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INTERIM REPORT

REJUVENATING AGENT RATE FOR ONE-INCH SURFACE RECYCLE ON K-9 NEAR WETMORE

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Topeka, Kansas

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16 Abstract

The one (1) inch surface recycle process for asphalt pavement preservation has been used for many years in Kansas. The recycling process typically uses four (4) propane heating units, a tined scarifying unit attached to the last heating unit and a paving machine to achieve a three-quarter to one inch total depth of recycled material. This recycled layer is then covered with a 1 to 1½ inch thick overlay wearing surface.

The intent of the investigation was twofold: first, to determine the property changes of the recycled material in comparison with the original pavement material, and second, to determine how the properties of the recycled material change when the emulsion rate is changed. This specific project was in Nemaha County on K-9 near Wetmore. Two test sections (#1 & #2) and a control section (#3), all 990 feet in length, were installed. The east end of test section #1 is at Milepost 280 and the other two sections are consecutive to the west of test section #1, all in the eastbound lane. The before and after gradation, asphalt content and thermal cracking properties were determined, as well as the potential rutting stability of the recycled mixture. Cores taken after the project was completed were used to determine the lift thicknesses and the compaction effort on the recycle and surface lifts.

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A Report on Research Sponsored By

THE KANSAS DEPARTMENT OF TRANSPORTATION
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INTRODUCTION

The one (1) inch surface recycle process for asphalt pavement preservation has been used for many years in Kansas. The recycling process typically uses four (4) propane heating units, a tined scarifying unit attached to the last heating unit and a paving machine to achieve a three quarter to one inch total depth of recycled material. This recycled layer is then covered with a 1 to 1½ inch thick overlay wearing surface.

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RESEARCH APPROACH

The approach was to obtain Hot Mix Asphalt (HMA) material from each of the test and control sections and to do the testing at the Materials & Research Center (MRC) in Topeka. Material with and without rejuvenating agent was obtained from each section; except for test section #2 where only material with the rejuvenating agent was obtained. The rejuvenating agent addition rate to be used for the project was determined to be 0.110 gal/yd^2. Test section #1 had a rejuvenating agent rate of 0.127 gal/yd^2, test section #2 had a rate of 0.137 gal/yd^2 and the control section (section #3) had a rate of 0.110 gal/yd^2.

The HMA material was collected from the processed material by the on-site KDOT Construction personnel and they delivered the material to the MRC Asphalt Laboratory. The Research Asphalt Laboratory personnel performed all the testing for this investigation.

The theoretical maximum specific gravity (Gmm) of each specimen was determined from the loose HMA material. An ignition oven test (KT-57) was used to determine the percent asphalt content of each specimen and the aggregate gradation was found from a sieve analysis of the aggregate after the ignition oven burnoff.

The loose mix was compacted with the Superpave Gyratory Compactor and the plug was cored to obtain 2 inch diameter specimens for the Thermal Stress Restrained Specimen Test (TSRST). The TSRST equipment was used to obtain the cold temperature vs. stress relationship of the material for both the before and after the addition of rejuvenating agent cases. The test restrains the specimen from changing length while lowering the temperature until tensile fracture of the specimen occurs. The

data generated gives an approximation of the low temperature cracking characteristics of the binder.

The Gyratory Testing Machine (GTM), sometimes referred to as the Corps of Engineers Gyratory, was used to determine the stability of the compacted recycle mix which is related to the rutting potential.

The Bulk Specific Gravity (Gmb) of the finished pavement was found by testing slices of 4 inch cores using Kansas Test Method KT-15, Procedure III.

DISCUSSION OF RESULTS

The final gradation behind the paver and the gradation immediately in front of the paver before the rejuvenating agent is added, but after the scarification, are basically the same. This would imply that the pavers' milling head isn't breaking the aggregate into smaller pieces. The final gradation appears to be slightly finer than the original surface mix design, especially the minus #50 material; but, there is only a 2-3% difference on the amount retained on the #100 and #200 sieves. However, comparing the final gradation to the gradation of the road cores taken before construction could indicate that the overall surface recycle operation broke the aggregate into smaller pieces creating a finer mix gradation by 5-10% for each sieve size smaller than 3/8 inch. Refer to Table A1 in Appendix A for the gradation data.

The Gmm before the rejuvenating agent was added averaged 2.384 and after the rejuvenating agent was added the Gmm was 2.358, 2.352 and 2.362 for test sections 1, 2 & 3 respectfully. For reference, the rejuvenating agent was added at a rate of 0.127, 0.137 and 0.110 gal/yd^2 for Sections 1, 2 & 3 respectfully. Refer to Table A2 in Appendix A for the Gmm data.

The Asphalt Binder Content averaged 6.16% for the scarified material before the rejuvenating agent was added; however, the binder content of the pre-construction road cores averaged 6.25%. The content after the rejuvenating agent was added was 6.78, 7.01 and 6.76% for test sections 1, 2 & 3 respectfully. For reference, the rejuvenating agent was added at a rate of 0.127, 0.137 and 0.110 gal/yd^2 for Sections 1, 2 & 3 respectfully. Refer to Table A2 in Appendix A for the percent asphalt data.

The TSRST data indicates that the cold temperature cracking resistance increased from -18.4ºC before the rejuvenating agent was added to an average of -25.6ºC (average of data from Sections 1, 2 & 3) after the rejuvenating agent was added for an increase of approximately 39%. These temperatures are a close approximation of the “low temperature grade” of the binder. Also, the transition temperature, where the mixture starts to act brittle rather than flexible, went from -11.8ºC to an average of -19.9ºC for an approximate 69% increase. Refer to Table A3 in Appendix A for the TSRST data.

The data from the GTM testing indicates that the addition of the rejuvenating agent caused the mixture to go “unstable” or be more susceptible to rutting as the rate of rejuvenating agent increased beyond the design rate. A Gyratory Stability Index (GSI) value greater than 1.02 at 60 revolutions indicates an unstable mix. This “unstable mix” would be of great concern if this recycled layer was the wearing surface; however, since the overlay is the wearing surface there is less, if any, concern. Refer to Table A4 in Appendix A for the Gmm data.

Lift thickness was determined by measuring 4 inch diameter cores obtained from the roadway in the eastbound lane of each test section. Five cores were obtained from each test section at random locations both along the length of the section and across the lane width. The overlay (surface lift) averaged 0.75 inches for all three sections and the recycle lift averaged 1.01 inches thick for all three sections. Refer to Table A5 in Appendix A for the lift thickness data.

The specific gravity, density and air voids for the overlay (surface lift) and recycle lift were found by cutting the cores apart at the lift interface and testing the individual

slices. The percent air voids for the surface lift averaged 6.8%, 8.3% and 7.8% for Sections 1, 2 & 3 with a range from 4.7 to 11.7%. The overall combined average is 7.6% air voids. The corresponding average densities are 140, 138 and 139 lbs/ft^3 with a range from 133 to 143 lbs/ft^3.

The percent air voids for the recycle lift averaged 4.7%, 6.1% and 5.4% for Sections 1, 2 & 3 with a range from 3.4 to 11.1%. The overall combined average is 5.4% air voids. The corresponding average densities are 140, 138 and 139 lbs/ft^3 with a range from 130 to 142 lbs/ft^3.

The roadway was open to traffic for approximately one month after construction before the cores were obtained. Refer to Table A6 in Appendix A for the specific gravity, density and air void data.

ONGOING MONITORING

The MRC Research Asphalt Unit and other KDOT personnel should continue to monitor these sections of K-9 for signs of rutting and/or other distress.

The Research Asphalt Team is scheduled to monitor the sections on an annual basis with a performance survey that will include crack mapping, rutting checks and visual observations.

APPENDIX A

Table A1: Sieve Analysis Data

KT-57 Sieve Analysis - K-9 - KA 0296-01 - (1" Surface Recycle Lift)										
(% Retained)										
Location / Sieve Size	Test Section #1 W/O	Test Section #1 W/Rejuv	Test Section #2 W/Rejuv	Test Section #3 W/O	Test Section #3 W/Rejuv	Average of all locations **W/O**	Average of all locations **W/Rejuv**	Prior to Road Cores 9/9/05	Prior to Road Cores 9/22/05	Original Surface Mix Design
3/4"	0	0	0	0	0	0	0	0	0	0
1/2"	0	0	0	0	0	0	0	T	0	0
3/8"	2	3	2	2	2	2	2	2	2	2
#4	15	17	16	17	18	16	17	22	23	18
#8	35	37	36	35	37	35	37	42	44	36
#16	50	52	52	49	52	50	52	61	61	51
#30	67	68	68	66	69	67	68	75	75	69
#50	82	84	83	82	84	82	84	87	87	86
#100	91	91	91	90	92	91	91	93	93	94
#200	93.1	93.4	93.6	92.7	94.3	92.9	93.8	95.1	94.9	96.1

Note 1: Sample location for without rejuvenator added (W/O) is after the scarifier but before the paver
Note 2: Sample location for with rejuvenator added (W/Rejuv) is behind the paver
Note 3: The original pavement surface course mix design was 1G00002A

Table A2: Gmm & Percent Asphalt Data

K-9 - KA 0296-01 - (1" Surface Recycle Lift)							
Location	**W or W/O Rejuv Added**	**Amount Rejuv. Added (gal/yd²)**	**Gmm W/O Rejuv**	**Gmm W/ Rejuv**	**% Asphalt W/O Rejuv**	**% Asphalt W/ Rejuv.**	**% Asphalt Added**
Test Section #1	W/O	0	2.387		6.17		
Test Section #1	W	0.127		2.358		6.78	0.61
Test Section #2	W	0.137		2.352		7.01	0.84
Test Section #3	W/O	0	2.380		6.15		
Test Section #3	W	0.110		2.362		6.76	0.59
(Control)							
Bit. Rd Cores*	W/O	9/9/2005*			6.3		
Bit. Rd Cores*	W/O	9/22/2005*			6.2		
		Column Average =	2.384	2.357	6.21	6.85	

* Cores taken prior to construction

Table A3: TSRST Data

K-9 - KA 0296-01 - (1" Surface Recycle Lift)						
Test Section (rejuv)	Specimen Number	With or Without Rejuv	Failure Temperature	Transition Temperature	Fracture Stress	Slope of Stress Curve
			ºC	ºC	psi	
3	423	W/O	-17.4	-11.5	279	19.0
	424	W/O	-19.3	-12.0	308	22.2
		Average =	-18.4	-11.8	294	20.6
1 (0.127)	425	W	-24.5	-19.5	375	28.6
	426	W	-26.1	-19.3	406	26.7
	427	W	-23.6	-18.5	380	33.3
		Average =	-24.7	-19.1	387	29.5
2 (0.137)	428	W	-26.2	-20.5	376	30.8
	429	W	-27.8	-21.5	441	26.7
	430	W	-25.1	-20.5	411	30.8
		Average =	-26.4	-20.8	409	29.4
3 (0.110)	431	W	-25.9	-19.8	416	26.7
	432	W	-25.7	-19.3	404	28.6
	433	W	-25.5	-20.3	402	26.7
		Average =	-25.7	-19.8	407	27.3
		Average W =	-25.6	-19.9	401	28.8
		Average W/O =	-18.4	-11.8	294	20.6

Table A4: GTM Data

K9 - KA 0269-01 - (1" Surface Recycle Lift)			
Location	**Mix Type**	**Rev.'s**	**GSI**
Test Section #1	W/Rejuv (0.127 gal/yd²)	30	1.00
		45	1.03
		60	1.07
		90	1.14
Test Section #2	W/Rejuv (0.137 gal/yd²)	30	1.02
		45	1.06
		60	1.12
		90	1.23
Test Section #3 (Control)	W/Rejuv (0.110 gal/yd²)	30	1.00
		45	1.01
		60	1.03
		90	1.06
Test Section #3	W/O Rejuv	30	1.00
		45	1.00
		60	1.01
		90	1.01

Table A5: Lift Thickness Data

K-9 - KA 0296-01 - (1" Surface Recycle Project)						
Lift Thickness measured from cores (inches)						
Core Id	Surface Lift	2nd Lift*	3rd Lift	4th Lift	5th Lift	Total of All
Test Section # 1						
1C	1.00	1.00	1.80	1.40	**	5.20
2C	0.75	0.92	1.47	1.10	**	4.24
3C	0.70	0.75	1.50	1.35	**	4.30
4C	0.75	1.20	0.90	1.10	1.50	5.45
5C	0.75	1.20				1.95
average =	0.79	1.01	1.42	1.24		
Test Section # 2						
1B	0.70	1.00	1.00	1.40		4.10
2B	0.75	1.15	1.55	0.75	**0.80	5.00
3B	0.70	1.20	0.85	0.90	0.90	4.55
4B	0.70	1.05	0.75	0.90	0.60	4.00
5B	0.90	1.10	1.35	0.75	0.55	4.65
average =	0.75	1.10	1.10	0.94		
Test Section # 3 (Control)						
1A	0.77	0.55	1.00	1.60	** 0.65	4.57
2A	0.80	1.09	1.72	0.45	0.60	4.65
3A	0.75	1.17	1.18	1.10	** 1.30	5.50
4A	0.50	0.75	0.90	1.60	** 0.73	4.48
5A	0.70	1.00	1.50	0.85		4.05
average =	0.70	0.91	1.26	1.12		

Notes:

* 2nd lift is the surface recycled lift

** Saw trimmed bottom to smooth surface

Road Cores - as received from District 1 on 6/7/06

Date Measured: 7/17/06

Table A6: Specific Gravity, Density and Air Voids Data

K-9 - KA 0296-01 - (1" Surface Recycle Project)						
Specimen ID	**Rejuv. Added**	**Gmm**	**Gmb**	**% Air Voids**	**lbs/ft^3**	**Core Location**
	(gal /yd^2)					
Test Section 1 - Surface Lift						
1C-1	n/a	2.416	2.247	7.0	139.83	inside wheel path
2C-1	n/a	2.416	2.199	9.0	136.87	outside wheel path
3C-1	n/a	2.416	2.303	4.7	143.33	middle of lane
4C-1	n/a	2.416	2.250	6.9	140.07	2' from shoulder
5C-1	n/a	2.416	2.264	6.3	140.92	2' off centerline
Average =			2.253	6.8	140.20	
Test Section 1 - Recycle Lift						
1C-2	0.127	2.358	2.262	4.1	140.80	inside wheel path
2C-2	0.127	2.358	2.191	7.1	136.40	outside wheel path
3C-2	0.127	2.358	2.277	3.4	141.75	middle of lane
4C-2	0.127	2.358	2.232	5.3	138.93	2' from shoulder
5C-2	0.127	2.358	2.272	3.6	141.44	2' off centerline
Average =			2.247	4.7	139.86	
Test Section 2 - Surface Lift						
1B-1	n/a	2.416	2.197	9.1	136.73	outside wheel path
2B-1	n/a	2.416	2.133	11.7	132.73	middle of lane
3B-1	n/a	2.416	2.225	7.9	138.47	middle of lane
4B-1	n/a	2.416	2.246	7.0	139.79	middle of lane
5B-1	n/a	2.416	2.277	5.8	141.73	inside wheel path
Average =			2.216	8.3	137.89	
Test Section 2 - Recycle Lift						
1B-2	0.137	2.352	2.254	4.2	140.28	outside wheel path
2B-2	0.137	2.352	2.092	11.1	130.21	middle of lane
3B-2	0.137	2.352	2.232	5.1	138.90	middle of lane
4B-2	0.137	2.352	2.200	6.5	136.93	middle of lane
5B-2	0.137	2.352	2.268	3.6	141.16	inside wheel path
Average =			2.209	6.1	137.50	

Table A6: Specific Gravity, Density and Air Voids Data (continued)

Specimen ID	Rejuv. Added	Gmm	Gmb	% Air Voids	lbs/ft^3	Core Location
Test Section 3 - Surface Lift						
1A-1	n/a	2.416	2.227	7.8	138.65	outside wheel path
2A-1	n/a	2.416	2.256	6.6	140.44	middle of lane
3A-1	n/a	2.416	2.273	5.9	141.48	outside wheel path
4A-1	n/a	2.416	2.166	10.3	134.80	outside wheel path
5A-1	n/a	2.416	2.220	8.1	138.21	middle of lane
Average =			2.228	7.8	138.72	
Test Section 3 - Recycle Lift (Control)						
1A-2	0.110	2.362	2.252	4.7	140.17	outside wheel path
2A-2	0.110	2.362	2.194	7.1	136.57	middle of lane
3A-2	0.110	2.362	2.278	3.6	141.78	outside wheel path
4A-2	0.110	2.362	2.251	4.7	140.09	outside wheel path
5A-2	0.110	2.362	2.192	7.2	136.42	middle of lane
Average =			2.233	5.4	139.01	

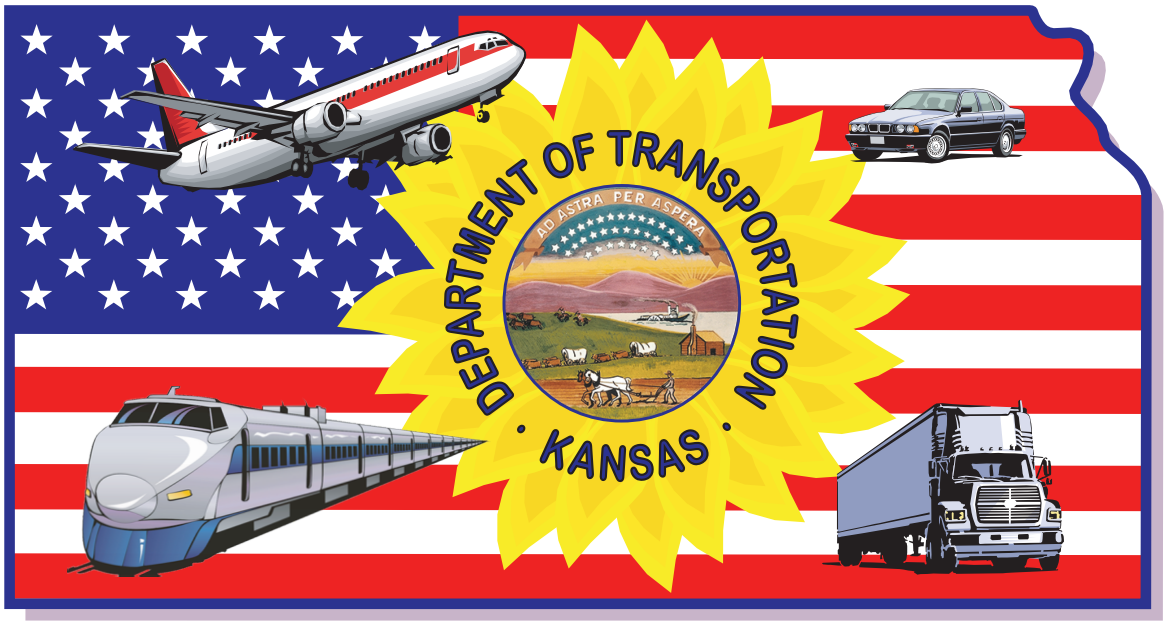
NOTES:

1.) Surface Recycled on May 10 & 12, 2006

2.) Overlay placed May 17, 2006

3.) Cores taken on 6/7/06 from the eastbound lane

4.) Overlay Mix Design #1G06011A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