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Project Owner:

Phoenix Industries
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Research Description:

Brief investigation into the moisture susceptibility of two pelleted asphalt products produced and marketed by Phoenix Industries: Sample A (PelletPATCH™) and Sample B (PelletPAVE™).

Research Performed By:

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Project Description:

Moisture susceptibility of asphalt mixes is a major concern when evaluating the performance capabilities of asphalt mixes. Typically moisture susceptibility of asphalt mixes is determined by the use of AASHTO-T-283. Most states have their own version of AASHTO-T-283 including South Carolina. SCDOT moisture susceptibility testing and requirements can be found in SC-T-70:

<http://www.scdot.org/doing/pdfs/TestProcedures/Asphalt/SCT70.pdf>

For this project, brief investigation into the moisture susceptibility of two pelleted asphalt products produced and marketed by Phoenix Industries was conducted: Sample A (PelletPATCH™) and Sample B (PelletPAVE™). The two pellet products were tested, analyzed, and these will be designated as *Patch* and *Pave* pellets throughout this report. The binder testing analysis and results are included in a separate document.

One binder source PG 76-22 was selected for comparison purposes with the pellet products. The pellet products, in general, contain approximately 18% rubber by binder weight which makes the product a binder polymer modifier (76+ PG grade binder). Therefore, we believe this comparison is more reasonable than comparing the results with the moisture susceptibility of a non-modified polymer binder.

Two aggregate sources were chosen for the initial study. One source (L) was chosen due to its known moisture susceptibility issues. Another source (C) was chosen to represent the control. To conduct the moisture susceptibility testing, all samples were compacted to have 7 ± 1 percent air voids at optimum binder contents.

The recommended gradation provided by Phoenix Industries (Table 1) and a target AC content of 6% (by ignition oven burn) was chosen for comparison purposes with commonly used SCDOT Type A mixes using PG 76-22. These various SCDOT Type A mixes and associated data are included in Table 2.

Table 1. Phoenix Industries Recommended Gradation for Use With Pellets

	Percent Passing		
	Minimum %	Maximum %	Target
1/2"	85	100	92.5
3/8"	60	85	72.5
#4	25	42	33.5
#200	0	2	1

Table 2. Gradation of Aggregate Source L (Course Type C)

Source	Type	%AGG
Liberty	#789	45
Liberty	Man Sand	22
Liberty	Reg. Scrn.	32
Carmesuse	Lime	1

Table 3. Combined Aggregate Gradation for Source L (Course Type C)

Sieve	789	Man Sand	Reg. Scrn.	Lime	Comb.	Target
3/4"	100	100	100	100	100	100
1/2"	96	100	100	100	98	99
3/8"	89	100	100	100	95	95
#4	31	95	98	100	67	67
#8	10	89	91	100	54	54
#30	6	46	48	100	29	30
#100	4	10	19	100	11.1	12
#200	0.9	4.2	10.3	80	5.43	6

Table 4. Gradation of Aggregate C (Course Type C)

Source	Type	%AGG
N. Cola.	#789	45
N. Cola.	Wash Scr	10
N. Cola.	Reg Scr	44

Table 5. Combined Aggregate Gradation for Source C (Course Type C)

Sieve	789	Wash Scr	Reg. Scr	Comb.	Target
3/4"	100	100	100	100	100
1/2"	96	100	100	98	98
3/8"	89	100	100	95	85
#4	31	95	98	68	54
#8	10	89	91	54	36
#30	6	46	48	29	20
#100	4	10	19	11.4	8
#200	0.9	4.2	10.3	5.46	4.5

Results of SC-T-70 Moisture Sensitivity Analysis

The procedure followed was to heat each aggregate source (L or C) to 400 degrees F (205 C) and then add the fine or coarse pellets at the desired weight to achieve target binder contents (6% - ignition oven burn). These samples were then compacted at a minimum of 325 degrees F (163 C). The gradations were checked after ignition oven burns to ensure the target gradations were met.

Tables 6 and Table 7 contain the pan aggregate weights and the pellets plus aggregate pan weight targeting 6% binder content for the gyratory specimens prepared for the moisture susceptibility testing. Ignition oven burns confirmed that Patch pellet binder contents averaged 6.12% and Pave pellets average 6.04% with these weights shown below.

Table 6. Patch Pellet Aggregate Pan Weights at 6.0% Binder Content.

Sample #	Patch Pellets Agg. Wt.	Pellets plus agg. (480g of Patch pellets)
1	3196.9	3679.3
2	3198.0	3679.8
3	3195.3	3677.6
4	3197.9	3679.5

Table 7. Pave Pellet Aggregate Pan Weights at 6.0% Binder Content.

Sample #	Pave Pellets Agg. Wt.	Pellets plus agg. (480g of Pave pellets)
1	3197.3	3679.3
2	3195.6	3679.8
3	3196.5	3677.6
4	3196.6	3679.5

Tables 8 and 9 contain the Patch pellets and Pave pellets' Bulk Specific Gravity measurements and air voids determinations for the various samples. Average Maximum Rice Specific Gravities for the Patch pellets was 2.345 and the Pave average MSG was 2.376

Table 8 Patch Pellets Volumetric Analysis.

Sample	Core #	Dry Wt.	Sub Wt.	SSD Wt.	Volume	BSG	% AV	Ht.
Patch Pellets @ 6.12 % AC	1	3548.0	1960.1	3575.8	1615.7	2.197	6.31	94.8
	2	3547.3	1958.1	3573.6	1615.5	2.196	6.35	94.9
	3	3548.0	1954.8	3570.2	1615.4	2.196	6.35	94.8
	4	3547.5	1954.8	3571.9	1617.1	2.194	6.44	94.8
<ul style="list-style-type: none"> Data above meets requirements of SC-T-70 								

Table 9 Pave Pellet Volumetric Analysis.

Sample	Core #	Dry Wt.	Sub Wt.	SSD Wt.	Volume	BSG	% AV	Ht.
Pave Pellets @ 6.08 % AC	1	3578.4	1999.1	3611.8	1620.7	2.208	7.07	95.0
	2	3578.7	1994.0	3611.5	1617.5	2.212	6.90	94.9
	3	3578.0	1994.7	3611.7	1617.0	2.212	6.86	94.9
	4	3579.1	1994.3	3610.7	1616.4	2.214	6.82	94.8
<ul style="list-style-type: none"> Data above meets requirements of SC-T-70 								

As per SC-T-70 Core numbers 1 and 4 were selected as the dry specimens and cores 2 and 3 were selected as the wet specimens for the Patch pellets. For the Pave pellets, cores numbers 1 and 4 were assigned to be dry specimens and cores 2 and 3 were assigned to be wet specimens.

The wet specimens are required to be saturated between 70 and 80%. Saturation levels for the four wet specimens for both Patch and Pave pellets ranged from a low of 70.3% to a high of 72.8%. The wet samples were placed in a 140 F (60 C) water bath for 24 hrs. The dry samples were maintained at 77 F (25 C) until Indirect Tensile Strength (ITS) testing. After the 24 hours, the wet samples were then placed in a 77 F (25 C) water bath for 2 hrs. After two hours they were removed then the Indirect Tensile Strength Test (ITS) was performed. Tables 10 and 11 contain the results of the ITS and TSR analysis for the Patch and Pave pellets, respectively. Figure 1 is a graphical representation of the data.

Table 10. Patch Pellets' TSR Analysis

Sample	Load	ITS, psi	AVG ITS, psi	TSR, %
Wet 1 (C)	5283	152.6	156.9	96.5
Wet 2 (C)	5584	161.1		
Dry 1 (C)	5448	157.4	162.6	
Dry 2 (C)	5788	166.9		

Table 11. Pave Pellets' TSR Analysis

Sample	Load	ITS, psi	AVG ITS, psi	TSR, %
Dry 1 (F)	5676	163.8	171.8	100.2
Dry 2 (F)	6224	179.8		
Wet 1 (F)	6027	173.7	172.1	
Wet 2 (F)	5909	170.5		

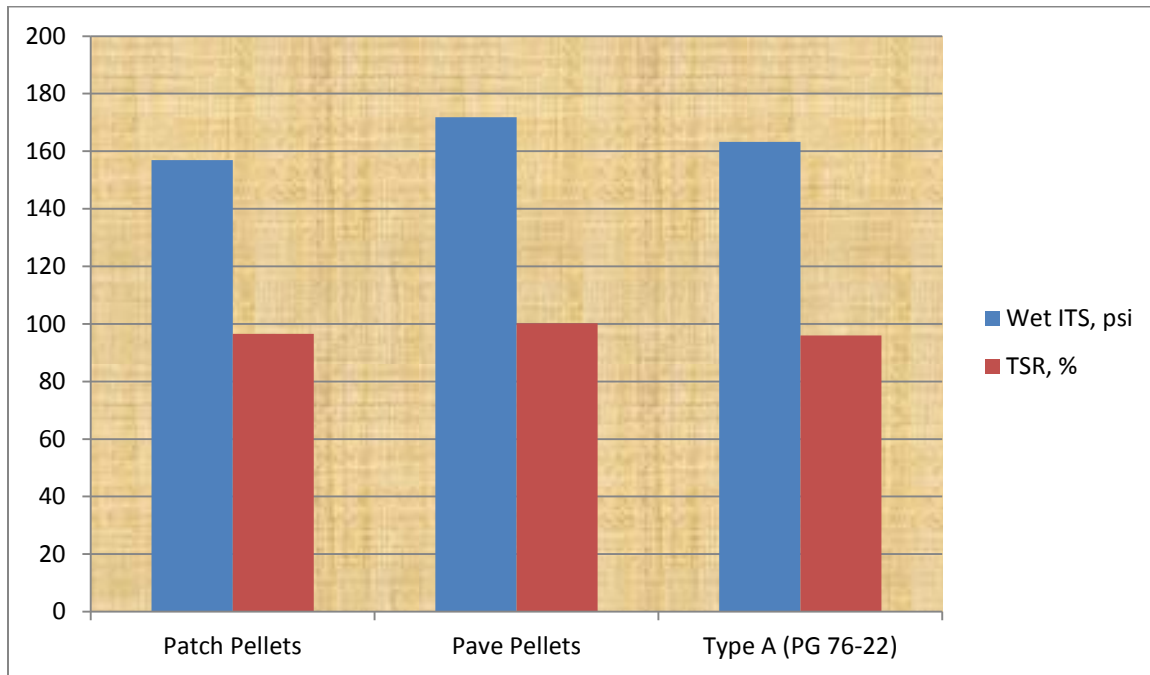


Figure 1. Wet ITS (psi) and TSR values for Patch Pellets, Pave Pellets, and Typical SCDOT Surface A (PG 76-22) mixes in SC.

SCDOT requires a minimum Wet ITS of 65 and minimum TSR of 85. Both the Patch and Pave pellets met this requirement with aggregate source C at a targeted 6.0% binder content.

The closest gradation that could be used from SC to compare to the gradation received from Phoenix Industries (Table 5) is SCDOT's OGFC mix. However, there are no TSR requirements on OGFC mixes in SC. The next closest gradation that used a polymer modified binder (PG 76-22) is the SCDOT Surface A mix. TSR records for a Surface Type A mixes using various quarries and a PG 76-22 binder is included in Table 12. These ITS and TSR values appear to be comparable to the pellet products that use a much more open gradation. This would indicate that the moisture susceptibility of the pellet products is comparable to a similar SBS PG 76-22 mixtures containing 1% lime tested in different time periods.

Table 12. Wet ITS and TSR Values for SCDOT Surface Course Type A – PG 76-22 Using Various Quarries.

Quarry	Date	Wet ITS, psi	TSR
P	11/03/10	148.5	94.5
CY	04/24/09	123.3	96.3
CY	11/04/09	190.5	99.6
CY	02/19/10	182.3	93.2
CY	09/18/09	171.6	96.7

Observations and Conclusions:

- 1) The pellet products should be used with gap-graded and open graded mixes. They may be used, in some cases, in dense graded mixes as well but the swelling affect of the rubber in the binder must be taken into account.
- 2) The moisture susceptibility of the pellet products compared favorably to other SBS PG 76-22 mixes which are in use in SC today.
- 3) The binder analysis indicated the original binder (before pelletizing process) satisfied the AR (asphalt rubber) requirements of ASTM D8 and D6114.