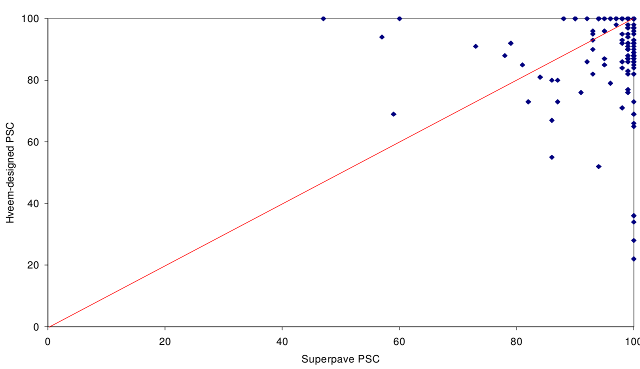

Figure 2. Comparison of PSC.

Roughness Performance

The Superpave IRI ranges from 25 inches/mile to 204 inches/mile while the Hveem-designed IRI ranges from 48 inches/mile to 319 inches/mile. Almost all of the Superpave sections have a lower IRI (smoother) than the Hveem-designed mixes (Figure 3). After a maximum of six years performance:

- 91 percent of the Superpave section's IRI values are lower than the Hveem-designed sections

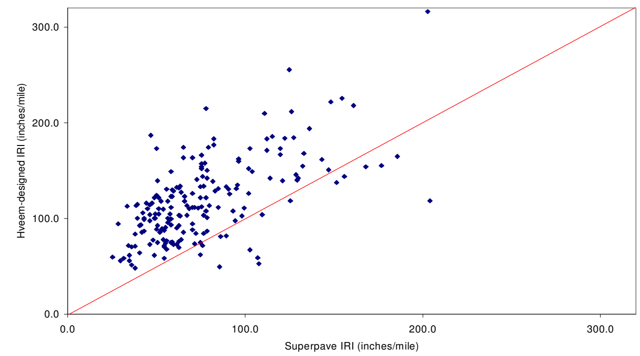

Figure 3. Comparison of IRI.

Rutting Performance

The range of rut depths for the Superpave sections was 0 inches to ¼ inch while the Hveem-designed mixes ranged from 1/32 inch to 7/16 inch (Figure 4). The rut depths for the Hveem-designed sections were usually higher than the rut depths of the Superpave sections. After a maximum of six years performance:

- 60 percent of the Superpave sections had lower rut depths than the Hveem-designed sections
- Of the remaining 40 percent, 12 percent had the same rut depths and 28 percent of the Superpave sections had higher rut depths than the Hveem-designed sections

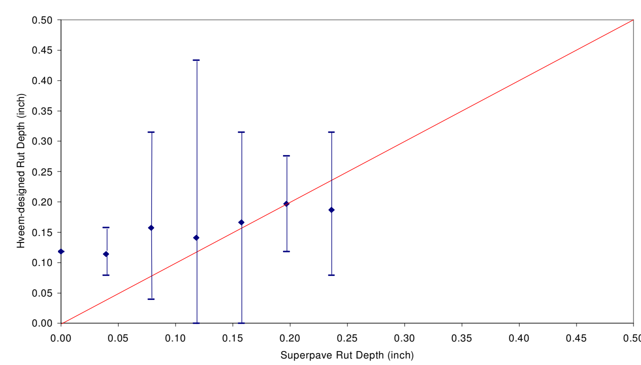

Figure 4. Comparison of rut depths.

Performance Results

Although these results favor Superpave over the conventional Hveem-designed mixes, recall that 68 percent of the Hveem-designed sections were placed prior to 1990. In recent years, there has been an increased focus on improving construction practices, improving initial smoothness, and improved design methods that cannot be taken into account with this type of comparative study. Therefore, an additional check was performed on Hveem-designed projects constructed at approximately the same time as the Superpave projects. To ensure that the traffic levels and environment were similar, only projects constructed near or adjacent to the Superpave projects were chosen. Another constraint was to limit the construction year of the Hveem-designed projects from 1990 to 2002. Due to these constraints, there were only 8 comparison projects (all constructed in 1997 and 1998). The results for these 8 projects were comparable in regards to PSC, IRI, and rutting, but the IRI result was not as remarkably in favor of the Superpave designed sections.

- PSC: 75 percent of the Superpave projects have the same or less surface distress than the Hveem-designed projects
- IRI: 63 percent of the Superpave projects are smoother than the Hveem-designed projects
- Rutting: 63 percent of the Superpave projects have less rutting than the Hveem-designed projects

At this time, Superpave seems to be performing as well as the Hveem-designed mixes in terms of PSC, IRI, and rutting. The comparison sections ranged in age from one to six years, but the majority of the sections were one to three years old. The expected overlay life cycle for Eastern and Western Washington is approximately 12 and 15 years, respectively, so a similar analysis will be performed in the near future to verify these results.

Performance-Graded Binder Performance

Since Superpave consists of an asphalt binder specification and a mix design method, an examination of the performance-graded (PG) binders was also conducted.

For the intersection rutting analysis, there were 8 projects that had signalized intersections. The high-temperature binder grades used were PG 76, PG 70, and PG 64, which corresponds to one or two bumps (four projects each) from the base grade at 98 percent reliability. WSDOT requires a two-grade bump for standing traffic, but depending on the length of the project, the number of intersections within the project, and the previous rut depth severity, a one-grade bump may have been selected for the entire project.

With three years of data, the maximum rut depth was ¼ inch. After the first year, the maximum rut depths for intersections using a PG 76, PG 70, and PG 64 were 1/8 inch, ¼ inch, and 3/16 inch, respectively. Figure 5 shows a comparison of the average rut depths by grade of binder for the overlays up to three years of age. Although none of the average rut depths exceed 1/8 inch, the rut depths for the PG 76 and PG 70 binders remained fairly constant over the three years, while the PG 64 binder increased each year.

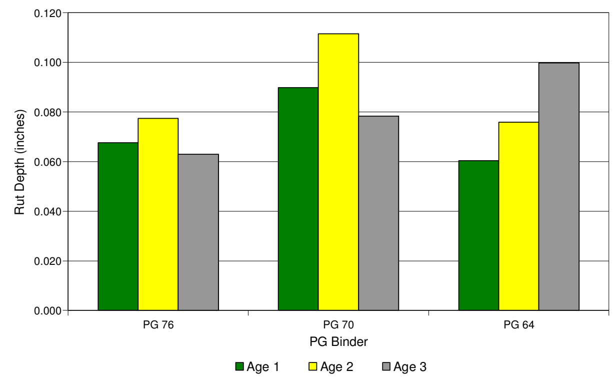

Figure 5. Average intersection rutting by binder grade.

An evaluation of low temperature cracking was performed, but since all of the Superpave projects were overlays, any transverse crack is likely due to reflective cracking and not low temperature cracking. Therefore, this evaluation is more an assessment of a PG binder's impact on delaying reflective cracking. Based on the WSPMS, the Hveem-designed sections have two to three times more transverse cracking than the Superpave sections at the same location and age.

At this time, there is insufficient data to draw specific conclusions on the effectiveness of PG binders for rutting or low temperature cracking. As additional years of performance data become available, the benefits of PG binders will be reassessed.

Cost Comparison

Three types of cost comparisons where performed: 1) unit price of Superpave per year, 2) unit prices of Superpave and Hveem-designed HMA by class of mix, and 3) cost per lane-mile.

The unit price of Superpave per year is presented in Figure 6 along with the tonnage placed (the 1996 test section is not included because the cost was a lump sum change order). The average cost for producing and placing Superpave in 1997 (four projects) was $36.99/ton, but after the first year, the average cost decreased to $27.87/ton and has remained around $28/ton since.

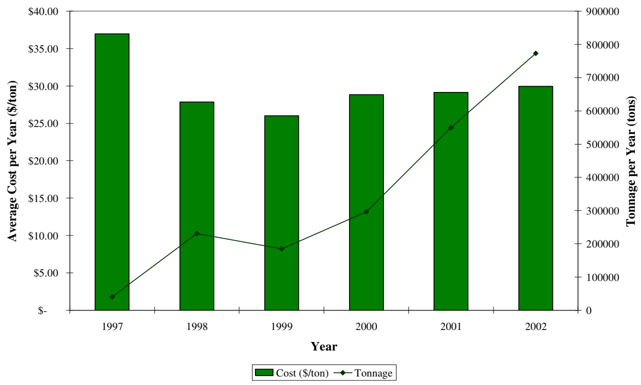

Figure 6. Superpave unit price and tonnage by year.

The comparison of unit prices is presented in Table 1. The Superpave ½ inch and ¾ inch mixes are $28.66/ton and $26.40/ton, respectively, while the Hveem-designed mixes (A, B, and E) are between $27.41/ton and $27.64/ton. Overall, the costs are very similar with an average of $27.51/ton. Although not shown in Table 1, there was a slight increase in the Hveem-designed HMA cost when PG binders were introduced. Also, Table 1 shows that HMA, in general, is more expensive in Western Washington than Eastern Washington – as expected.

Table 1. Unit price ($/ton) comparison.

	Superpave		Hveem-designed		
	½ inch	¾ inch	A	B	E
East	$26.38	$25.01	$24.11	$25.15	$26.57
West	$34.12	$35.44	$28.59	$28.67	$27.86
Average	$28.66	$26.40	$27.41	$27.44	$27.64

The final comparison was based on the project cost per lane-mile. These costs include only the costs related to paving – safety, drainage, bridge work, etc. have been excluded. As expected, there are differences between the cost in rural and urban areas as well as Western versus Eastern Washington. Paving in rural areas and/or Eastern Washington is typically less expensive, as illustrated in Table 2. The average cost per lane-mile for Superpave and Hveem-designed HMA are $87,637/lane-mile and $94,835/lane-mile, respectively.

Since market forces cannot be factored into the costs (low-bid process), these results indicate that there is no significant cost difference between Superpave and Hveem-designed HMA.

Table 2. Cost per lane-mile comparison.

Superpave HMA						
East	Rural	$76,694	Urban	$76,056	Average	$76,490
West		$80,739		$134,257		$109,930
Avg		$77,705		$102,918		$87,637
Hveem-designed HMA						
East	Rural	$79,500	Urban	$91,550	Average	$85,525
West		$88,100		$120,200		$104,150
Avg		$83,800		$105,875		$94,835

Conclusions

- Superpave seems to be performing as well as Hveem-designed HMA in terms of structural condition, smoothness, and rutting.
- The PG binder evaluation is, at this time, inconclusive, as to whether the high temperature binder properties reduce the severity of rutting and whether the low temperature properties prevent or delay transverse cracking.
- The cost for Superpave and Hveem-designed HMA is approximately the same.

Even though not all the improvement can be attributed to the use of Superpave and PG binders, WSDOT has found that Superpave is performing as well as Hveem-designed HMA and costs about the same. Given that Superpave is the national focus and that it is performing well to date, WSDOT will continue to use Superpave mix design methods and PG binders while continuing its implementation schedule.

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