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Department of Transportation

Applied Research and Innovation Branch

USE OF WASTE TIRES (CRUMB RUBBER) ON COLORADO HIGHWAYS

Scott Shuler

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16. Abstract
The objective of this study was to determine the feasibility of using waste tires (crumb rubber) in the construction of asphalt pavements in Colorado. Two pilot test sections and one control section were constructed and observed over a five-year period to meet this objective. The two pilot test sections were built using two crumb rubber modified (CRM) asphalt processes. One process uses ground tire rubber (GTR) blended with hot asphalt cement at the asphalt plant to form the hot mix asphalt. This is referred to as the Wet Process. The other process blends GTR and asphalt cement at a remote blending facility and is then transported to the hot mix plant to produce the hot mix asphalt. This process is the Terminal Blend method. In addition, a control section was constructed containing a conventional binder. Binders in the two test sections containing GTR and the control section met the specifications for PG 64-28 asphalt. Each of the three test sections contains approximately 1,000 tons of 2-inch asphalt overlay placed over a cold-milled surface in the eastbound driving lane of US 34 Bypass near Greeley, CO. Construction of the test and control sections occurred in the summer of 2009.

The goal of this research project is to evaluate the performance of the crumb rubber test sections compared with the conventional control section and depending on performance, develop Colorado-specific materials and construction specifications for ground tire modified asphalt pavements. Also, the research project aims to develop guidelines and best management practices for the construction of ground tire modified asphalt pavements. Transverse cracking began in the rubber modified sections after 22 months of service and longitudinal cracking began after 29 months. The control sections have no transverse cracking to date with longitudinal cracking beginning to appear after 56 months.

Implementation: None.

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CONVERSION TABLE

U. S. Customary System to SI to U. S. Customary System

(multipliers are approximate)

Multiply (symbol)	by	To Get (symbol)	Multiply	by	To Get
LENGTH					
Inches (in)	25.4	millimeters (mm)	mm	0.039	in
Feet (ft)	0.305	meters (m)	m	3.28	ft
yards (yd)	10.914	meters (m)	m	1.09	yd
miles (mi)	1.61	kilometers (km)	m	0.621	mi
AREA					
square inches (in^2)	645.2	square millimeters (mm^2)	mm^2	0.0016	in^2
square feet (ft^2)	0.093	square meters (m^2)	m^2	10.764	ft^2
square yards (yd^2)	0.836	square meters (m^2)	m^2	1.195	yd^2
acres (ac)	0.405	hectares (ha)	ha	2.47	ac
square miles (mi^2)	2.59	square kilometers (km^2)	km^2	0.386	mi^2
VOLUME					
fluid ounces (fl oz)	29.57	milliliters (ml)	ml	0.034	fl oz
gallons (gal)	3.785	liters (l)	l	0.264	gal
cubic feet (ft^3)	0.028	cubic meters (m^3)	m^3	35.71	ft^3
cubic yards (yd^3)	0.765	cubic meters (m^3)	m^3	1.307	yd^3
MASS					
ounces (oz)	28.35	grams (g)	g	0.035	oz
pounds (lb)	0.454	kilograms (kg)	kg	2.202	lb
short tons (T)	0.907	megagrams (Mg)	Mg	1.103	T
		<u>TEMPERATURE (EXACT)</u>			
Farenheit (°F)	5(F-32)/9 (F-32)/1.8	Celcius (° C)	° C	1.8C+32	° F
ILLUMINATION					
foot candles (fc)	10.76	lux (lx)	lx	0.0929	fc
foot-Lamberts (fl)	3.426	candela/m (cd/m)	cd/m	0.2919	fl
FORCE AND PRESSURE OR STRESS					
poundforce (lbf)	4.45	newtons (N)	N	.225	lbf
poundforce (psi)	6.89	kilopascals (kPa)	kPa	.0145	psi

DEFINITIONS OF TERMS

DSR	Dynamic Shear Rheometer
BBR	Bending Beam Rheometer
RTFO	Rolling Thin-Film Oven
E*	Complex Modulus
S	CDOT HMA with 1 inch nominal maximum size aggregate
SX	CDOT HMA with ¾-inch nominal maximum size aggregate
VTM	Voids in the Total Mix
VMA	Voids in the Mineral Aggregate
VFA	Voids Filled with Asphalt

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Thank you all.

EXECUTIVE SUMMARY

The objective of this study was to determine the feasibility of using waste tires (crumb rubber) in the construction of asphalt pavements in Colorado. Two pilot test sections and one control section were constructed and observed to meet this objective. The two pilot test sections were built using two crumb rubber modified (CRM) asphalt processes. One process uses ground tire rubber blended with hot asphalt cement at the asphalt plant to form the hot mix asphalt. This will be referred to as the Wet Process. The other process blends ground tire rubber and asphalt cement at a remote blending facility and is then transported to the hot mix plant to produce the hot mix asphalt. This process will be referred to as the Terminal Blend method. In addition, a control section was constructed containing a conventional binder. Binders in the two test sections containing ground tire rubber and the control section met the specifications for a PG 64-28 asphalt. Each of the three test sections contains approximately 1,000 tons of 2-inch asphalt overlay placed over a cold-milled surface in the eastbound driving lane of US 34 near Greeley, CO. Construction of the test and control sections occurred in the summer of 2009.

The goal of this research project is to evaluate the performance of the crumb rubber test sections compared with the conventional control section and depending on performance, develop Colorado-specific materials and construction specifications for ground tire modified asphalt pavements. Also, the research project aims to develop guidelines and best management practices for the construction of ground tire modified asphalt pavements. Transverse cracking began in the rubber modified sections after 22 months service and longitudinal cracking began after 29 months. After 56 months of service, transverse cracking has not been observed in the control sections. However, one longitudinal crack was observed in one of the control sections after this period.

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INTRODUCTION

The Colorado Department of Transportation (CDOT) has used rubber in hot mix asphalt (HMA) for over 25 years. Since the early 80's, CDOT used Asphalt Cement-20 Rubberized (AC-20R) which was an Asphalt Cement-20 (AC -20) base grade of asphalt cement with a styrene-butadiene-rubber polymer blended at a terminal plant and shipped to the various locations throughout Colorado. Since CDOT's AC-20R was performing well, CDOT retained the ductility value along with the toughness and tenacity requirements for the newly initiated Performance Grade 64-28 (PG 64-28) grade of binder when the Department switched to the SuperPave performance graded HMA specifications in 1995. In 1994, CDOT built three trial sections in Colorado where crumb rubber was blended into the dense graded HMA using the dry method (crumb rubber is added as a component of the aggregates). Based on the information from Research Report Number CDOT-DTD-R-99-9, these trial sections proved to be a feasible asphalt pavement alternative and were performing well. The research noted that this process increased the cost per ton by 21 percent when the crumb rubber was added at a rate of 20 pounds per ton. It was recommended that CDOT not pursue any use of crumb rubber until it became cost effective. Other state DOTs have tried the dry method with their dense graded HMA but opted not to continue using the process because of similar concerns and other problems. Therefore, CDOT will not pursue investigating this method at this time.

The use of crumb rubber in chip seal using the wet method was also investigated in the late 80's with the results and findings documented in the Research Report Number CDOH-DTP-R-86-3. The finished product performed comparably well with the conventional chip seal materials used for pavement rehabilitation but was found to be more expensive. With the influx of improved crumb rubber technologies, it is thought that the asphalt pavement life could be longer and the use of crumb rubber employing the wet and terminal blend method might prove cost-effective. For this reason, CDOT is revisiting the use of crumb rubber in HMA utilizing pilot test sections to gather the required information for developing specifications for the wet and terminal blend methods.

This research evaluated the feasibility of using waste tires (crumb rubber) in the construction of asphalt pavements. As part of the evaluation, two pilot test sections and one control section using the Superpave PG 64-28 asphalt binder in dense graded HMA were built. The two pilot test sections were built with crumb rubber modified (CRM) asphalt mix using the wet method (crumb rubber is mixed with asphalt binder at the asphalt plant producing the HMA mixture) and the terminal blend method (crumb rubber is mixed with asphalt binder at a remote location and transported to the hot mix plant). Each test section consisted of approximately 1,000 tons of 2-inch thick asphalt overlay placed in the eastbound driving lane of US 34 in Greeley, Colorado. The control section was constructed with a conventional PG 64-28 binder.

Objectives

This research has eight objectives:

1. To develop a pilot specification for building two test sections with CRM using the wet and terminal blend methods.
2. To determine if CRM asphalt cement pavements can be designed and produced for a typical dense graded HMA for Colorado that either meets or exceeds the CDOT's design/construction (including placement and compaction) criteria.
3. To determine if the asphalt binder for the wet and terminal blend method either meets or exceeds PG 64-28 requirements for CDOT's ductility/toughness, and tenacity specifications.
4. To compare the cost effectiveness of the wet and terminal blend methods with that of the conventional method using PG 64-28 binder. Determine the cost differential from using crumb rubber from out-of-state versus estimated costs from using an in-state source of crumb rubber.
5. To determine the energy consumption, types and levels of air pollutants associated with the production of pavement mix using the wet, terminal blend and plain PG 64-28 binders.
6. To develop guidelines and best management practices for the successful method(s) of incorporating crumb rubber in dense graded HMA pavements.

7. To update the initial pilot specification to produce a special project provision as appropriate using the information obtained from monitoring this project and other applicable data derived from the experiences of federal, other state and local agencies.
8. To perform annual pavement condition surveys for a maximum of five years and submit results/analysis to CDOT. To prepare a report documenting the construction and monitoring of pavement performance during the first 21 months of service life.

LITERATURE REVIEW

Granulated tire rubber has been used as a modifier for asphalt cement binders since the late 1960's. The first use of this modified binder in pavements was as a chip seal binder in Phoenix, Arizona (McDonald 1981). McDonald found that after thoroughly mixing crumb rubber with asphalt and allowing it to react for periods of forty-five minutes to an hour, new material properties were obtained. This material captured beneficial engineering characteristics of both base ingredients; he called it asphalt-rubber (Huffman, 1980). The mixing of crumb rubber with conventional asphalt binders results in stiffer binder (Dantas Neto *et al*., 2003; Way, 2003) with improved rutting and cracking properties.

One explanation for this is the absorption of some of the asphalt constituents in the rubber. When rubber absorbs these components the rubber particles swell. The extent of swelling is dependent on the nature, temperature and viscosity of the asphalt (Treloar 1975, Shuler, *et al* 1979). The bulk of the rubber absorbs the solvent, which increases the dimensions of the rubber network until the concentration of liquid is uniform and equilibrium swelling is achieved. Previous research has indicated that the crumb rubber particles reacting with asphalt binder swell and form a viscous gel due to absorption of some of the lighter fractions in the asphalt binder (Green and Tolonen, 1997; Heitzman, 1992; Bahia and Davies, 1994; Zanzotto and Kennepohl, 1996; Kim *et al*., 2001). Furthermore, Leite *et al*. discovered that the proportion of the crumb rubber in the mixture changes significantly since a rubber particle can swell from 3 to 5 times its original size when blended with an asphalt binder (Leite *et al*., 2003).

Many experimental studies and field test sections have been constructed and tested (Shuler, et al 1982) using asphalt rubber as a chip seal or interlayer between an old cracked asphalt pavement and the new overlay. Performance of these test sections was documented based on a Federal Highway Administration (FHWA) pooled fund study (Shuler, et al 1985) where over 200 field test sections were evaluated. Although the results of this research indicated a range of performance from very poor to extremely good, work continued to develop asphalt rubber as a binder for sprayed seal applications and HMA. The National Cooperative Highway Research Programs (NCHRP) "Synthesis of Highway Practice 198 – Uses of Recycled Rubber Tires in Highways" provides comprehensive review of the use of recycled rubber tires in highways based on a review of nearly 500 references and on information recorded from state highway agencies' responses to a 1991 survey of current practices (Epps 1994).

A study from Virginia (Maupin 1996) reported that the mixes containing asphalt rubber performed at least as well as conventional mixes. In Virginia mixes, the inclusion of asphalt rubber in HMA pavements increases construction cost by 50 to 100 percent as compared to the cost of conventional mixes. Nevada (Troy, et al 1996) conducted research on CRM asphalt pavements and concluded that the conventional sample geometry in Superpave binder test protocols cannot be used to test the CRM binders and that the Hveem compaction is inadequate for mixtures containing CRM binders. The Louisiana Department of Transportation and Development (LADOTD) started a research project to evaluate different procedures of CRM applications in 1994 in which the long-term pavement performance of the CRM asphalt pavements was compared to that of the control sections built with conventional asphalt mixtures (LTRC 1996).

Construction practices in Arizona, California and Florida has been compiled (Hicks et al, 1995) as well as an interim report on construction guidelines (Hanson, 1996) and a compilation of specification requirements (Shuler 1982). These reports have been helpful to agencies that wish to develop specifications for crumb rubber modified asphalt.

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, Section 1038 mandated the use of rubber modified asphalt pavements. However, AASHTO was opposed to the mandate

because facts regarding fume emissions, cost effectiveness, durability, longevity, and recyclability were unknown. Therefore, U.S. Congress was persuaded to repeal Section 1038 of ISTEA making use of asphalt rubber in federally funded projects optional.
The economic savings related to using asphalt rubber has been presented using the FHWA Life Cycle Cost Analysis (Hicks, et al 1999)

The Texas Transportation Institute conducted a study of two recycled crumb rubber pavements (Crockford, 1995). The study concluded that recycling was possible and that emissions from the project were no more severe than conventional asphalt hot mix. Recycling of an asphalt rubber pavement occurred in Los Angeles, California. (Youssef, 1995). The pavement was cold milled and added to the virgin mixture at 15 percent of the total mix. Air sampling during paving and recycling determined that employee exposure to air contaminants were below the Occupational Safety and Health Administration (OSHA) permissible exposure limits (PEL), and in most cases below detection limits.

Fume emissions have been studied extensively in a number of asphalt-rubber projects since, and in all cases they have been determined to be below the National Institute for Occupational Safety and Health (NIOSH) recommended exposure limits. (Gunkel, 1994).

Combustion technologies are effective in the disposal of large quantities of waste tires and should be used where feasible and acceptable to the public. However, the combustion of tires does not provide a continuous public benefit and results in a net energy loss when all is considered. Although approximately 15,000 BTUs are recaptured when a tire is combusted, 30,000 BTUs were expended to create each tire. In contrast, the United States Department of Energy has estimated that over 90,000 BTUs/lb. of production can be saved by utilizing asphalt-rubber through reduced materials usage and its long lasting performance (Gaines and Wolsky, 1979.

MATERIALS

Testing binder and mixture materials properties was accomplished by CDOT Region 4, CDOT Headquarters and the paving contractor, Aggregate Industries, Inc. during construction. Results of the binder tests are summarized in Table 1 and the precise grading of each asphalt material is shown in Table 2.

Table 1 – Asphalt Binder Test Results*

Material	DSR, min 1.00 kPa	Ductility, Min 50 cm	Toughness, Min 110i/p	Tenacity, min 75i/p	RTFO DSR, min 2.20 kPa	RTFO Ductility, min 20 cm	BBR, S max, 300 MPa	BBR, m min 0.300
Control PG64-28	1.66	60	190	174	3.23	35	123	0.355
	1.66	60	210	194	3.20	41	122	0.356
	1.75	60	249	231	3.32	33	137	0.352
	1.55		150	138				
	1.56		150	136				
	1.69	60	213	197	3.24	34	135	0.347
PG6428 WP*	2.06	*6*	*40*	*5*	4.47	*3*	195	0.306
	1.91	*6*	*32*	*3.3*	4.86	*4*	192	0.308
PG64-28 TB***	2.10	*29*	*102*	*2.1*	3.48	*16*	117	0.365
	2.01	*30*	115	*2.0*	3.35	*17*	288	0.302
	2.08	*29*	*106*	*1.9*	3.49	*16*	124	0.358

* Test results not meeting specifications are shown in italics

** WP refers to the wet process rubber modification at the site

*** TB refers to the terminal blend rubber modification at the Wright asphalt terminal in Texas

Table 2 – Precise PG Grading of Project Asphalts

Material	Actual Grading
Control PG 64-28	PG 68.8-34.0
PG 64-28 WP*	PG 73.1-29.6
PG 64-28 TB	PG 68.6-32.4

* The original asphalt used to create the ‘wet process’ rubber modified asphalt was a PG 58.9-31.4 blended with an average of 9.25 percent crumb rubber by total blend weight at the site.

Further characterization of the binders was done using the Dynamic Shear Rheometer (DSR) at multiple loading rates to create so-called mastercurves for G* as a function of loading time. This data is shown in Figure 1.

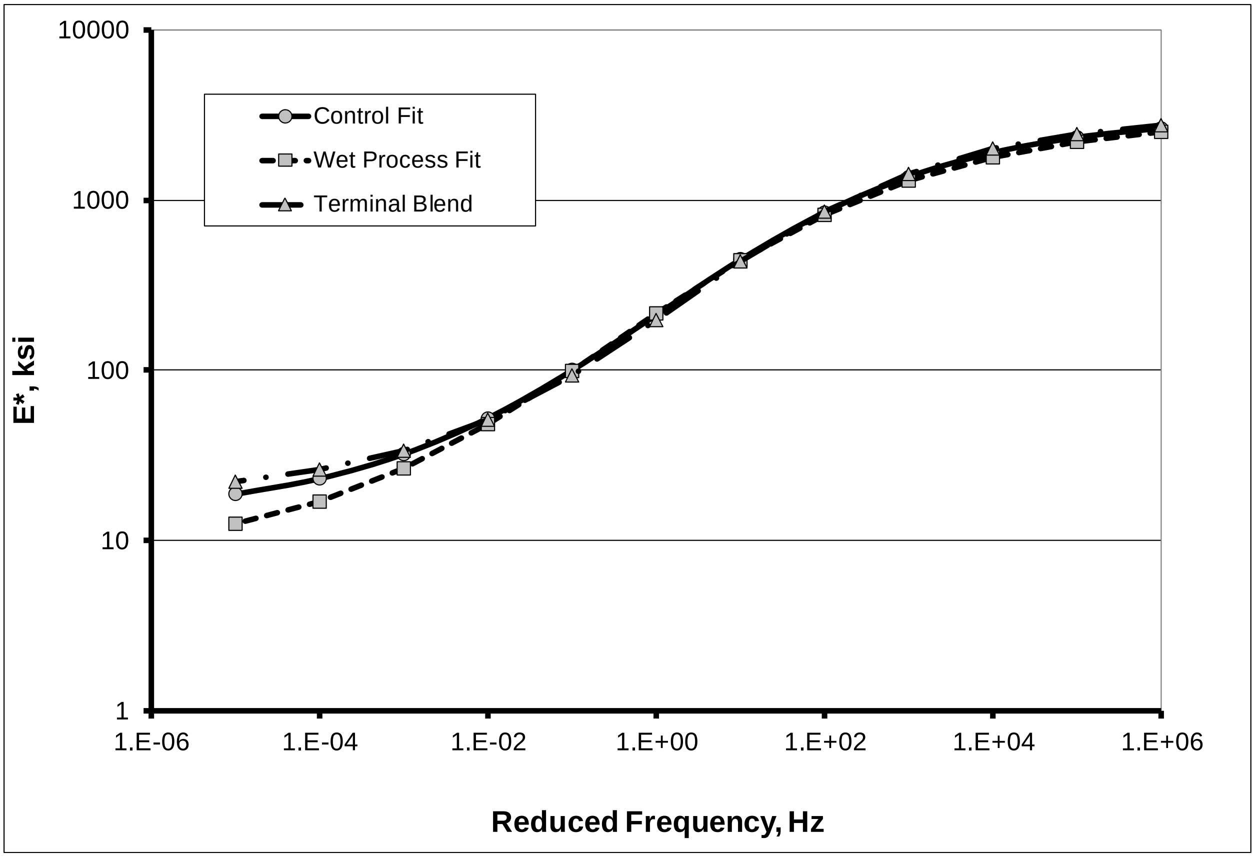

Figure 1 – G* Mastercurves for Project Asphalt Binders

The asphalt mixture used for all three test sections was a CDOT grading SX at 100 design Superpave gyrations of compaction. Mixture design properties are shown in Tables 3, 4 and 5 for the control, terminal blend, and wet process l mixtures, respectively.

Table 3 – Mixture Design Properties – Control

Sieve, mm	Passing, %	Specification
19	100	100
12.5	**95**	**90-100**
9.5	86	80-92
4.75	62	57-67
2.36	47	42-52
1.18	34	
0.60	22	18-26
0.30	14	
0.15	9	
0.075	5.8	3.8-7.8
AC, %	5.70	5.8-6.4
VTM, %	3.6	2.7-5.1
VMA, %	14.8	13.7-15.1
VFA, %	n/a	65-75
Hveem Stability	30	
ITS-dry, psi	n/a	
TSR, %	n/a	
Mix Design	170947	
FS#	n/a	

Table 4 – Mixture Design Properties – Terminal Blend

Sieve, mm	Passing, %	Specification
19	100	100
12.5	95	90-100
9.5	86	80-92
4.75	62	57-67
2.36	47	42-52
1.18	34	
0.60	22	18-26
0.15	9	
0.075	5.8	3.8-7.8
AC, %	5.60	5.3-5.9
VTM, %	3.9	2.7-5.1
VMA, %	14.9	13.7-15.1
VFA, %	n/a	65-75
Hveem Stability	30	
ITS-dry, psi	n/a	
Retained ITS, %	n/a	
Mix Design	180610TB	
FS#	n/a	

Table 5 – Mixture Design Properties – Wet Process

Sieve, mm	Passing, %	Specification
19	100	100
12.5	95	90-100
9.5	86	80-92
4.75	62	57-67
2.36	47	42-52
1.18	34	
0.60	22	18-26
0.30	14	
0.15	9	
0.075	5.8	3.8-7.8
AC, %	6.10	5.8-6.4
VTM, %	3.9	2.7-5.1
VMA, %	16.5	13.7-15.1
VFA, %	n/a	65-75
Hveem Stability	30	
ITS-dry, psi	n/a	
Retained ITS, %	n/a	
Mix Design	180610WP	
FS#	n/a	

CONSTRUCTION

Construction of the control pavement sections was accomplished on July 27 and 28, 2009, the terminal blend on August 3 through 6, 2009 and the wet process on August 10 through 12, 2009 by Aggregate Industries West Central Region. The project consisted of removing the top two inches of the existing pavement by cold milling and replacing this material with two inches of the test and control pavement materials. The condition of the pavement prior to milling and overlay operations is shown in Figures 2, 3 and 4 for the control, wet process and terminal blend sections, respectively. Properties of the materials are shown in Tables 6, 7 and 8 for the control, terminal blend and wet process products, respectively.

Figure 2. Control Section Looking East

Figure 3. Wet Process Section Looking East

Figure 4. Terminal Blend Section Looking East

Table 6 – Control Properties As-Built (Contractor Quality Control Data)

Sieve		Passing, %		Specification
Standard	SI, mm	7/27/2009	7/28/2009	
¾”	19	100	100	100
½”	12.5	97	92	90-100
3/8”	9.5	84	85	80-92
4	4.75	62	60	57-67
8	2.36	46	45	42-52
16	1.18	36	34	
30	0.60	24	22	18-26
50	0.30	15	15	
100	0.15	9	9	
200	0.075	5.3	5.9	3.8-7.8

Property	Date				Spec
	7/27/2009	7/27/2009	7/28/2009	7/28/2009	
AC, %	5.34	5.29	5.22	5.36	5.3.5.9
VTM, %	3.14		2.59		2.7-5.1
VMA, %	14.1		13.2		13.7-15.1
VFA, %					65-75
Compaction, %	94.6		94.0	94.3	

Table 7a – As Built Properties-Terminal Blend Binder (CDOT Quality Assurance Data)

	Passing, %				Specification
Sieve, mm	8/3/09	8/4/09	8/4/09	8/6/09	
19	100	100	100	100	100
12.5	98	96	96	98	90-100
9.5	90	87	86	89	80-92
4.75	65	64	63	65	57-67
2.36	50	51	50	51	42-52
1.18	37	37	36	37	
0.60	25	25	24	25	18-26
0.30	16	16	15	16	
0.15	10	10	10	10	
0.075	6.6	7.1	6.7	6.2	3.8-7.8
AC, %	5.58	5.26	5.40	5.49	5.30-5.90
VTM, %	4.0	3.0	3.4	3.9	2.7-5.1
VMA, %	14.4	13.4	14.0	14.4	13.7-15.1
VFA, %	72.5	77.7	75.7	72.8	65-75
Hveem Stability	39	42	43	39	
ITS-dry, psi	73.2			88.7	30
Retained ITS, %	87			89	70
Sample No.	118HQ	2	3	126HQ	
FS#	14976	14977	14978	14977	

Table 7b – As Built Properties-Terminal Blend Binder (WesTest Quality Assurance Data)

Property	8/3/09	8/4/09	8/4/09	Spec
AC, (nuc/ign), %	5.16/5.38	5.28/n/a	5.19/n/a	5.30-5.90
VTM, %	4.6	4.0	4.2	2.7-5.1
VMA, %	14.5	14.3	14.7	13.7-15.1
VFA, %	68.3	71.8	71.6	65-75
Hveem Stability	47	n/a	n/a	
Lottman, dry, psi	80	n/a	n/a	30
TSR, %	79	n/a	n/a	70

Table 8a – As Built Properties-Wet Process Binder (CDOT Quality Assurance Data)

	Passing, %				Specification
Sieve, mm	8/10/09	8/11/09	8/11/09	8/12/09	
19	100	100		100	100
12.5	94	95		95	90-100
9.5	86	87		86	80-92
4.75	60	66		65	57-67
2.36	46	52		50	42-52
1.18	33	37		36	
0.60	21	24		23	18-26
0.30	13	16		14	
0.15	9	10		9	
0.075	5.9	6.7		5.8	3.8-7.8
AC, %	6.37	6.31	6.25	6.42	5.8-6.4
VTM, %	5.1	4.9	3.4	5.2	2.7-5.1
VMA, %	17.5	17.3	16	17.2	13.7-15.1
VFA, %	70.8	71.8	78.5	69.7	65-75
Hveem Stability	28	31	32	30	
ITS-dry, psi	83.6			82.6	
Retained ITS, %	91	87			
Sample No.	1	2	3	136HQ	
FS#	14979	14980	14981	14979	

Table 8b – As Built Properties-Wet Process Binder (WesTest Quality Assurance Data)

Property	8/10/09	8/10/09	8/11/09	Spec
AC, (nuc/ign), %	5.91/n/a	5.96/n/a	6.27/n/a	5.8 – 6.4
VTM, %	4.4	3.7	4.6	3.1 – 5.5
VMA, %	16.3	15.5	17.0	15.3 – 17.7
VFA, %	72.8	76.4	73.0	65-75
Hveem Stability	37	n/a	n/a	30
Lottman, dry, psi	86	n/a	n/a	30
TSR, %	84	n/a	n/a	70

Placement of the HMA was by a conventional self-propelled asphalt laydown machine fed by rear discharge tractor trailer units directly into the paver hopper. Compaction was achieved using a steel vibratory breakdown roller followed by a seven-wheel pneumatic and finally a static steel finish roller. Compaction, air voids, VMA, asphalt content, and aggregate gradation were generally very consistent as shown in the quality level charts in Appendix D.

The terminal blend asphalt rubber was produced in Channelview, Texas and shipped by tank truck to the Aggregate Industries asphalt plant in Greeley, CO.

The wet process asphalt rubber was blended at the asphalt plant by EcoPath. This process involves adding ground tire rubber (GTR) to hot liquid asphalt cement in a mixing tank and then pumping the resulting blended mixture to the HMA plant. A portable control trailer shown in Figures 5 and 6 monitors the quantity of rubber and asphalt combined as well as temperature. The asphalt cement and GTR are blended in a horizontal tank shown in

Figure 5 – EcoPath Control Trailer and Mixer

Figure 6 – EcoPath Control Room

Figure 7 until the mixture is ready to be transferred to the HMA plant for blending with aggregates.

Figure 7 – EcoPath Mixing Tank

When the mixture of blended asphalt and rubber is ready for transfer to the hot mix plant the viscosity is determined using a portable rotational viscometer as shown in Figure 8.

All three types of asphalt mixtures were produced in a Gencor counterflow drum mix plant.

Figure 8 – Rotational Viscosity

DATA COLLECTION

Air Emissions

Since asphalt rubber must be produced at higher temperatures than conventional HMA emissions have historically been significantly greater than on conventional HMA projects. Therefore, the data on quality of air emissions during construction generated from the asphalt plant was collected by Airtech Environmental Services, Inc. of Arvada, Colorado. The air quality was monitored during construction by instrumenting the asphalt plant as shown in Figure 9 and analyzing the results in a mobile laboratory at the site as shown in Figures 10 and 11. Results of this testing are shown in Appendix A.

Figure 9 – Air Emissions Data Collection

Figure 10 – Air Emissions Analysis

Figure 11 – Air Emissions Chemistry

Test Sections

Test and control sections are located on the US 34 Bypass in Greeley, CO in the eastbound driving lane between 71st Avenue and 35th Avenue. The 'Control Test' sections are between 71st and 65th Avenue, the 'Wet Process' test sections are between 65th and 47th Avenue, and the 'Terminal Blend' test sections are between 47th and 35th Avenue. Performance of the materials was determined by observing distress within two 500-foot long segments established within each test and control pavement section. These segments are shown in Figures 12, 13, and 14. Each five hundred foot long segment is subdivided into five 100-foot long sample sections. These are shown as the shaded areas on each figure. That is, Samples 1-5 and 6-10 are the control sections, Samples 11-15 and 16-20 are the 'wet process' sections and Samples 21-25 and 26-30 are the 'terminal blend' sections.

A precondition survey was conducted on the test and control sections prior to milling and overlay operations. This baseline data will be used to compare performance of each section relative to the condition prior to rehabilitation. Condition surveys have been conducted since placement of the test and control sections beginning 2010.

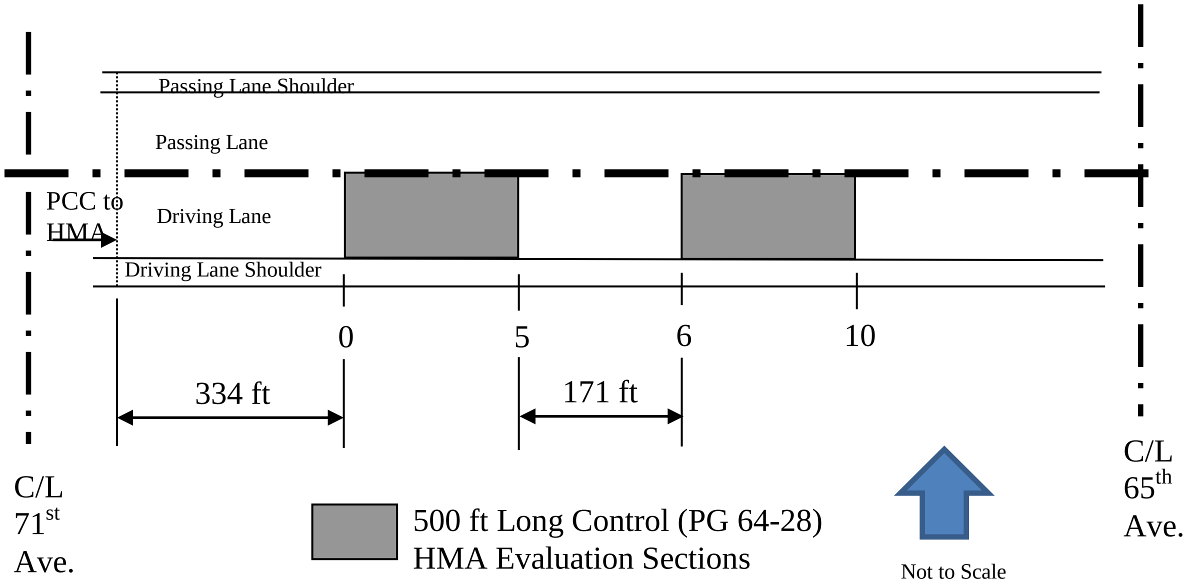

Figure 12 – Location of Control PG 64-28 Evaluation Sections on US 34

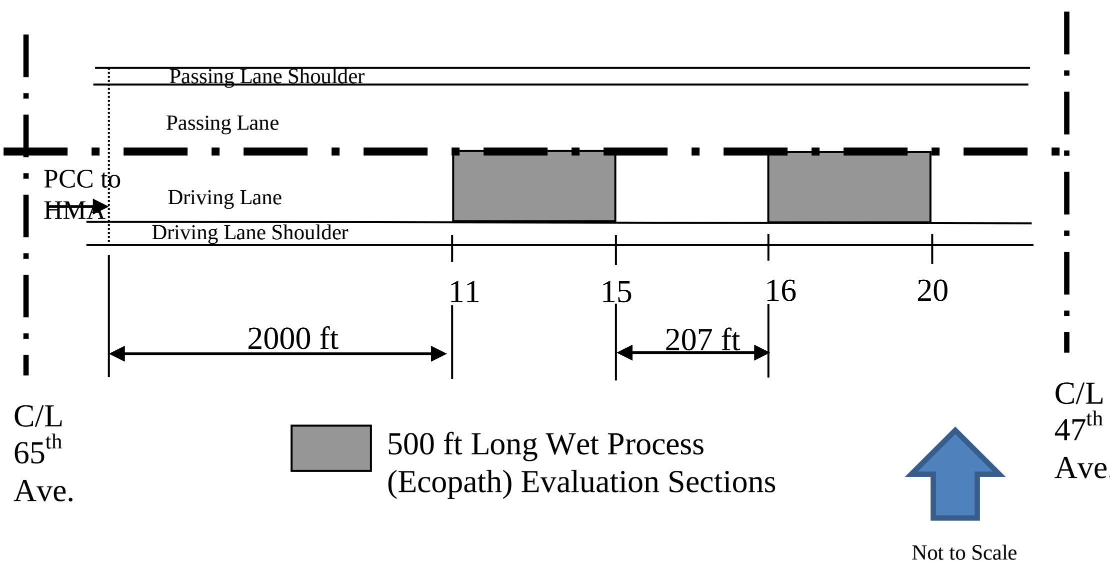

Figure 13 – Location of Wet Process Evaluation Sections on US 34

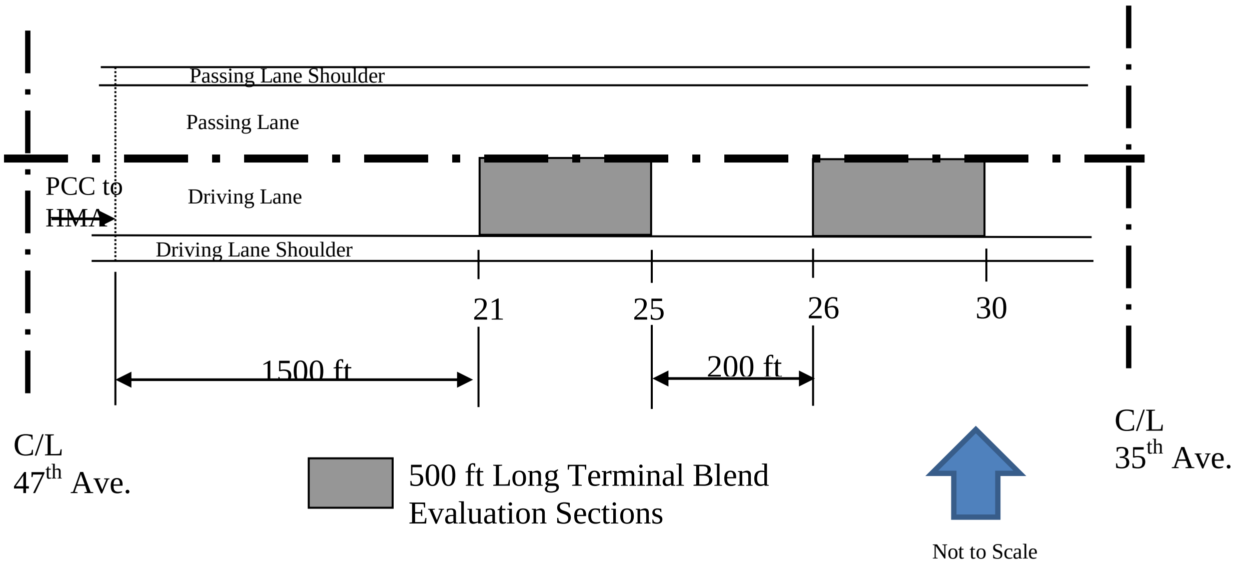

Figure 14 – Location of Terminal Blend Evaluation Sections on US 34

Permeability of the Surface

The air permeability of the pavement was measured by CDOT Headquarters Materials and Goetechnical Branch Asphalt Program personnel after construction. Results of this testing are shown in Appendix B.

ECONOMIC ANALYSIS

The following is a cost analysis of three asphalt pavement overlays placed on US 34 near Greeley, Colorado in 2009. The overlay materials analyzed consist of HMA containing a control PG 64-28, a binder containing GTR blended at a terminal away from Greeley (terminal blend), and a binder containing tire rubber blended at the hot mix plant (wet process blend).
The difference in cost of these three HMA products as produced for this experimental project is summarized below in Table 9:

Table 9 - Cost of Mixtures Placed on US 34, Greeley

	Control	Wet	Terminal
Tons placed >	22,642	1,072	955
Sale Cost/ton, $	70.20	104.25	129.74
Sale Cost, $	1,589,501	111,790	123,989
Plant Modifications, $		13,119	21,159
Mobilization, $		35,505	
Total Costs, $	1,589,501	160,415	145,148
Adjusted Cost/ton, $	70.20	149.60	151.88
Tons/mi	766	766	766
Cost/mi, $	53,745	114,530	116,280

Further Economic Analysis

The analysis above was based on the actual costs to construct the test sections. However, since test sections are usually customized experimental features, costs are often higher than when materials are produced for routine use. Therefore, an additional analysis was conducted inserting prices for the 'terminal blend' GTR modified asphalt from data obtained from the City of Colorado Springs where the 'terminal blend' material was utilized beginning in 2006. In a report published by Colorado Springs (Khattak and Syme) the added cost of the 'terminal blend' GTR modified HMA was 22 percent higher than conventional materials. Therefore, using this as a guide, the cost per ton shown in Table 9 for the terminal blend material has been adjusted downward from $129.74 to $85.64.

Further analysis was done assuming tonnages of the two GTR test sections were equal to that of the control material. CDOT has significant data on the cost of HMA around Region 4 where the test sections are located and has developed a relationship between cost per ton and tons of asphalt placed. The equation in Table 10 for cost/ton adjusts the price of hot mix as a function of HMA quantities utilized. This equation is used to determine the 'economy of scale factor' which is obtained by calculating the ratio of the unit cost of larger quantity to the unit cost of smaller quantity of HMA. For example, the 'economy of scale factor' for the 'Wet Process,' in Table 10 is 0.86 which is the ratio of the unit cost $77.32 for the given tonnage of 22,642 to the unit cost $89.98 for the given tonnage of 1,072. Using similar calculation to determine the 'economy of scale factor' for the 'Terminal Blend,' the resulting ratio of 0.85 ($77.32/$90.49) is obtained. For the control pavement, the information on actual cost per ton and total tonnage of conventional HMA is used in the economic analysis since this is the best cost data available. In this case, the 'economy of scale factor,' is equal to 1.00 since the basis of the calculation is the actual quantity of conventional HMA used and therefore no adjustment is needed to account for economy of scale. This procedure eliminates the bias for small quantities. The 'economy of scale factor' is then used to calculate the 'scale factor adjusted cost per ton'.

Based on initial cost of conventional HMA, the number of years (n) for GTR pavement materials to become equivalent to that of conventional HMA are shown in Table 11 which are calculated from Present Value Formula assuming a design discount rate of 2.6% (CDOT 2015 ME Pavement Design Manual) and no rehabilitation and maintenance costs are required for all these types of pavement materials. From this analysis, it is evident that the 'wet process' pavement to be equal in cost to the conventional HMA, no maintenance would be required of the 'wet process' pavement for about 10 years. Using the CO Springs adjusted cost for the 'terminal blend' pavement to equal the cost of the conventional HMA pavement, there would be no maintenance required for this pavement until after approximately 8 years of service. However, neither of the GTR pavements is performing as well as the control section, and is likely to require maintenance sooner, rather than later, compared to the conventional HMA pavement sections.

Table 10 - Economic Analysis Assuming Equal Quantities of Materials

	Material				
	Actual Project HMA	Figure 13.32 HMA**	Wet Process**	Terminal Blend**	CO Springs Adjustment
Cost/ton, $ = 127.27$(\text{Tons})^{-0.0497}$	70.20	77.32	89.98	90.49	85.64
Tons	22642	22642	1072	955	
Economy of Scale Factor:		1.00	0.86	0.85	
Sale Cost/Ton, $:	70.20		104.25	129.74	
Scale Factor Adjusted Cost/Ton, $	70.20		89.66	110.28	85.64
Tons/mi	766.00		766.00	766.00	766.00
Cost/mi, $	53,773		68,680	84,474	65,600
Cost Increase from Conventional HMA, %	0.0%		27.7%	57.1%	22.0%

**Polymer Modified HMA Unit Cost Equation
(Region 4, Figure 13.32 , 2015 ME Pavement Design Manual page 460)

Table 11 - Comparative Cost Analysis Using Present Value Formula

	Present Value Formula: **$PV=FV/(1+i)^n$** **$n=\log(FV/PV)/\log(1+i)$** where: PV= present value; FV= future value; i= discount rate, 2.6 %; n= number of years for GTR pavements to become equivalent to conventional HMA pavement assuming no rehabilitation and maintenance will be required			
Pavement Material	Cost per lane-mile,$	PV (based on conventional HMA as reference pavement)	FV (cost to be discounted to PV to become equivalent to conventional HMA)	n (years required to become equivalent to conv. HMA)
Conventional HMA	$ 53,773	$ 53,773	$ 53,773	0
Wet Process	$ 68,680	$ 53,773	$ 68,680	9.5
Terminal Blend	$ 84,474	$ 53,773	$ 84,474	17.6
Terminal Blend (with CO Springs adjustment factor)	$ 65,600	$ 53,773	$ 65,600	7.7

ENERGY UTILIZATION COMPARISON

Crumb rubber modified asphalt (CRM) is composed of crumb tire rubber derived from the grinding of scrap tires blended with hot asphalt binder. CRM used in this study is blended with asphalt at a terminal and shipped to the asphalt plant (terminal blend) or it is blended with asphalt at the asphalt plant (wet method). Both of these processes are used to make modified asphalt which when mixed with aggregates produces a HMA. The energy used to produce GTR and HMA has been evaluated (Gaines 1979) using the amount of BTUs of energy required per pound of each product as shown in Table 12.

Table 12 - BTU Utilization for Asphalt Rubber and HMA

Process	BTUs/Pound	
	Asphalt Rubber	HMA
Tire Shredding	-750	0
Transportation of Shred	-750	0
Granulation	-1542	0
CRM Transportation	-750	0
Steel Recovery	+817	0
Asphalt Used	-90,000	-90,000
Aggregate Used	-47,000	-47,000
Gain+/Loss-	**-139,975**	**-137,000**

Since both the wet and terminal blend HMAs require similar processes to obtain the crumb rubber and the blending with asphalt, they are not substantially different with respect to energy consumption. However, the energy required to produce conventional HMA is substantially less since it does not require GTR.

RESULTS

Distresses observed during condition surveys from 2010 and 2014 include transverse, longitudinal, and fatigue cracking. Results of the condition surveys for each 100-foot sample segment are shown in Figure 15 for transverse cracking, Figure 16 for longitudinal cracking and Figure 17 for fatigue cracking.

Transverse and longitudinal cracking are represented in linear feet of crack, fatigue cracking is represented in square feet of cracking. The legends in Figure 15, 16 and 17 indicate the dates when cracking was observed during each condition survey. For example, in Figure 15 for Evaluation Section 24, 4 feet of cracking was observed during the July 2013 survey, and 7 feet of cracking was observed during the April 2014 survey, an increase of 3 feet of transverse cracking for this 100 foot segment of pavement. Cracking was low to moderate severity until April 2014. However, evaluation sections with greater than 20 feet of transverse cracking in April 2014 tended to be moderate severity.

Table 13 is a summary of the air temperatures recorded during the field condition surveys.

Table 13 - Air Temperatures During Condition Surveys

	Survey Date						
	6/1/10	1/18/11	6/29/11	12/23/11	10/7/12	7/31/13	4/25/13
Temperature, F	74	32	82	26	65	78	75

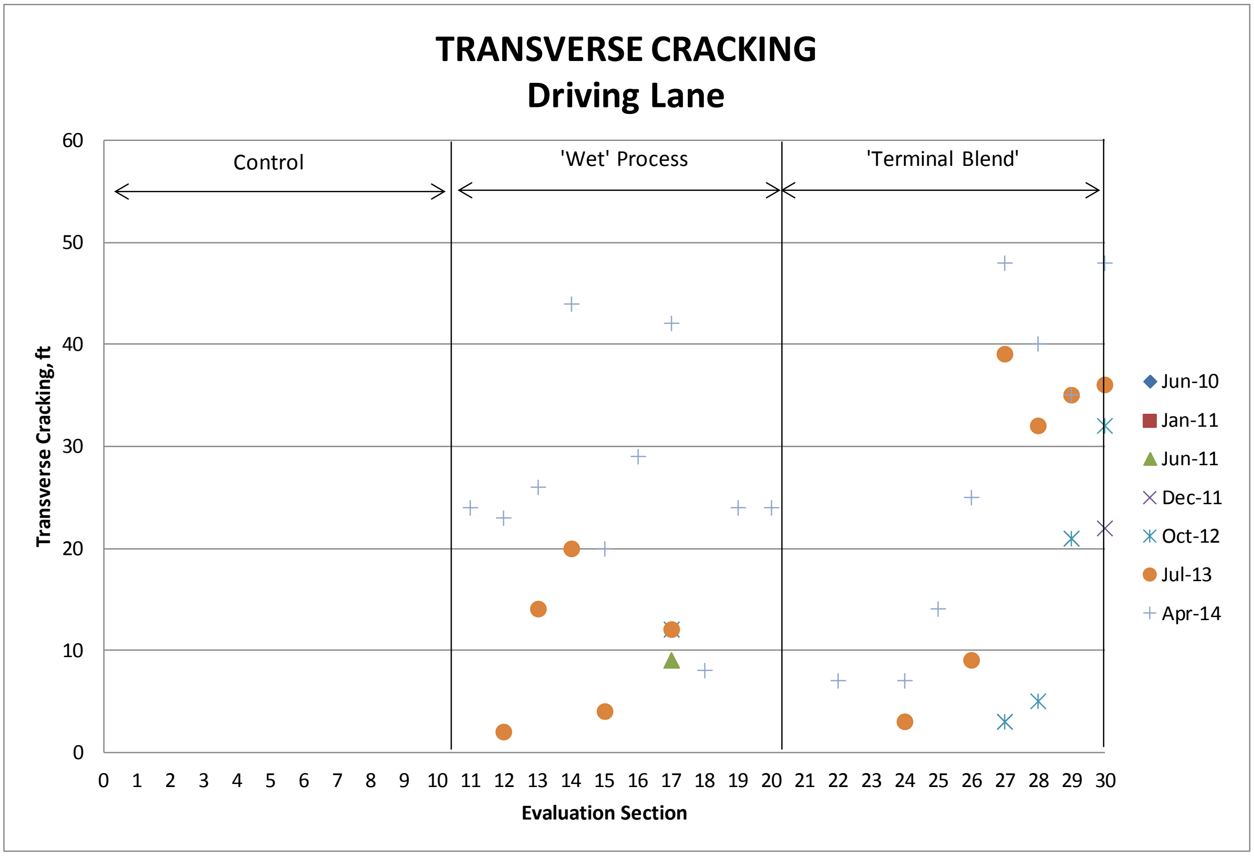

Figure 15 – Transverse Cracking by Sample Segment

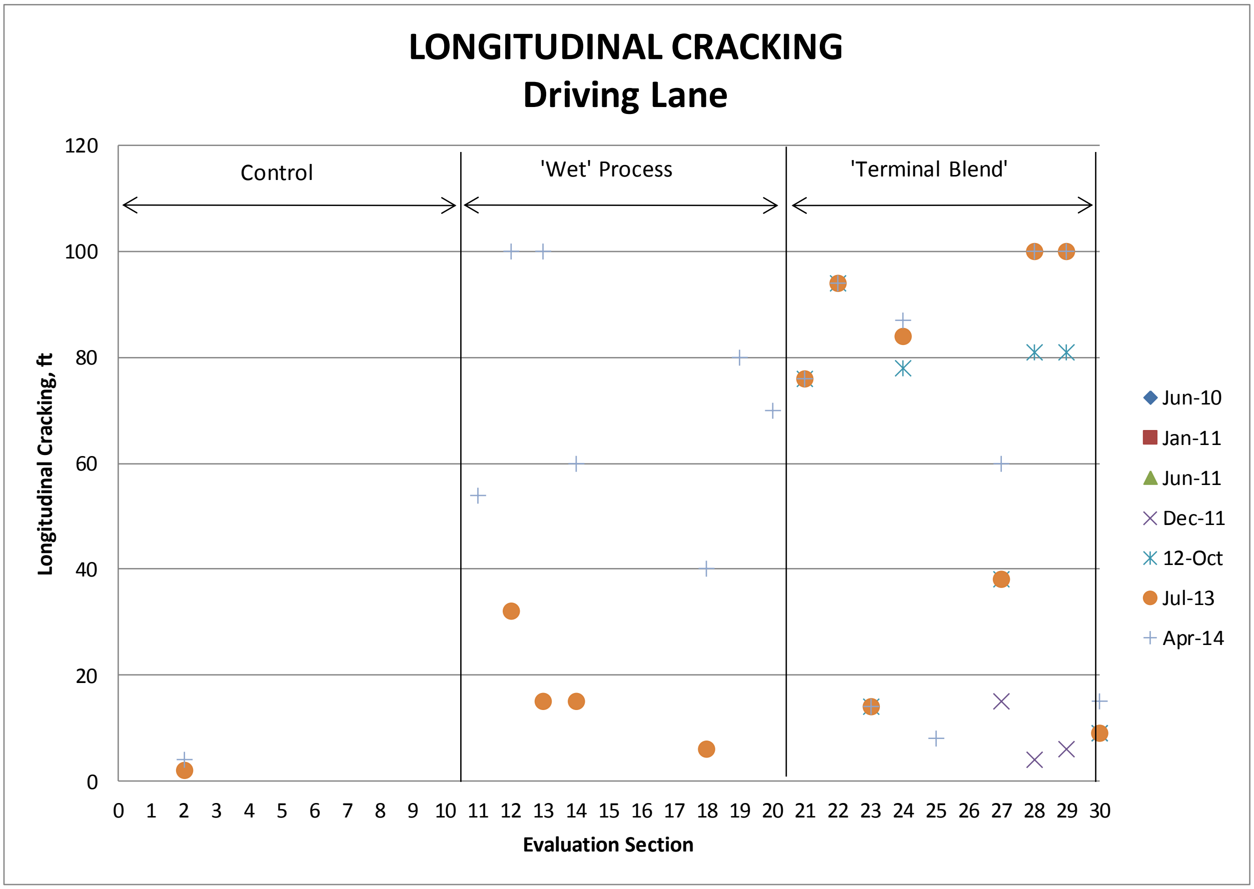

Figure 16 – Longitudinal Cracking by Sample Segment

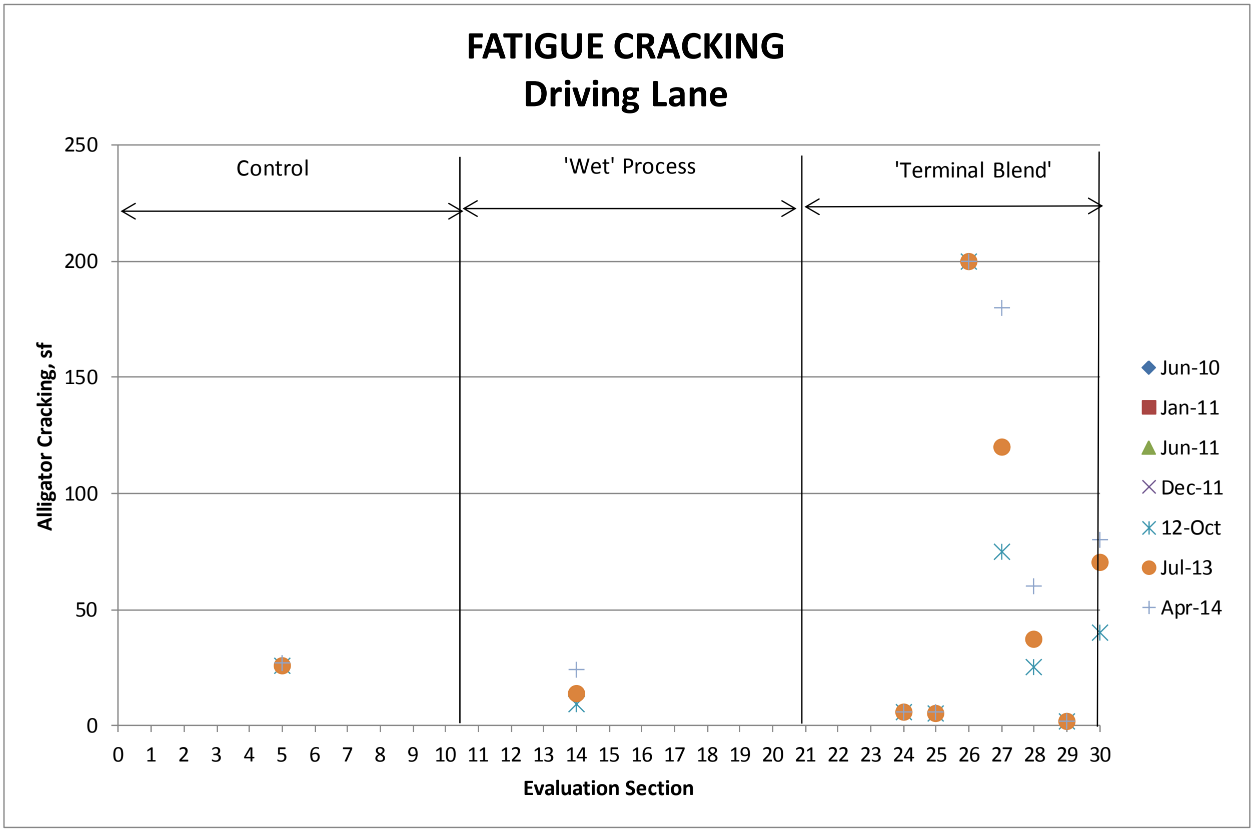

Figure 17 – Fatigue Cracking by Sample Segment

ANALYSIS

A comparative analysis of the performance of the three materials has been done by averaging the quantity of distress over the five 100-foot sample segments for each evaluation period and plotting this distress over time. These summaries are shown in Figures 18, 19 and 20 for transverse, longitudinal and alligator cracking.

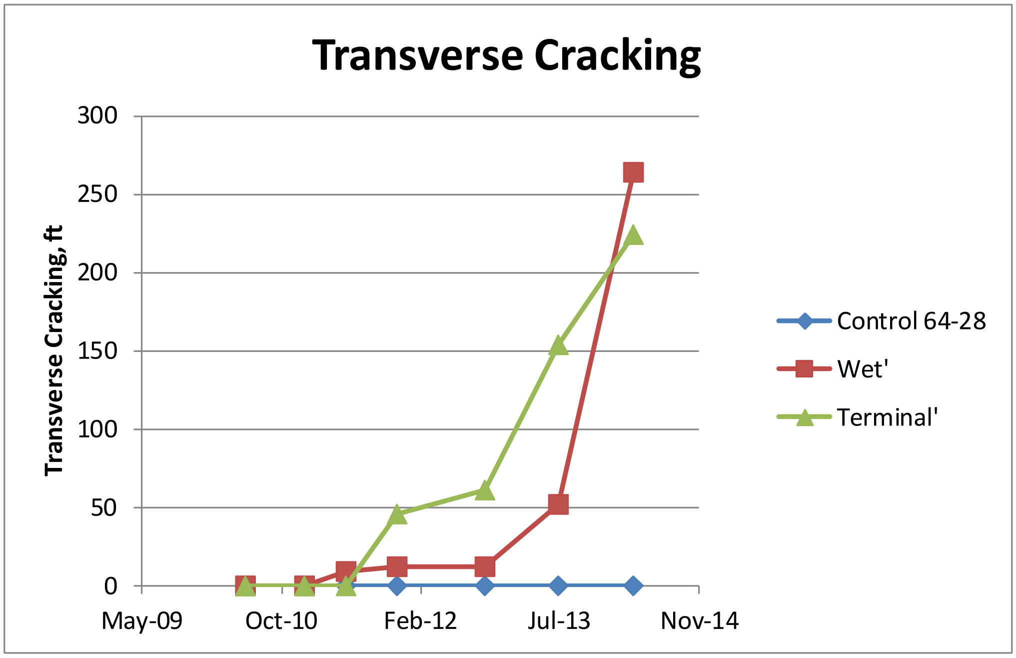

Figure 18 – Transverse Cracking Over Time

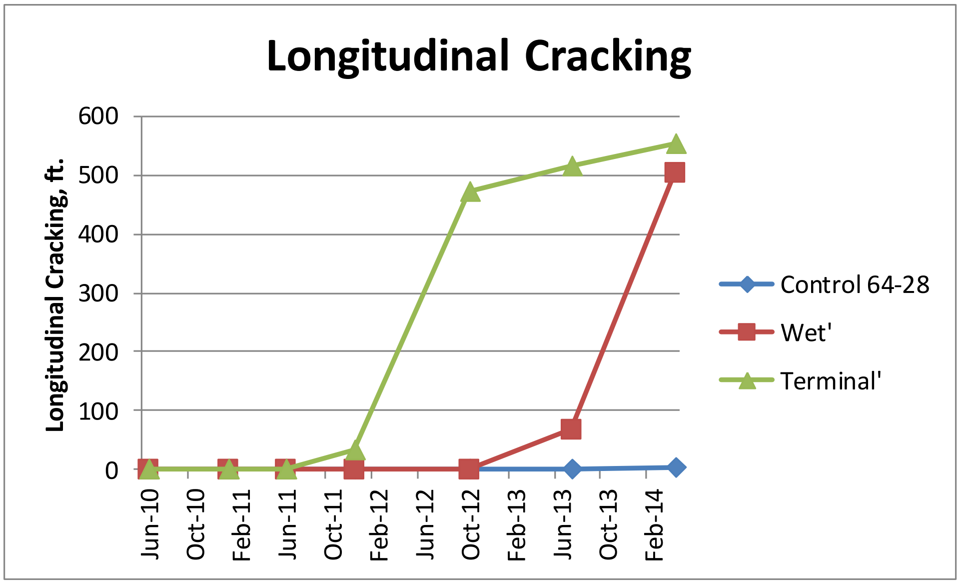

Figure 19 – Longitudinal Cracking Over Time

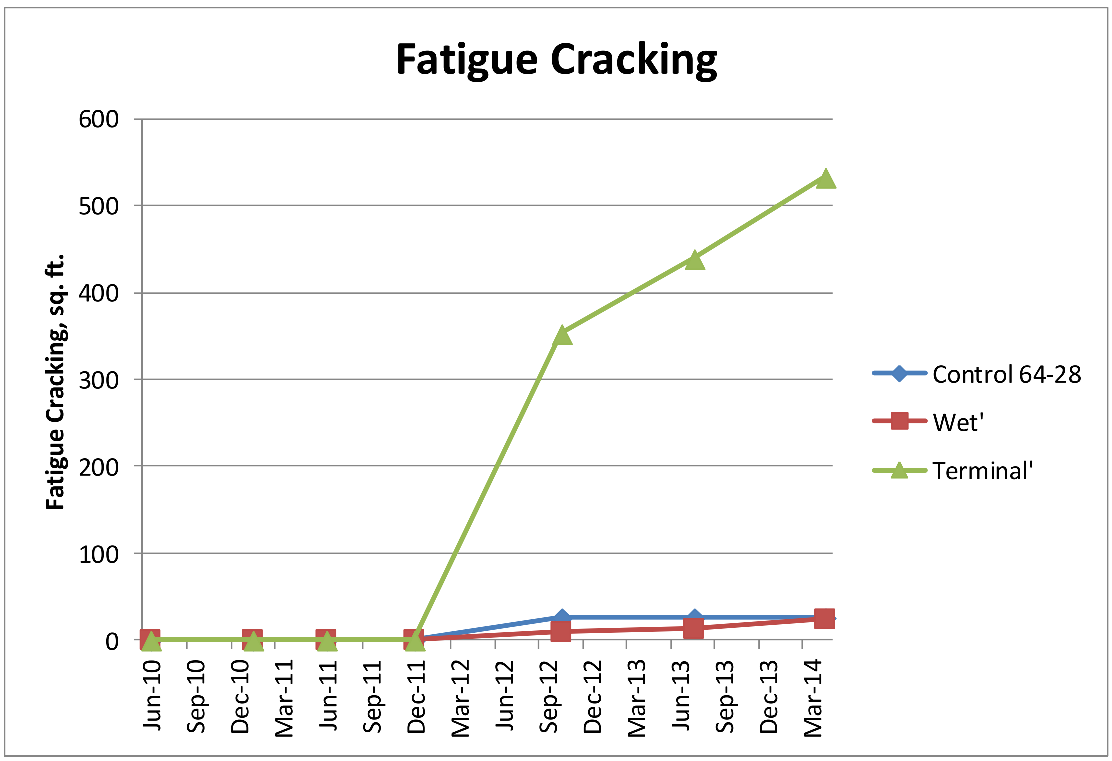

Figure 20 – Fatigue Cracking Over Time

Further Analysis

Besides observing performance in the driving lane only, performance was also observed for both the passing lane shoulder, the passing lane, and the driving lane shoulder. Although these pavements are not carrying the same traffic as the driving lane and did not contain GTR, they should be considered for comparison since they are immediately adjacent the GTR test sections and within the geometric boundaries of the study. Materials used in the construction of these other lanes was the same as that in the control sections of the driving lane between 71st Avenue and 65th Avenue. Therefore, these could be considered control sections lying immediately adjacent each of the test sections.

The analysis is shown below for each segment of US34 within the confines of the 'control' (between 71st Ave and 65th Ave), 'wet' (between 65th Ave and 47th Ave), and 'terminal' (between 47th Ave and 35th Ave) sections. Recall that the 'wet' and 'terminal' processes are present only in the driving lane, between 65th and 47th Avenue for the 'wet' process and between 47th and 35th Avenue for the 'terminal' process.

Only transverse and longitudinal cracking was observed in the passing lane shoulder, passing lane and driving lane shoulder.

Performance Between 71st and 65th Avenue (PG 64-28 in all lanes)

Figures 21 shows performance for transverse cracking of the passing lane shoulder, passing lane, driving lane and driving lane shoulder respectively for the control segment of US 34 between 71st and 65th Avenue.

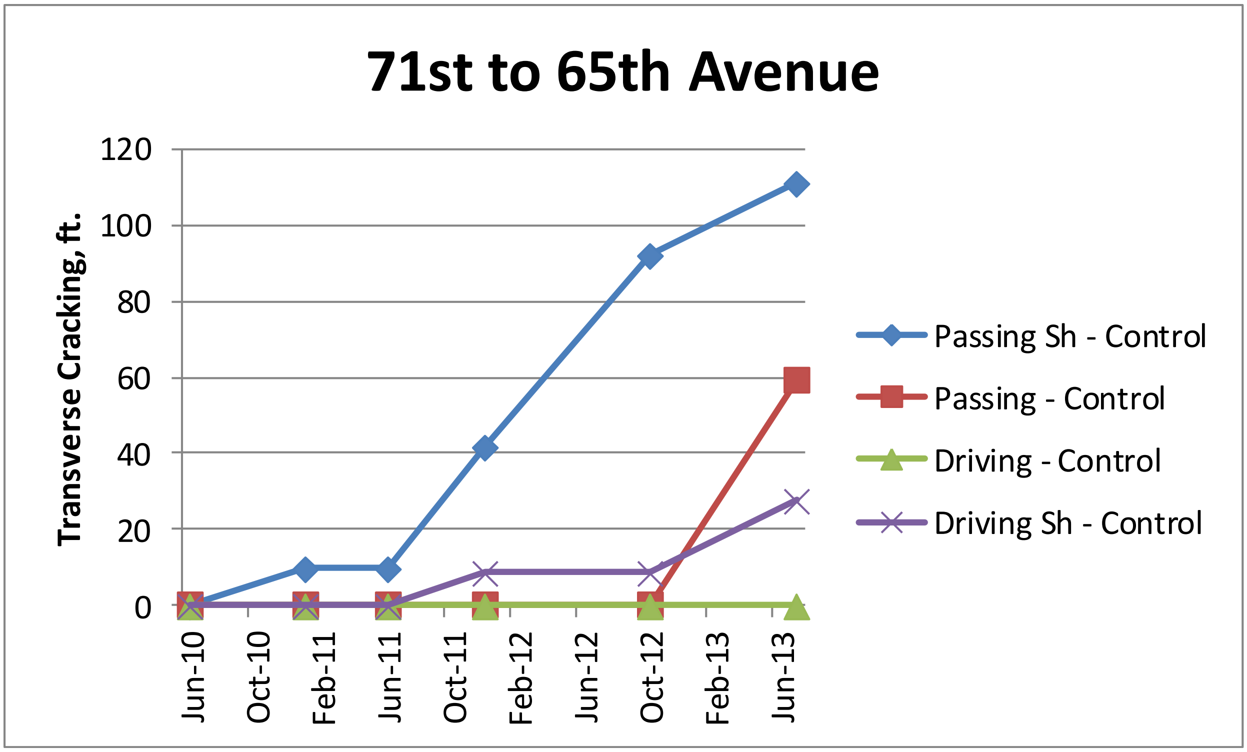

Figure 21 –Transverse Cracking – 'Control' Segment

The rate of transverse cracking in the passing lane shoulder of this segment has steadily increased since the second condition survey in 2011. The driving lane shoulder began cracking after the third condition survey in June 2011 and the passing lane after the fifth survey in 2012. Although the shoulders and passing lane of this segment of US 34 contain transverse cracks, the driving lane does not.

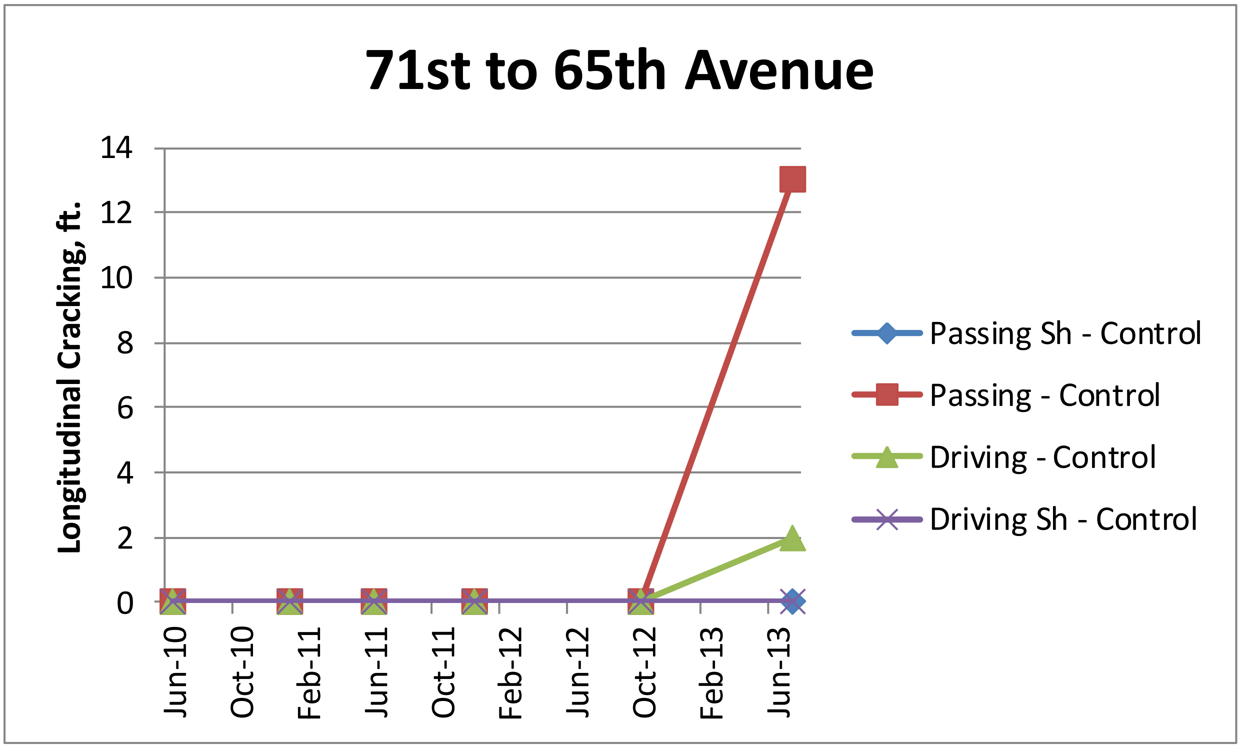

Figure 22 –Longitudinal Cracking – 'Control' Segment

Longitudinal cracking appeared in the passing lane and driving lane of the control segment during the last condition survey in 2013.

Performance Between 65th and 47 th Avenue ('Wet Process' in Driving Lane, only)

Figures 23 and 24 show performance for transverse and longitudinal cracking for the passing lane shoulder, passing lane, driving lane and driving lane shoulder respectively for the segment of US 34 with the 'wet process' in the driving lane.

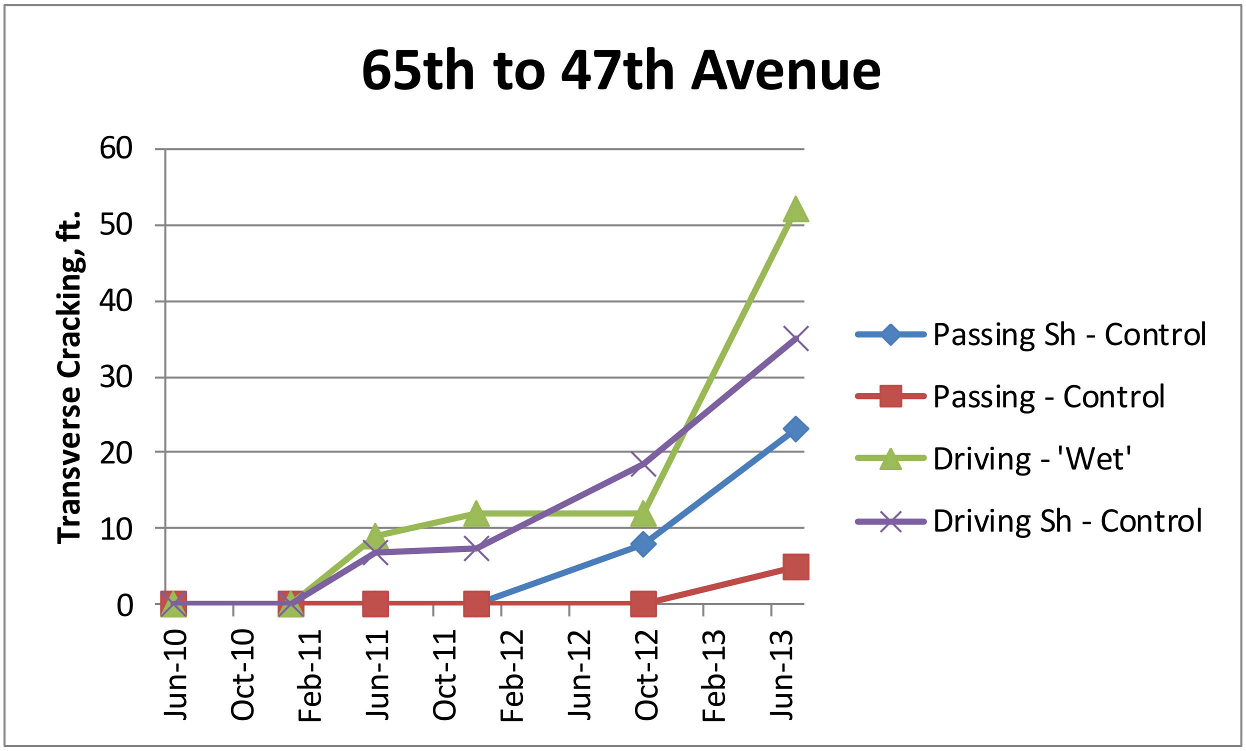

Figure 23 –Transverse Cracking - ‘Wet’ Segment

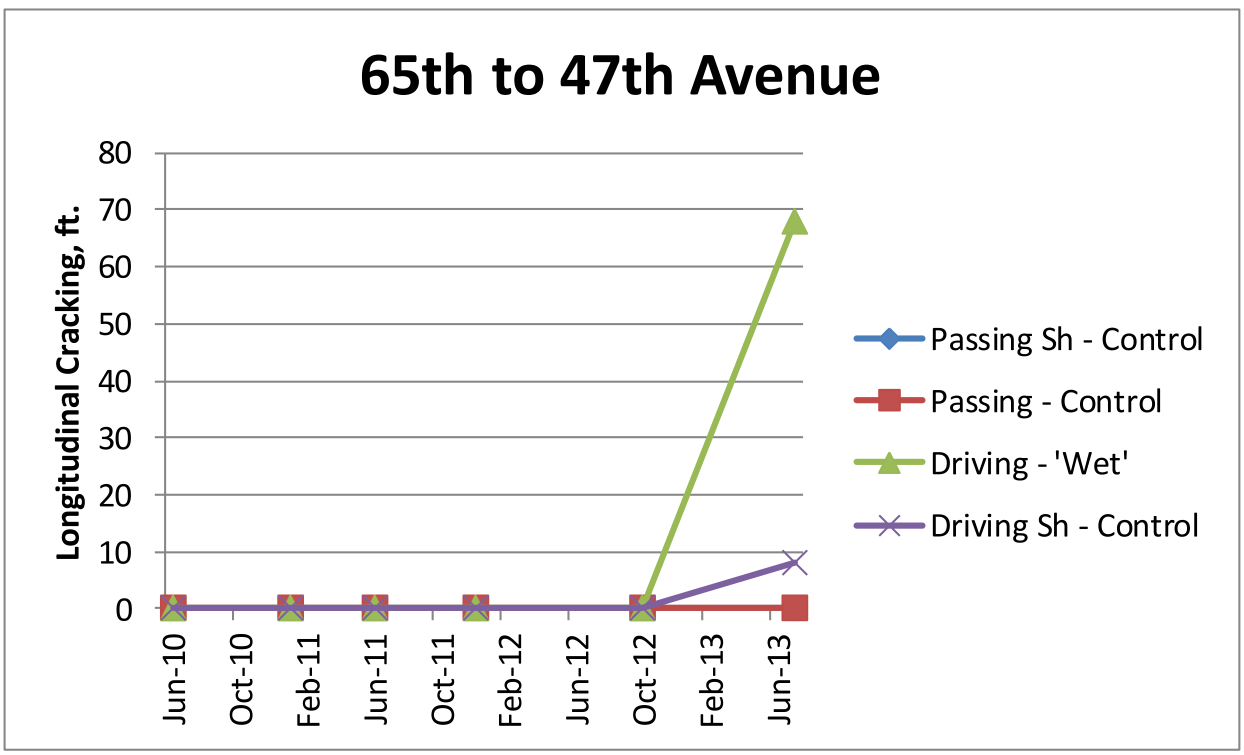

Figure 24 –Longitudinal Cracking - ‘Wet’ Segment

Transverse cracking first appeared in this segment of US 34 in the driving lane (‘wet’ process) and the driving lane shoulder (control PG 64-28) at the second condition survey in 2010. Transverse cracking has steadily increased in all the sections with the highest increase occurring in the ‘wet’ process driving lane.

Performance Between 47th and 35th Avenue (‘Terminal Blend in Driving Lane, only)

Figures 25 and 26 show performance for transverse and longitudinal cracking for the passing lane shoulder, passing lane, driving lane and driving lane shoulder respectively for the ‘terminal blend’ segment of US 34 between 47th and 35th Avenue.

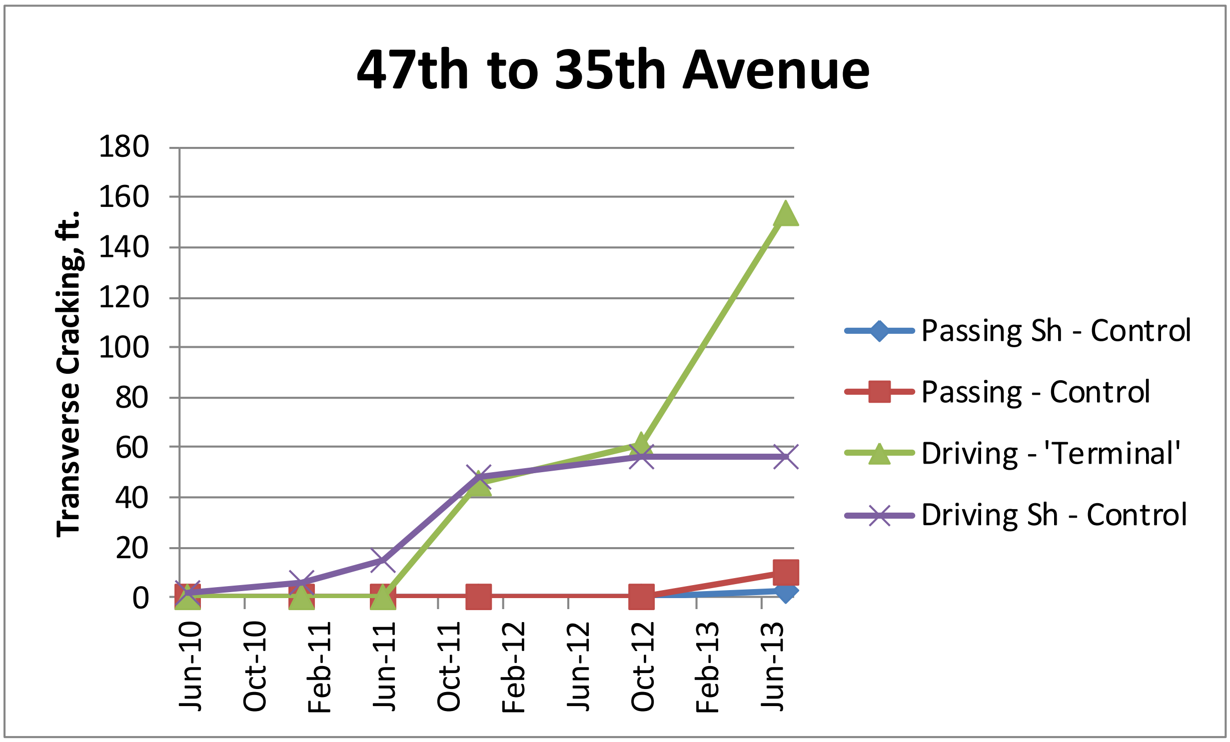

Figure 25 –Transverse Cracking - ‘Terminal Blend’ Segment

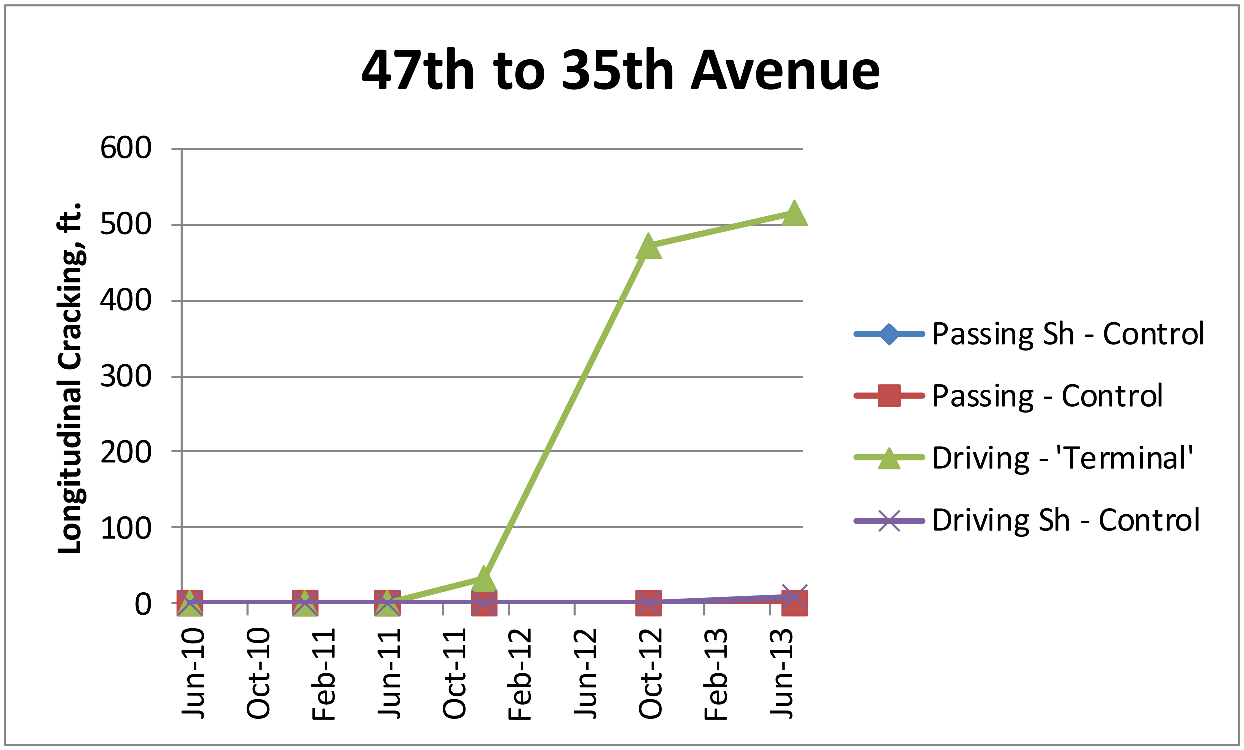

Figure 26 –Longitudinal Cracking - 'Terminal Blend' Segment

Transverse cracking first appeared in this segment of US 34 in the driving lane shoulder (control PG 64-28) at the second condition survey in 2010 followed by the driving lane ('terminal blend') during the fourth survey in 2011. Transverse cracking in the driving lane advanced to the same level as the driving lane shoulder by the fourth survey in 2011and then steadily increased in the driving lane ('terminal') sections surpassing the cracking on the shoulder.

Longitudinal cracking first began in the driving lane ('terminal blend') in 2011 during the fourth survey, steadily increased during the fifth survey in 2012 and leveled off for the last survey in 2013.

CONCLUSIONS

1. Construction of two experimental GTR modified asphalt pavements was successful using a pilot specification including both the terminal blend and wet process to modify the asphalt binders used.

2. The control and GTR binders were fabricated to meet a Superpave PG 64-28 binder specification, however, the GTR modified asphalt binders failed to meet the Colorado ductility and toughness and tenacity portions of the specification.

3. The HMA produced using the two GTR modified asphalts met CDOT design and construction requirements for 100 gyration Superpave mixtures.

4. Longitudinal and transverse cracking in the 'wet process' and 'terminal blend' test sections has steadily increased since approximately two years after construction. No transverse cracking has appeared in the control section in the driving lane, to date, and 4 feet of longitudinal cracking has occurred.

5. Fatigue cracking has steadily increased in the 'terminal blend' sections since three years after construction and is significantly greater than the control or 'wet process' sections. Fatigue cracking in the control and 'wet process' sections is approximately equal and significantly less than the 'terminal' blend section.

6. Transverse and longitudinal cracking has occurred in the control PG 64-28 pavement sections in the passing lane and both shoulders immediately adjacent the terminal blend and wet process sections. However, the quantity of this cracking is still significantly lower than the amount of cracking in the terminal blend and wet process sections.

7. The GTR pavements cost more to construct than the control pavement. Therefore, to be more economical both GTR pavements should require less maintenance than the control pavement. In fact, for the 'wet process' pavement to be equal in cost to the conventional HMA pavement using the simple Present Value Formula and CDOT's design discount rate no maintenance would be required of the 'wet process' pavement for about 10 years. For the 'terminal blend' pavement to be equal in cost to the conventional HMA

pavement, there would be no maintenance required for this pavement until after approximately 8 years of service. However, neither of the GTR pavements is performing as well as the control section, and is likely to require maintenance sooner, rather than later, compared to the conventional HMA pavement sections.

8. The energy consumption of the GTR pavements is approximately 3,000 BTU/pound greater than the conventional asphalt pavement.

RECOMMENDATIONS

The GTR pavements evaluated in this research study appear to cost more to construct than equivalent control HMA pavement with a PG 64-28 binder. These GTR pavements performed poorer than the control pavement with respect to cracking during the five-year observation period. The energy consumption required to produce the GTR pavements is higher than the conventional asphalt pavement.

These results indicate that use of GTR as a modifier in asphalt pavements is probably not justified when the GTR modified asphalt meets conventional PG 64-28 binder specifications. However, GTR modified asphalt pavements have performed well in other states. This may indicate that GTR modified asphalts must be produced to meet requirements other than the Superpave PG specification to provide economical results.

An experiment should be conducted to compare HMA produced using GTR modified asphalt to HMA produced using a PG binder. However, instead of producing the GTR modified asphalt to meet a specific PG specification, the GTR modified asphalt should be produced in accordance with the recommended method of the GTR modified asphalt supplier. The test GTR pavement section should be of sufficient size so that a consistent quantity of material is produced by the contractor and so the cost of the material is representative of that which would be expected during routine use for a similar quantity. The pavement to be rehabilitated should be visually surveyed prior to construction to map existing distress and analyzed by falling weight deflectometer to determine structural integrity. Test and control sections should be located within areas of the existing pavement that are as equivalent as possible with respect to distress and substrate modulus. Condition surveys should be performed within two 500-foot evaluation sections identified within each test pavement considered representative of the materials being evaluated. Condition surveys should be conducted at approximately six-month intervals in the early spring and late fall each year for a minimum of five years after construction or until sufficient distress is recorded to indicate differences in performance.

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Appendix A – Air Emissions Test Results

AIRTECH
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Report on the Air Emissions Test Program

Conducted for the Colorado Department of Transportation at the Aggregate Industries Facility Located in Greeley, Colorado

Report No. 3017
October 9, 2009

Project Overview

General

Airtech Environmental Services Inc. was contracted by the Colorado Department of Transportation (CDOT) to perform an air emissions test program at the Aggregate Industries facility located in Greeley, Colorado. The specific objectives of the test program were as follows:

- Determine the emissions of filterable particulate matter (PM) from the exhaust stack of an Asphalt Drum Mix (ADM) unit.
- Determine the emissions of nitrogen oxides (NO_X), carbon monoxide (CO) and total hydrocarbons (THC) as propane from the ADM stack.
- Determine the opacity of emissions from the ADM stack.
- Determine the emissions of multi-metals from the ADM stack.

Testing was to be conducted under three conditions. The first condition was Hot Mix Asphalt (HMA) using PG 64-28, the second was PG 64-28 using a terminal blend and the third was PG 64-28 using a wet process. Due to a scheduling conflict, the second condition was not measured. Testing was performed on August 10, 11, 12 and 18, 2009. Coordinating the field portion of the test program were:

Brendan Lawlor – Airtech Environmental Services Inc.

Allon Kienitz – Airtech Environmental Services Inc.

Methodology

EPA Method 5 was used to determine the PM concentration at the test location. In Method 5, a sample of the gas stream was withdrawn isokinetically from the stack and the filterable PM is collected in a sample probe and on a quartz-glass fiber filter. EPA Method 5 was developed to measure total filterable particulate matter. Analysis of the samples for PM was performed gravimetrically. The opacity of the emissions from the ADM stack were determined visually by an observer and procedures found in EPA Method 9.

EPA Methods 3A, 7E, 10 and 25A were used to measure the oxygen (O_2), carbon dioxide (CO_2), NO_X, CO and THC concentrations at the test location. A sample of the gas stream was withdrawn from the source at a constant rate and analyzed using a temporary continuous emissions monitoring system (CEMS).

EPA Method 29 was using to measure the multi-metals concentration at the test location. In Method 29, a sample of the gas stream was withdrawn isokinetically and multi-metals were collected on a quartz-glass fiber filter, in a sample probe and in a series of chilled impingers. EPA Method 29 was operated in conjunction with the EPA Method 5 sampling train.

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AIRTECH Environmental Services Inc.

In order to convert the concentrations of the pollutants to mass flow rates, the gas volumetric flow rate was determined concurrent with each EPA Method 5/29 sample train using EPA Methods, 1, 2, 3A and 4.

Parameters

The following specific parameters were determined at the test location:

- gas velocity
- gas temperature
- oxygen concentration
- carbon dioxide concentration
- moisture content
- concentration of filterable particulate matter
- nitrogen oxides concentration
- carbon monoxide concentration
- opacity of emissions
- total hydrocarbon concentration, as propane
- multi-metals concentration[1]

Results

A complete summary of test results is presented in Tables 1 and 2 on Pages 4 and 5.

Runs 1, 3, 4 and 5 were conducted under the third process condition (PG 64-28) and Run 6 was conducted under the first process condition (PG 64-28). Due to production issues a second run on the first condition was not performed.

Run 2 was set up and never used due to process problems. Run 5, on August 12, 2009, was only 42.5 minutes long due to process problems. The isokinetics for Run 1 on August 10, 2009 were 116.7%, which exceeded the EPA Method 5 specification of 90% to 110% isokinetic. This likely has no significant impact on the results. A portable analyzer was used to collect O_2, CO_2, NO_X and CO data on August 18, 2009. No THC data was collected on this date because the THC analyzer was not available.

Submitted by:	Reviewed by:
Timothy Wojtach	Patrick Clark, P.E.

[1] Multi-metals included arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), lead (Pb), mercury (Hg), nickel (Ni), selenium (Se), silver (Ag), and zinc (Zn).

AIRTECH Environmental Services Inc.

Summary of Results

Table 1 – Summary of PM, NO_X, CO, THC and Opacity Test Results

Test Parameters	Run 1	Run 3	Run 4	Run 5	Run 6
Date	8/10/2009	8/11/2009	8/11/2009	8/12/2009	8/18/2009
Start Time	9:20	7:10	8:42	11:05	9:45
Stop Time	10:27	8:15	9:46	11:52	12:49
Gas Conditions					
Temperature (°F)	222	223	226	215	237
Volumetric Flow Rate (acfm)	46,400	48,000	46,400	38,800	41,100
Volumetric Flow Rate (scfm)	30,000	31,000	29,800	25,200	26,000
Volumetric Flow Rate (dscfm)	23,100	23,800	23,000	20,000	19,300
Carbon Dioxide (% dry)	4.12	3.95	4.58	3.80	4.59
Oxygen (% dry)	14.7	15.1	14.0	15.1	12.7
Moisture (%)	23.0	23.4	23.1	20.6	26.8
Particulate Matter Results					
Concentration (grains/dscf)	0.00510	0.00723	0.00717	0.00664	0.00925
Emission Rate (lb/hr)	1.01	1.47	1.41	1.14	1.51
Nitrogen Oxides Results					
Concentration (ppmdv)	56.3	89.8	69.3	32.6	75.6
Emission Rate (lb/hr)	9.32	15.3	11.4	4.68	10.3
Carbon Monoxide Results					
Concentration (ppmdv)	511	597	348	842	658
Emission Rate (lb/hr)	51.4	61.9	34.8	73.6	54.6
Total Hydrocarbon Results					
Concentration (ppmwv as propane)	52.3	44.3	27.8	140	NA
Emission Rate (lb/hr as propane)	10.8	9.43	5.71	24.3	NA
Opacity Results					
Minimum Opacity (%)	0	0	0	0	0
Maximum Opacity (%)	0	0	0	0	5
Average Opacity (%)*	0.00	0.00	0.00	0.00	0.833

*The average opacity is based on the highest six-minute average.

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Table 2 – Summary of Multi-Metals Test Results (Continued)

Test Parameters	Run 1	Run 3	Run 4	Run 5	Run 6
Date	8/10/2009	8/11/2009	8/11/2009	8/12/2009	8/18/2009
Start Time	9:20	7:10	8:42	11:05	9:45
Stop Time	10:27	8:15	9:46	11:52	12:49
Mercury Results					
Concentration (µg/dscm)	2.09	3.12	2.54	2.17	2.17
Emission Rate (lb/hr)	1.81E-04	2.76E-04	2.19E-04	1.63E-04	1.54E-04
Nickel Results					
Concentration (µg/dscm)	1.94	1.39	1.62	2.55	1.73
Emission Rate (lb/hr)	1.68E-04	1.24E-04	1.39E-04	1.91E-04	1.23E-04
Selenium Results					
Concentration (µg/dscm)	<0.175	<0.196	<0.206	<0.329	<0.220
Emission Rate (lb/hr)	<1.51E-05	<1.75E-05	<1.77E-05	<2.47E-05	<1.57E-05
Silver Results					
Concentration (µg/dscm)	<0.175	<0.198	<0.206	<0.329	<0.220
Emission Rate (lb/hr)	<1.51E-05	<1.75E-05	<1.77E-05	<2.47E-05	<1.57E-05
Zinc Results					
Concentration (µg/dscm)	36.7	32.0	29.6	51.9	23.2
Emission Rate (lb/hr)	3.17E-03	2.85E-03	2.55E-03	3.90E-03	1.65E-03

APPENDIX B – AIR PERMEABILITIES

Crumb Rubber Control Site -- Passing Lane

8/4/2009

Equivalent Water Permeability Calculations Using ROMUS Air Permeameter Data

Viscosity of air	1.84E-05	kg/m*s	
Atmospheric Pressure	101353	Pa	
Volume of air Chamber	0.02186	m^3	0.02186
Density of water	1000	kg/m^3	
Viscosity of water	0.001	kg/m*s	

Test Sample	NMAS	Voids	Gradation	$L^{(1)}$ (m)	A (m^2)	t_1 (sec)	t_2 (sec)	t_3 (sec)	t_4 (sec)	k_{w1} (10^{-5}cm/s)	k_{w2} (10^{-5}cm/s)	k_{w3} (10^{-5}cm/s)	k_{w4} (10^{-5}cm/s)	k_{avg} (10^{-5}cm/s)	$k_{overall}$ (10^{-5}cm/s)
STA 61+60	SX			0.025	0.01824	0.714	0.838	1.038	1.442	138	144	150	152	146	147
STA 61+60	SX			0.025	0.01824	0.762	0.893	1.103	1.677	129	135	141	131	134	134
STA 61+60	SX			0.025	0.01824	0.794	0.939	1.169	1.927	124	129	133	114	125	123
STA 61+60	SX			0.025	0.01824	0.797	0.949	1.179	1.905	124	127	132	115	125	123
STA 61+10	SX			0.025	0.01824	0.65	0.756	0.95	1.671	152	160	164	131	152	148
STA 61+10	SX			0.025	0.01824	0.668	0.776	0.969	1.616	148	156	161	136	150	148
STA 61+10	SX			0.025	0.01824	0.663	0.779	0.967	1.619	149	155	161	136	150	148
STA 61+30	SX			0.025	0.01824	0.644	0.747	0.928	1.315	153	162	168	167	162	164
STA 61+30	SX			0.025	0.01824	0.667	0.777	0.962	1.627	148	155	162	135	150	147
STA 61+30	SX			0.025	0.01824	0.654	0.758	0.94	1.281	151	159	166	171	162	164
STA 61+30	SX			0.025	0.01824	0.656	0.773	0.961	1.642	150	156	162	134	151	147
STA 61+30	SX			0.025	0.01824	0.661	0.778	0.952	1.649	149	155	164	133	150	147
STA 61+30	SX			0.025	0.01824	0.674	0.778	0.968	1.613	146	155	161	136	150	147

(1) Thickness of specimen or layer

Crumb Rubber: Terminal Blend

7/20/2009

Equivalent Water Permeability Calculations Using ROMUS Air Permeameter Data

Viscosity of air	1.84E-05	kg/m*s	
Atmospheric Pressure	101353	Pa	
Volume of air Chamber	0.02186	m^3	0.02186
Density of water	1000	kg/m^3	
Viscosity of water	0.001	kg/m*s	

Test Sample	NMAS	Voids	Gradation	$L^{(1)}$ (m)	A (m^2)	t_1 (sec)	t_2 (sec)	t_3 (sec)	t_4 (sec)	k_{w1} (10^{-5}cm/s)	k_{w2} (10^{-5}cm/s)	k_{w3} (10^{-5}cm/s)	k_{w4} (10^{-5}cm/s)	k_{avg} (10^{-5}cm/s)	$k_{overall}$ (10^{-5}cm/s)
STA 129+70	SX			0.025	0.01824	1.001	1.190	1.498	2.356	99	101	104	93	99	98
STA 129+70	SX			0.025	0.01824	1.02	1.22	1.53	2.277	97	99	102	96	98	98
STA 129+70	SX			0.025	0.01824	1.034	1.23	1.539	2.245	95	98	101	98	98	98
STA 130+00	SX			0.025	0.01824	2.516	3.09	4.025	5.66	39	39	39	39	39	39
STA 130+00	SX			0.025	0.01824	2.628	3.257	4.196	6.022	38	37	37	36	37	37
STA 130+00	SX			0.025	0.01824	2.653	3.276	4.253	5.928	37	37	37	37	37	37
STA 130+45	SX			0.025	0.01824	1.391	1.668	2.094	2.911	71	72	74	75	73	74
STA 130+45	SX			0.025	0.01824	1.426	1.731	2.169	3.138	69	70	72	70	70	70
STA 130+45	SX			0.025	0.01824	1.463	1.754	2.221	3.427	67	69	70	64	68	67
STA 130+45	SX			0.025	0.01824	1.489	1.789	2.271	3.319	66	68	69	66	67	67

(1) Thickness of specimen or layer

Crumb Rubber Control Site -- Driving Lane

7/20/2009

Equivalent Water Permeability Calculations Using ROMUS Air Permeameter Data

Viscosity of air	1.84E-05	kg/m*s	
Atmospheric Pressure	101353	Pa	
Volume of air Chamber	0.02186	m^3	0.02186
Density of water	1000	kg/m^3	
Viscosity of water	0.001	kg/m*s	

Test Sample	NMAS	Voids	Gradation	L[(1)] (m)	A (m^2)	t_1 (sec)	t_2 (sec)	t_3 (sec)	t_4 (sec)	k_{w1} (10^{-5}cm/s)	k_{w2} (10^{-5}cm/s)	k_{w3} (10^{-5}cm/s)	k_{w4} (10^{-5}cm/s)	k_{avg} (10^{-5}cm/s)	$k_{overall}$ (10^{-5}cm/s)
STA 20+30	SX			0.025	0.01824	0.590	0.675	0.820	1.138	167	179	190	193	182	184
STA 20+30	SX			0.025	0.01824	0.607	0.696	0.847	1.469	163	174	184	149	167	164
STA 20+30	SX			0.025	0.01824	0.616	0.712	0.862	1.43	160	170	181	153	166	164
STA 20+30	SX			0.025	0.01824	0.626	0.72	0.879	1.397	158	168	177	157	165	164
STA 20+40	SX			0.025	0.01824	0.498	0.558	0.679	1.091	198	216	229	201	211	210
STA 20+40	SX			0.025	0.01824	0.504	0.569	0.688	1.066	196	212	226	206	210	210
STA 20+40	SX			0.025	0.01824	0.514	0.578	0.704	1.031	192	209	221	213	209	210
STA 20+40	SX			0.025	0.01824	0.517	0.588	0.711	1.011	191	205	219	217	208	210
STA 20+30	SX			0.025	0.01824	0.48	0.542	0.659	1.147	206	223	236	191	214	210
STA 20+30	SX			0.025	0.01824	0.492	0.552	0.675	1.11	201	219	231	198	212	210
STA 20+30	SX			0.025	0.01824	0.502	0.562	0.69	1.076	197	215	226	204	210	210
STA 20+30	SX			0.025	0.01824	0.507	0.574	0.699	1.051	195	210	223	209	209	210

(1) Thickness of specimen or layer

Appendix C - Pilot Specification for Rubberized Asphalt Pavement

REVISION OF SECTIONS 401, 403 AND 702
RUBBERIZED ASPHALT PAVEMENT

Sections 401, 403, and 702 of the Standard Specifications are hereby revised for this project as follows:

Subsection 401.01 shall include the following:

This work includes furnishing, placing and compacting one or more courses of rubberized bituminous mixture on a prepared foundation in accordance with these specifications and the specific requirements, and in conformity with the lines, grades, thicknesses, and typical cross sections as established by the Engineer.

Subsection 401.02 (a) shall include the following:

Laboratory mixing and compaction of terminal blended (TB) rubberized asphalt cement PG 64-28TB and wet process (WP) rubberized asphalt cement PG 64-28WP shall be in conformance with the requirements of Colorado Procedure CP-L 5114 using the mixing and compaction temperature for asphalt grade PG 64-28. The Contractor shall determine the target amount of asphalt-rubber binder PG 64-28TB and PG 64-28WP to be mixed with the aggregate in conformance with the requirements in Colorado Procedure 52.

Subsection 401.06 shall include the following:

Asphalt-rubber binder PG 64-28TB and PG 64-28WP shall consist of a mixture of paving asphalt, asphalt modifier such as styrene-butadiene-styrene, and crumb rubber modifier (CRM). At least 2 weeks before construction is scheduled to begin, the Contractor shall furnish the Engineer, for approval, a binder formulation and four (4) one-liter cans filled with the asphalt-rubber binder proposed for use on the project. The asphalt cement shall meet the applicable requirements of Table 702-1A.

Subsection 401.07 shall include the following:

All gradings and all layer thicknesses of HMA using PG 64-28TB and PG 64-28WP shall be placed only when the surface and air temperatures are 65°F or above.

Subsection 401.08 shall include the following:

The method and equipment for combining paving asphalt, asphalt modifier, and CRM for PG 64-28WP shall be so designed and accessible that the Engineer can readily determine the percentages by mass for each material being incorporated into the mixture.

The Contractor shall use, but is not limited to, the following for the wet process production of PG 64-28WP:

A. Asphalt heating tanks equipped to heat and maintain the blended paving asphalt and asphalt modifier mixture at the necessary temperature before blending with the CRM. This unit shall be equipped with a thermostatic heat control device and a temperature reading and recording device that shall be accurate to within ± 35°F.

B. A mechanical mixer for the complete, homogeneous blending of paving asphalt, asphalt modifier, and CRM. The blending system shall be capable of varying the rate of delivery of paving asphalt and asphalt modifier proportionate with the delivery rate of CRM. During the proportioning and blending of the liquid ingredients, the temperature of paving asphalt and the asphalt modifier shall not vary more than ± 60°F. The mixing system for paving asphalt, asphalt modifier, and CRM feeds shall be equipped with devices by which the rate of feed can be determined during the proportioning operation.

   Meters used for proportioning individual ingredients shall be equipped with rate-of-flow indicators to show the rates of delivery and resettable totalizers so that the total amounts of liquid ingredients introduced into the mixture can be determined. The liquid and dry ingredients shall be fed directly into the mixer at a uniform and controlled rate. The rate of feed to the mixer shall not exceed that which will permit complete mixing of the materials. Dead areas in the mixer, in which the material does not move or is not sufficiently agitated, shall be corrected by a reduction in the volume of material or by other adjustments. Mixing shall continue until a homogeneous mixture of uniformly distributed and properly blended asphalt-rubber binder of unchanging appearance and consistency is produced.

   The Contractor shall provide a safe sampling device capable of delivering a representative sample of the completed asphalt-rubber binder of sufficient size to permit the required tests.

C. An asphalt-rubber binder storage tank equipped with a heating system furnished with a temperature reading device to maintain the proper temperature of the asphalt-rubber binder and an internal mixing unit capable of maintaining a homogeneous mixture of paving asphalt, asphalt modifier, and CRM. The equipment shall be approved by the Engineer prior to use.

D. A manufactures representative shall be present during production.

E. The Contractor shall provide a hand-held Haake Viscometer Model VT-02 with Rotor 1, 24 mm in depth and 53 mm in height, or equivalent, at the production site during combining of asphalt-rubber binder materials.

Subsection 401.13 shall include the following:

The PG 64-28WP shall be blended paving asphalt and the CRM combined and mixed together at the production site in a blender unit to produce a homogeneous mixture. The temperature of the blended paving asphalt mixture shall be between 375°F and 440°F when the CRM is added. The CRM shall be combined at the production site and shall contain 100 percent scrap tire CRM, by mass.

The combined materials shall be reacted for a minimum of 45 minutes after incorporation of the CRM and maintained at a temperature between 375°F and 425°F. The temperature shall be at least 45°F below the actual flash point of the asphalt-rubber binder.

If any of the material in a batch of asphalt-rubber binder is not used within 4 hours after the 45-minute reaction period, heating of the material shall be discontinued. Any time the asphalt-rubber binder cools below 375°F and is reheated shall be considered a reheat cycle. The PG 64-28WP shall not be reheated more than twice. The material shall be uniformly reheated to a temperature between 375°F and 425°F prior to use. Additional scrap tire CRM may be added to the reheated binder and reacted for a minimum of 45 minutes. The cumulative amount of additional scrap tire CRM shall not exceed 10 percent of the total binder mass. Reheated asphalt-rubber binder shall conform to the provisions for PG 64-28WP.

During the injection process of the PG 64-28WP into the plant, the Contractor shall take viscosity readings of asphalt-rubber binder from samples taken from the feed line connecting the storage and reaction tank to the HMA plant. The readings shall be taken at least every hour with at least one reading for each batch of asphalt-rubber binder. The Contractor shall log these results, including time and asphalt-rubber binder temperature, and a copy of the log shall be submitted to the Engineer daily. The Contractor shall either notify the Engineer at least 15 minutes prior to each test or provide the Engineer a schedule of testing times. The Contractor shall immediately notify the Engineer if any viscosity reading falls below 1000 Pa·s ($x10^{-3}$) when tested at 185°C.

Subsection 401.15 shall include the following:

The minimum mix discharge temperature for PG 64-28TB and PG 64-28WP shall be 320°F. The minimum delivered mix temperature for PG 64-28TB and PG 64-28WP shall be 280°F.

Subsection 401.17 shall include the following:

Further compaction effort shall not be applied to HMA containing PG 64-28TB or PG 64-28WP when the surface temperature of the mixture falls below 230 °F.

Subsection 401.22 shall include the following:

Facilities for blending and storing PG 64-28WP will not be measured and paid for separately, but

shall be included in the work. Facilities for storing PG 64-28TB will not be measured and paid for separately, but shall be included in the work.

Subsection 403.02 shall include the following:

The design mix for hot mix asphalt shall conform to the following:

Table 403-1

Property	**Test Method**	**Value For Grading**	
		SX(100)	SX(100)
Air Voids, percent at: N (design)	CPL 5115	3.5 – 4.5	3.5 – 4.5
Lab Compaction (Revolutions): N (design)	CPL 5115	100	100
Stability, minimum	CPL 5106	30	30
Aggregate Retained on the 4.75 mm (No. 4) Sieve with at least 2 Mechanically Induced fractured faces, % minimum	CP 45	60	60
Accelerated Moisture Susceptibility Tensile Strength Ratio (Lottman), minimum	CPL 5109 Method B	80	80
Minimum Dry Split Tensile Strength, kPa (psi)	CPL 5109 Method B	205 (30)	205 (30)
Grade of Asphalt Cement, Top Layer		PG 64-28TB	PG 64-28WP
Voids in the Mineral Aggregate (VMA) % minimum	CP 48	See Table 403-2	See Table 403-2
Voids Filled with Asphalt (VFA), %	AI MS-2	65 - 75	65 - 75
Dust to Asphalt Ratio Fine Gradation Coarse Gradation	CP 50	0.6 – 1.2 0.8 – 1.6	0.6 – 1.2 0.8 – 1.6

Note: AI MS-2 = Asphalt Institute Manual Series 2

Note: The current version of CPL 5115 is available from the Region Materials Engineer.

Note: Mixes with gradations having less than 40% passing the 4.75 mm (No. 4) sieve shall be approached with caution because of constructability problems.

Note: Gradations for mixes with a nominal maximum aggregate size of one-inch or larger are considered a coarse gradation if they pass below the maximum density line at the #4 screen. Gradations for mixes with a nominal maximum aggregate size of ¾ inch or smaller are considered a coarse gradation if they pass below the maximum density line at the #8 screen.

All mix designs shall be run with a gyratory compaction angle of 1.25 degrees and properties must satisfy Table 403-1. Form 43 will establish construction targets for Asphalt Cement and all mix properties at Air Voids up to 1.0 percent below the mix design optimum.

Table 403-2

Minimum Voids in the Mineral Aggregate (VMA)			
Nominal Maximum Size*, mm (inches)	*****Design Air Voids ****		
	3.5%	**4.0%**	**4.5%**
37.5 (1½)	11.6	11.7	11.8
25.0 (1)	12.6	12.7	12.8
19.0 (¾)	13.6	13.7	13.8
12.5 (½)	14.6	14.7	14.8
9.5 (⅜)	15.6	15.7	15.8

***** The Nominal Maximum Size is defined as one sieve larger than the first sieve to retain more than 10%.

****** Interpolate specified VMA values for design air voids between those listed.

*** Extrapolate specified VMA values for production air voids beyond those listed.

The Contractor shall prepare a quality control plan outlining the steps taken to minimize segregation of HMA. This plan shall be submitted to the Engineer and approved prior to beginning the paving operations. When the Engineer determines that segregation is unacceptable, the paving shall stop and the cause of segregation shall be corrected before paving operations will be allowed to resume.

A minimum of 1 percent hydrated lime by weight of the combined aggregate shall be added to the aggregate for all hot mix asphalt.

Acceptance samples shall be taken at the location specified in either Method B or C of CP 41, as determined by the Engineer.

Subsection 403.03 shall include the following:

The Contractor shall construct the work such that all roadway pavement placed prior to the time paving operations end for the year, shall be completed to the full thickness required by the plans. The Contractor's Progress Schedule shall show the methods to be used to comply with this requirement.

Subsection 403.05 shall include the following:

The accepted quantities of hot mix asphalt will be paid for in accordance with subsection 401.22, at the contract unit price per ton for the bituminous mixture.

Payment will be made under:

Pay Item	**Pay Unit**
Hot Mix Asphalt Grading SX(100)PG 64-28TB	Ton
Hot Mix Asphalt Grading SX(100)PG 64-28WP	Ton

AGGREGATE, ASPHALT RECYCLING AGENT, ADDITIVES, HYDRATED LIME, AND ALL OTHER WORK NECESSARY TO COMPLETE EACH HOT MIX ASPHALT ITEM WILL NOT BE PAID FOR SEPARATELY, BUT SHALL BE INCLUDED IN THE UNIT PRICE BID. WHEN THE PAY ITEM INCLUDES THE PG BINDER GRADE, THE ASPHALT CEMENT WILL NOT BE MEASURED AND PAID FOR SEPARATELY, BUT SHALL BE INCLUDED IN THE WORK.

Subsection 702.01(a) Table 702-1 shall include the following:

REVISION OF SECTIONS 401, 403 AND 702
RUBBERIZED ASPHALT PAVEMENT

Table 702-1A

Property	AASHTO Test Method	Specification Grade		
			PG64-28TB	PG 64-28WP
Original Binder				
Flash Point, Minimum °C	T48		230	230
Solubility, Minimum %	T44		97.5	80
% Rubber Content, %, min.	-		10	10
Viscosity at 135°C, Maximum, Pa·s	T316		3.0	3.0
Dynamic Shear, Test Temp. at 10 rad/s, °C Minimum G*/sin(delta), kPa	T315		64 1.00	64 1.00
Ductility @ 4C, 5cm/min, cm, Min.	T 51		40	10
RTFO Test, Mass Loss, Maximum, %	CP-L 2215		1.00	1.00
RTFO Test Aged Binder				
Dynamic Shear, Test Temp. at 10 rad/s, °C Minimum G*/sin(delta), kPa	T315		64 2.20	64 2.20
Ductility @ 4C, 5cm/min, cm, Min.	T 51		20	5
PAV Aging, Temperature, °C	R28		100	100
RTFO Test and PAV Aged Binder				
Dynamic Shear, Test Temp. at 10 rad/s, °C Minimum G*sin(delta), kPa	T315		22 5000	22 5000
Creep Stiffness, Test Temperature, °C Maximum S-value, MPa Minimum M-value	T313		-18 300 0.300	-18 300 0.300

The binder formulations for PG 64-28TB and PG 64-28WP shall include the following information:

1. Paving Asphalt and Modifiers:
   - (1) Source and grade of paving asphalt.
   - (2) Source and identification (or type) of modifiers used.
   - (3) Percentage of the combined blend of paving asphalt and asphalt modifier by total mass of asphalt-rubber binder to be used.
2. Crumb Rubber Modifier (CRM):
   - (1) Source and identification (or type) of scrap tire CRM.
   - (2) Percentage of scrap tire CRM by total mass of the asphalt-rubber blend.
   - (3) If CRM from more than one source is used, the above information is required for each CRM source used.

REVISION OF SECTIONS 401, 403 AND 702
RUBBERIZED ASPHALT PAVEMENT

3. Asphalt-Rubber Binder: The minimum temperature and minimum reaction time in the storage vessel.

The paving asphalt and asphalt modifier shall be combined into a blended mixture that is chemically compatible with the crumb rubber modifier to be used. The tire rubber material shall be totally incorporated into the asphalt cement yielding a homogenous product of a singular composition. The tire rubber shall not settle or phase separate.

PG 64-28TB shall not be diluted with extender oil, kerosene, or other solvents. PG 64-28TB asphalt binder so contaminated shall not be used. Kerosene or other solvents used in the cleaning of equipment shall be purged from the system prior to subsequent use of that equipment.

Subsection 702.01 shall include the following:

(c) *Crumb rubber modifier (CRM).* Crumb rubber modifier (CRM) shall consist of scrap tire CRM. The scrap tire CRM shall consist of ground or granulated rubber derived from of automobile tires, truck tires, tire buffing, or a combination thereof. Steel and fiber separation may be accomplished by any method. Cryogenic separation, if utilized, shall be performed separately and shall be prior to grinding or granulating. CRM shall be ground or granulated at ambient temperature. Cryogenically produced CRM particles which can pass through the grinder or granulator without being ground or granulated respectively shall not be used. CRM shall not contain more than 0.01 percent wire (by mass of CRM) and shall be free of other contaminants, except fabric. Fabric shall not exceed 0.05 percent by mass of CRM. A Certificate of Compliance certifying these percentages shall be furnished to the Engineer in conformance with the subsection 106.12. The CRM shall be sufficiently dry so that the CRM will be free flowing and not produce foaming when combined with the blended paving asphalt and asphalt modifier mixture. Calcium carbonate or talc may be added at a maximum amount of 3 percent by mass of CRM to prevent CRM particles from sticking together. The CRM shall have a specific gravity between 1.1 and 1.2. Scrap tire CRM shall be delivered to the production site in separate bags and will be sampled and tested separately. CRM material shall conform to the following requirements of ASTM D 297:

SCRAP TIRE CRUMB RUBBER MODIFIER

Test Parameter	Percent	
	Min.	Max.
Acetone Extract	6.0	16.0
Ash Content	—	8.0
Carbon Black Content	28.0	38.0
Rubber Hydrocarbon	42.0	65.0

REVISION OF SECTIONS 401, 403 AND 702
RUBBERIZED ASPHALT PAVEMENT

The CRM for asphalt-rubber binder shall conform to the gradations specified below when tested in conformance with the requirements in ASTM C 136, except as follows:

1. Split or quarter 100 g ± 5 g from the CRM sample and dry to a constant mass at a temperature between 130°F and 145°F and record the dry sample mass. Place the CRM sample and 5.0 g of talc in a 0.5-L jar. Seal the jar: then shake it by hand for a minimum of one minute to mix the CRM and the talc. Continue shaking or open the jar and stir until particle agglomerates and clumps are broken and the talc is uniformly mixed.
2. Place one rubber ball on each sieve. Each ball shall have a mass of 8.5 g ± 0.5 g, have a diameter of 24.5 mm ± 0.5 mm, and shall have a Shore Durometer "A" hardness of 50 ± 5 in conformance with the requirements in ASTM Designation: D 2240. After sieving the combined material for 10 minutes ± 1 minute, disassemble the sieves. Material adhering to the bottom of a sieve shall be brushed into the next finer sieve. Weigh and record the mass of the material retained on the 850 µm sieve and leave this material (do not discard) on the scale or balance. Observed fabric balls shall remain on the scale or balance and shall be placed together on the side of the scale or balance to prevent the fabric balls from being covered or disturbed when placing the material from finer sieves onto the scale or balance. The material retained on the next finer sieve (425 µm sieve) shall be added to the scale or balance. Weigh and record that mass as the accumulative mass retained on that sieve (425 µm sieve). Continue weighing and recording the accumulated masses retained on the remaining sieves until the accumulated mass retained in the pan has been determined. Prior to discarding the CRM sample, separately weigh and record the total mass of fabric balls in the sample.
3. To account for the 5 g of talc added to the sample, determine the mass of passing the 150 µm sieve (or mass retained in the pan) by subtracting the accumulated mass retained on the 150 µm sieve from the accumulated mass retained in the pan. If the material retained in the pan has a mass of 5 g or less, cross out the recorded number for the accumulated mass retained in the pan and copy the number recorded for the accumulated mass retained on the 150 µm sieve as the accumulated mass retained in the pan. If the material passing the 150 µm sieve (or mass retained in the pan) has a mass greater than 5 g, cross out the recorded number for the accumulated mass retained in the pan, subtract 5 g from that number and record the difference next to the crossed out number.

CRM GRADATIONS

Sieve Size	Scrap Tire CRM Percent Passing
No. 20 (850 µm)	100
No. 40 (425 µm)	85-100
No. 60 (180 µm)	10-50
No. 80 (150 µm)	5-30

APPENDIX D – Quality Control Data

Aggregate Industries, West Central Region
Technical Services Department
Project: NH 0641-073
S.A. 16522
Location: SH 34 Bypass
3/8/2012

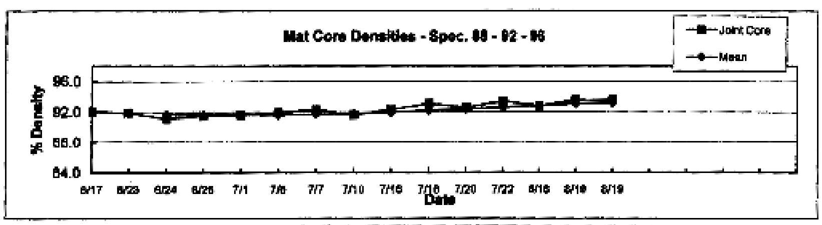
CDOT Mix Design # : 170947
Agg Ind Mix Design # : 64 (Greeley plant)
Grading: SX (100) , PG 64-28 (SGLP / Suncor)

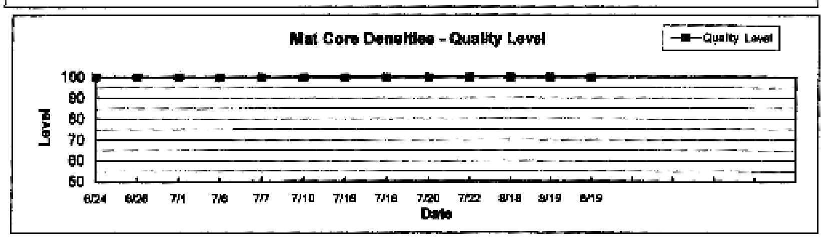
AGGREGATE

Joint Core Density Quality Level Charts

T upper = 96.0
T lower = 88.0

Test Number	Date	Joint Core	Quality Level	Mean	s	Q upper	Q lower	P upper	P lower
1	6/17/09	92.1							
2	6/23/09	91.9							
3	6/24/09	91.1	100	91.70	0.53	8.13	6.99	100	100
4	6/26/09	91.5	100	91.65	0.44	9.81	8.23	100	100
5	7/1/09	91.6	100	91.64	0.38	11.33	9.48	100	100
6	7/6/09	91.9	100	91.60	0.33	13.27	10.85	100	100
7	7/7/09	92.3	100	91.68	0.46	9.61	8.19	100	100
8	7/10/09	91.6	100	91.78	0.33	12.90	11.56	100	100
9	7/16/09	92.3	100	91.94	0.35	11.58	11.23	100	100
10	7/16/09	93.1	100	92.24	0.66	6.67	7.52	100	100
11	7/20/09	92.6	100	92.38	0.54	6.64	8.04	100	100
12	7/22/09	93.4	100	92.60	0.70	4.83	6.54	100	100
13	8/18/09	92.8	100	92.64	0.43	7.39	11.31	100	100
14	8/19/09	93.6	100	93.10	0.41	7.03	12.37	100	100
15	8/19/09	93.6	100	93.20	0.47	6.97	11.09	100	100
16									
17									
18									
19									
20									





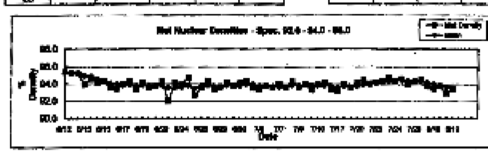
Aggregate Industries, West Central Region
Technical Services Department
Project: NH 0841-073
S.A. 16622
Location: SH 34 Bypass
2/6/09

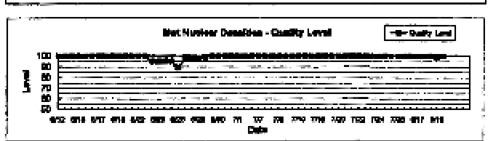
CDOT Mix Design # : 170947
Agg Ind Mix Design # : 64 (Greeley plant)
Grading: SX (100), PG 64-28 (SGLP / Suncor)

Nuclear Mat Density Quality Level Charts

T upper = 96.0
T lower = 92.0

Test			Quality						
Number	Date	Mat Density	Level	Mean	s	Q upper	Q lower	P upper	P lower
1	6/13/09	95.4							
2	6/13/09	95.3							
3	6/13/09	95.9	100	95.50	0.10	7.00	30.00	100	100
4	6/15/09	93.8	100	94.96	0.79	1.40	4.19	100	100
5	6/15/09	94.8	100	94.88	0.69	1.78	4.07	100	100
6	6/15/09	95.1	100	94.82	0.65	2.18	4.18	100	100
7	6/16/09	94.3	100	94.42	0.61	3.12	4.77	100	100
8	6/16/09	93.8	100	94.08	0.41	4.69	5.09	100	100
9	6/17/09	93.4	100	93.98	0.52	3.91	3.65	100	100
10	6/17/09	94.0	100	93.88	0.39	5.47	4.79	100	100
11	6/18/09	94.5	100	93.90	0.45	4.66	4.42	100	100
12	6/18/09	93.4	100	93.72	0.41	5.55	4.21	100	100
13	6/19/09	94.2	100	93.86	0.45	4.84	4.36	100	100
14	6/19/09	93.6	100	93.90	0.38	5.42	4.91	100	100
15	6/22/09	93.7	100	93.84	0.38	5.62	4.70	100	100
16	6/22/09	94.4	100	93.88	0.42	5.07	4.41	100	100
17	6/23/09	92.0	95	93.58	0.84	2.88	1.87	99	96
18	6/23/09	95.1	95	93.76	0.93	2.39	1.88	99	96
19	6/24/09	93.9	95	93.82	0.94	2.33	1.72	99	96
20	6/24/09	94.7	95	93.92	1.06	2.06	1.71	99	96
21	6/25/09	92.6	88	93.48	1.12	2.27	1.30	99	90
22	6/25/09	93.6	96	93.76	0.77	2.87	2.30	99	99
23	6/26/09	94.4	98	93.84	0.81	2.65	2.28	99	99
24	6/26/09	93.4	98	93.74	0.85	2.71	2.05	99	98
25	6/29/09	93.8	99	93.82	0.64	3.38	2.87	100	99
26	6/29/09	94.2	100	93.64	0.43	4.88	4.24	100	100
27	6/30/09	93.6	100	93.88	0.41	5.11	4.53	100	100
28	6/30/09	94.1	100	93.82	0.33	6.61	5.44	100	100
29	7/1/09	94.3	100	94.00	0.29	6.89	6.88	100	100
30	7/1/09	93.6	100	93.98	0.33	6.16	5.95	100	100
31	7/6/09	93.4	100	93.82	0.38	5.69	4.75	100	100
32	7/6/09	93.6	100	93.82	0.38	5.69	4.75	100	100
33	7/7/09	93.6	100	93.72	0.36	6.40	4.83	100	100
34	7/7/09	94.0	100	93.68	0.24	8.72	6.89	100	100
35	7/8/09	93.6	100	93.68	0.23	10.17	7.37	100	100
36	7/8/09	94.4	100	93.86	0.33	6.33	5.62	100	100
37	7/9/09	93.6	100	93.84	0.36	6.04	5.14	100	100
38	7/9/09	94.0	100	93.92	0.33	6.22	5.74	100	100
39	7/10/09	93.3	100	93.78	0.43	5.30	4.17	100	100
40	7/10/09	93.6	100	93.64	0.42	5.19	4.42	100	100
41	7/15/09	94.2	100	93.86	0.36	6.22	5.09	100	100
42	7/16/09	93.4	100	93.76	0.39	5.73	4.50	100	100
43	7/17/09	93.2	100	93.60	0.48	5.00	3.72	100	100
44	7/17/09	94.0	100	93.74	0.42	5.36	4.12	100	100
45	7/20/09	93.8	100	93.68	0.41	5.69	4.05	100	100
46	7/20/09	94.2	100	93.86	0.41	5.69	4.05	100	100
47	7/22/09	94.5	100	93.90	0.51	4.12	3.73	100	100
48	7/22/09	94.0	100	94.06	0.33	5.80	6.27	100	100
49	7/23/09	94.2	100	94.10	0.33	4.73	6.33	100	100
50	7/23/09	94.4	100	94.38	0.20	8.82	11.69	100	100
51	7/24/09	94.7	100	94.36	0.27	6.07	8.73	100	100
52	7/24/09	94.4	100	94.34	0.29	5.37	8.07	100	100
53	7/27/09	94.6	100	94.48	0.19	7.90	12.92	100	100
54	7/28/09	94.0	100	94.42	0.27	5.69	9.02	100	100
55	7/28/09	94.3	100	94.40	0.27	5.84	8.76	100	100
56	8/17/09	94.6	100	94.36	0.23	7.12	10.28	100	100
57	8/17/09	93.7	100	94.22	0.37	4.81	6.00	100	100
58	8/18/09	93.4	100	93.98	0.44	4.55	4.48	100	100
59	8/18/09	93.7	100	93.92	0.46	4.52	4.17	100	100
60	8/19/09	92.9	99	93.54	0.58	4.05	2.82	100	99
61	8/19/09	93.4	100	93.42	0.33	7.80	4.30	100	100
62									
63									
64									
65									





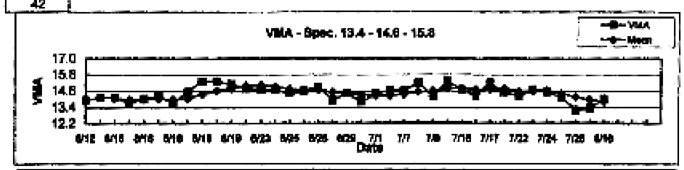
Aggregate Industries, West Central Region
Technical Services Department
Project: NH 0641-073
S.A. 16622
Location: SH 34 Bypass
3/8/2012

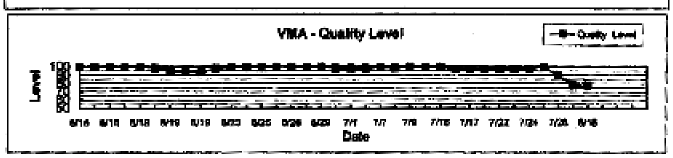
CDOT Mix Design # : 170947
Agg Ind Mix Design # : 64 (Greeley plant)
Grading: SX (100) , PG 64-28 (SGLP / Suncor)

Target = 14.6 (Revised 6/16)
T upper = 15.8
T lower = 13.4

Corrected VMA Quality Level Charts

Test Number	Date	VMA	Quality Level	Mean	s	Q upper	Q lower	P upper	P lower
1	6/12/09	13.9							
2	6/12/09	14.1							
3	6/15/09	14.1	100	14.03	0.12	15.30	5.48	100	100
4	6/15/09	13.7	100	13.95	0.19	9.66	2.87	100	100
5	6/16/09	14.0	100	13.96	0.17	11.00	3.35	100	100
6	6/17/09	14.2	100	14.02	0.19	9.25	3.22	100	100
7	6/18/09	13.7	100	13.94	0.23	8.08	2.35	100	100
8	6/19/09	14.5	98	14.02	0.34	5.20	1.81	100	98
9	6/19/09	15.3	95	14.34	0.61	2.39	1.54	100	95
10	6/19/09	15.3	94	14.60	0.70	1.71	1.71	97	97
11	6/19/09	15.1	93	14.78	0.69	1.48	2.01	94	99
12	6/22/09	14.6	98	15.00	0.35	2.31	4.82	99	99
13	6/23/09	14.7	99	15.04	0.28	2.72	5.97	99	100
14	6/24/09	14.7	100	14.92	0.27	3.26	6.88	100	100
15	6/25/09	14.4	100	14.74	0.25	4.22	5.34	100	100
16	6/26/09	14.6	100	14.64	0.15	7.65	8.18	100	100
17	6/26/09	14.9	100	14.66	0.16	6.29	8.94	100	100
18	6/29/09	13.9	100	14.60	0.36	3.41	2.89	100	100
19	6/29/09	14.4	100	14.44	0.36	3.73	2.85	100	100
20	6/30/09	13.8	98	14.32	0.47	3.18	1.97	100	98
21	7/1/09	14.4	98	14.28	0.44	3.42	1.98	100	98
22	7/6/09	14.7	98	14.24	0.38	4.13	2.22	100	98
23	7/7/09	14.6	99	14.38	0.35	4.07	2.81	100	99
24	7/8/09	15.2	98	14.64	0.51	2.48	2.24	99	99
25	7/9/09	14.2	100	14.62	0.38	3.13	3.24	100	100
26	7/16/09	15.3	99	14.80	0.46	2.21	3.09	99	100
27	7/16/09	14.7	99	14.80	0.45	2.21	3.09	99	100
28	7/16/09	14.2	97	14.72	0.53	2.05	2.51	98	99
29	7/17/09	15.2	97	14.72	0.53	2.05	2.51	98	99
30	7/20/09	14.5	97	14.78	0.47	2.19	2.96	98	99
31	7/22/09	14.2	97	14.58	0.42	2.96	2.79	98	99
32	7/23/09	14.7	97	14.58	0.42	2.96	2.79	98	99
33	7/24/09	14.5	97	14.62	0.37	3.19	3.30	98	99
34	7/27/09	14.1	100	14.40	0.24	5.72	4.06	100	100
35	7/28/09	13.2	89	14.14	0.58	2.88	1.28	99	90
36	8/17/09	13.3	78	13.96	0.66	2.69	0.82	99	79
37	8/18/09	14.0	77	13.82	0.65	3.57	0.76	100	77
38									
39									
40									
41									
42									





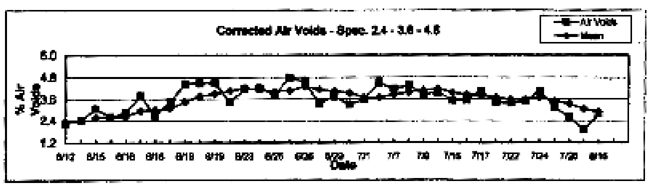
Aggregate Industries, West Central Region
Technical Services Department
Project: NH 0641-073
S.A. 15522
Location: SH 34 Bypass
3/5/2012

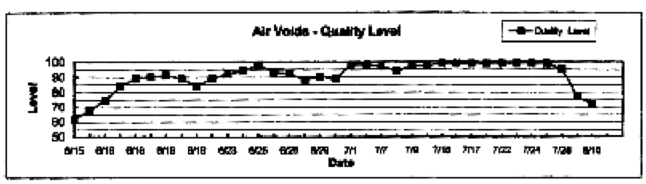
CDOT Mix Design # : 170947
Agg Ind Mix Design # : 64 (Greeley plant)
Grading: SX (100) , PG 64-28 (SGLP / Suncor)

Target = 3.6
T upper = 4.8
T lower = 2.4

Corrected Air Voids Quality Level Charts

Test Number	Date	Air Voids	Quality Level	Mean	s	Q upper	Q lower	P upper	P lower
1	6/12/09	2.27							
2	6/12/09	2.40							
3	6/15/09	3.08	62	2.58	0.42	5.25	0.42	100	62
4	6/15/09	2.61	68	2.59	0.35	6.40	0.53	100	68
5	6/16/09	2.82	75	2.63	0.32	6.82	0.73	100	75
6	6/17/09	3.79	84	2.84	0.64	3.47	1.00	100	84
7	6/18/09	2.88	89	2.96	0.48	3.76	1.22	100	89
8	6/18/09	3.45	90	3.07	0.53	3.28	1.27	100	90
9	6/19/09	4.44	91	3.43	0.73	1.88	1.42	98	93
10	6/19/09	4.49	89	3.77	0.76	1.39	1.81	92	97
11	6/19/09	4.47	84	3.90	0.82	1.09	1.83	86	98
12	6/22/09	3.44	89	4.06	0.66	1.33	2.55	91	98
13	6/23/09	4.13	92	4.19	0.45	1.35	4.02	92	100
14	6/24/09	4.19	94	4.14	0.43	1.54	4.10	94	100
15	6/25/09	3.83	98	4.01	0.39	2.01	4.11	98	100
16	6/26/09	4.78	93	4.07	0.49	1.47	3.38	93	100
17	6/26/09	4.83	92	4.29	0.37	1.38	5.13	92	100
18	6/29/09	3.34	88	4.13	0.57	1.17	3.04	88	100
19	6/29/09	3.73	90	4.04	0.60	1.27	2.78	90	100
20	6/30/09	3.28	89	3.93	0.69	1.26	2.23	90	99
21	7/1/09	3.59	98	3.69	0.50	2.20	2.58	99	99
22	7/6/09	4.51	98	3.69	0.49	2.25	2.61	99	99
23	7/7/09	4.16	97	3.85	0.48	1.95	3.00	98	99
24	7/8/09	4.35	94	3.98	0.52	1.57	3.02	95	99
25	7/9/09	3.88	97	4.09	0.37	1.90	4.85	97	100
26	7/15/09	3.95	97	4.17	0.34	1.88	5.24	97	100
27	7/15/09	3.53	99	3.97	0.37	2.25	4.25	99	100
28	7/16/09	3.54	99	3.85	0.38	2.53	3.83	99	100
29	7/17/09	4.04	99	3.76	0.24	4.30	5.88	99	100
30	7/20/09	3.40	99	3.69	0.28	3.90	4.55	99	100
31	7/22/09	3.36	99	3.67	0.27	4.50	4.31	99	100
32	7/23/09	3.48	99	3.56	0.28	4.49	4.23	99	100
33	7/24/09	4.05	99	3.67	0.35	3.25	3.83	99	100
34	7/27/09	3.14	99	3.49	0.34	3.87	3.20	100	99
35	7/28/09	2.69	96	3.32	0.53	2.78	1.74	99	96
36	8/17/09	1.90	77	3.03	0.83	2.14	0.77	99	78
37	8/18/09	2.77	72	2.89	0.79	2.42	0.62	99	73
38									
39									





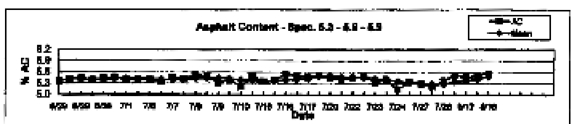
Aggregate Industries, West Central Region
Technical Services Department
Project: NH 0641-073
S.A. 16522
Location: SH 34 Bypass
3/6/2012

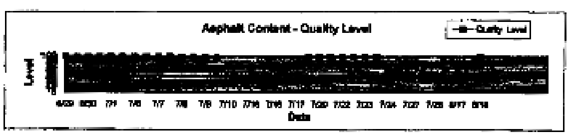
CDOT Mix Design # : 170947
Agg Ind Mix Design # : 64 (Greeley plant)
Grading: SX (100) , PG 64-28 (SGLP / Suncor)

Target = 6.6 (Adjusted 6/29/09)
T upper = 6.9
T lower = 6.3

Asphalt Content Quality Level Charts- Lot #2

Test Number	Date	AC	Quality Level	Mean	s	Q upper	Q lower	P upper	P lower	
1	6/29/09	6.35								EEC
2	6/29/09	6.41								EEC
3	6/29/09	6.44	100	6.40	0.05	10.91	2.18	100	100	Agg Ind
4	6/29/09	6.39	100	6.40	0.04	13.31	2.86	100	100	Agg Ind
5	6/30/09	6.43	100	6.40	0.04	13.86	2.91	100	100	EEC
6	6/30/09	6.48	100	6.43	0.03	17.54	4.86	100	100	Agg Ind
7	7/1/09	6.39	100	6.42	0.03	15.36	3.62	100	100	EEC
8	7/1/09	6.40	100	6.41	0.03	16.64	3.74	100	100	Agg Ind
9	7/6/09	6.40	100	6.42	0.03	16.80	4.03	100	100	EEC
10	7/6/09	6.34	100	6.40	0.04	11.77	2.30	100	100	Agg Ind
11	7/7/09	6.44	100	6.39	0.04	14.14	2.63	100	100	EEC
12	7/7/09	6.42	100	6.40	0.04	13.36	2.87	100	100	Agg Ind
13	7/8/09	6.53	97	6.43	0.07	6.66	1.62	100	97	EEC
14	7/8/09	6.48	98	6.44	0.07	6.46	2.00	100	98	Agg Ind
15	7/8/09	6.32	97	6.44	0.08	5.91	1.76	100	97	EEC
16	7/9/09	6.39	95	6.43	0.08	5.62	1.58	100	95	Agg Ind
17	7/10/09	6.21	76	6.38	0.13	4.03	0.69	100	76	EEC
18	7/16/09	6.47	74	6.37	0.11	4.68	0.66	100	74	EEC
19	7/16/09	6.35	69	6.35	0.10	6.78	0.50	100	69	EEC
20	7/16/09	6.38	73	6.36	0.09	5.69	0.65	100	73	EEC
21	7/16/09	6.54	78	6.38	0.13	4.08	0.72	100	78	EEC
22	7/17/09	6.50	78	6.41	0.12	4.07	0.80	100	78	Agg Ind
23	7/17/09	6.47	78	6.42	0.11	4.28	1.04	100	78	EEC
24	7/20/09	6.61	98	6.45	0.08	6.88	2.84	100	98	Agg Ind
25	7/20/09	6.44	100	6.49	0.04	10.64	5.01	100	100	EEC
26	7/22/09	6.41	100	6.47	0.04	10.43	3.99	100	100	Agg Ind
27	7/22/09	6.44	100	6.46	0.04	11.78	4.07	100	100	EEC
28	7/23/09	6.47	100	6.46	0.04	11.78	4.07	100	100	Agg Ind
29	7/23/09	6.38	99	6.42	0.05	9.00	2.20	100	99	EEC
30	7/24/09	6.40	99	6.41	0.05	9.34	2.10	100	99	Agg Ind
31	7/24/09	6.18	87	6.38	0.13	4.26	0.46	100	87	EEC
32	7/27/09	6.34	82	6.34	0.12	4.72	0.52	100	82	Agg Ind
33	7/27/09	6.29	51	6.30	0.09	6.39	0.02	100	51	EEC
34	7/28/09	6.22	42	6.26	0.10	6.31	-0.20	100	42	EEC
35	7/28/09	6.36	38	6.27	0.09	7.22	-0.32	100	38	Agg Ind
36	8/17/09	6.51	68	6.34	0.11	5.16	0.41	100	68	Agg Ind
37	8/17/09	6.46	71	6.37	0.12	4.68	0.68	100	71	EEC
38	8/18/09	6.56	81	6.41	0.12	4.06	0.88	100	81	EEC
39	8/18/09	6.66	96	6.46	0.08	6.60	2.33	100	96	Agg Ind
40										
41										
42										
43										
44										
45										





Technical Services Department
Project: NH 0841-073
S.A. 16522
Location: SH 34 Bypass

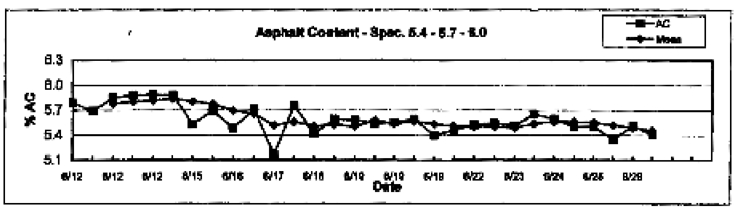
CDOT Mix Design # : 170947
Agg Ind Mix Design # : 94 (Greeley plant)
Grading: SX (100) , PG 64-28 (SGLP / Suncor)

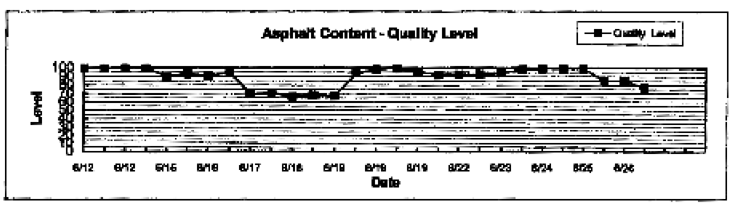
3/6/2012

Target = 5.7
T upper = 6.0
T lower = 5.4

Asphalt Content Quality Level Charts

Test Number	Date	AC	Quality Level	Mean	s	Q upper	Q lower	P upper	P lower	
1	6/12/09	5.79								EEC
2	6/12/09	5.69								EEC
3	6/12/09	5.85	100	5.78	0.08	2.76	4.86	100	100	EEC
4	6/12/09	5.88	100	5.80	0.08	2.38	4.80	100	100	EEC
5	6/12/09	5.89	100	5.82	0.08	2.18	5.09	100	100	EEC
6	6/12/09	5.88	100	5.84	0.08	1.93	6.21	100	100	Agg Ind
7	6/15/09	5.53	90	5.81	0.16	1.25	2.62	90	100	EEC
8	6/15/09	5.69	93	5.77	0.18	1.41	2.34	93	100	Agg Ind
9	6/16/09	5.48	91	5.69	0.19	1.60	1.54	96	95	EEC
10	6/16/09	5.71	95	5.66	0.16	2.15	1.82	99	96	Agg Ind
11	6/17/09	5.17	69	5.52	0.22	2.23	0.53	99	70	EEC
12	6/17/09	5.75	71	5.56	0.24	1.82	0.66	87	74	Agg Ind
13	6/18/09	5.42	66	5.51	0.24	2.10	0.45	99	67	EEC
14	6/18/09	5.59	68	5.53	0.24	1.99	0.54	98	70	Agg Ind
15	6/19/09	5.58	67	5.50	0.22	2.27	0.47	99	68	Agg Ind
16	6/19/09	5.54	94	5.58	0.12	3.58	1.48	100	94	EEC
17	6/19/09	5.55	98	5.54	0.07	5.82	2.00	100	98	EEC
18	6/19/09	5.59	100	5.57	0.02	18.34	7.26	100	100	EEC
19	6/19/09	5.40	96	5.53	0.08	6.11	1.72	100	96	EEC
20	6/22/09	5.48	92	5.51	0.08	6.42	1.41	100	92	EEC
21	6/22/09	5.52	92	5.50	0.08	6.61	1.39	100	92	Agg Ind
22	6/23/09	5.54	92	5.50	0.07	6.76	1.39	100	92	EEC
23	6/23/09	5.51	94	5.49	0.06	9.11	1.53	100	94	Agg Ind
24	6/24/09	5.65	98	5.54	0.07	6.61	1.94	100	98	EEC
25	6/24/09	5.58	99	5.56	0.06	7.54	2.79	100	99	Agg Ind
26	6/25/09	5.60	99	5.56	0.06	7.11	2.54	100	99	EEC
27	6/25/09	5.50	99	5.55	0.07	6.67	2.22	100	99	Agg Ind
28	6/26/09	5.35	85	5.52	0.11	4.25	1.04	100	85	EEC
29	6/26/09	5.51	85	5.49	0.09	5.87	1.04	100	85	EEC
30	6/26/09	5.41	77	5.45	0.07	7.70	0.76	100	77	Agg Ind
31										
32										
33										





Aggregate Industries, West Central Region
Technical Services Department
Project: NH 0641-073
S.A. 16522
Location: SH 34 Bypass

CDOT Mix Design # : 170947
Agg Ind Mix Design # : 64 (Greeley plant)
Grading: SX (100) , PG 64-28 (SGLP / Suncor)

AGGREGATE

Gradation Test Result Charts

	Range	100.0	90-100	80-92	57-67	42-62		18-26			3.8-7.8	3.0
	Mean	100	95	[illegible]	62	46	33.5	21.9	13.3	8.3	5.2	3.1
	Std. Dev.	0.0	1.3	1.6	2.0	1.7	1.1	1.1	0.9	1.0	0.52	
Test												
Number	Date	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	No. 200	Moisture
1	6/12/09	100	94	83	56	45	32	20	12	7.0	4.3	3.8
2	6/15/09	100	95	86	62	47	34	22	14	9	5.8	3.5
3	6/16/09	100	94	85	60	47	34	22	13	8	6.0	3.4
4	6/16/09	100	95	88	62	47	34	22	14	9	5.8	3.4
5	6/17/09	100	95	84	58	45	33	21	13	7	4.4	3.2
6	6/18/09	100	95	86	62	47	34	22	14	9	5.6	3.4
7	6/19/09	100	95	85	58	44	32	20	12	7	4.2	3.6
8	6/22/09	100	96	87	61	47	34	22	16	9	5.4	3.2
9	6/23/09	100	95	86	62	47	34	22	14	9	5.8	3.4
10	6/24/09	100	94	85	61	44	34	22	13	9	5.0	3.2
11	6/25/09	100	96	87	63	43	34	22	14	9	5.8	3.2
12	6/26/09	100	93	84	59	44	33	23	12	9	5.8	3.3
13	6/29/09											3.1
14	6/30/09	100	96	87	64	50	35	22	13	7	4.4	3.1
15	7/1/09	100	95	85	62	48	33	20	12	8	4.7	3.0
16	7/6/09	100	98	88	64	50	34	23	13	8	5.2	3.6
17	7/7/09	100	95	85	63	48	32	22	13	8	5.1	3.2
18	7/8/09	100	96	86	64	45	32	23	13	9	6.4	3.2
19	7/9/09	100	98	88	65	48	34	21	13	7	5.2	3.1
20	7/10/09	100	95	86	62	46	34	22	14	9	6.7	2.9
21	7/16/09	100	94	84	61	47	32	21	12	6	4.8	2.9
22	7/17/09	100	96	88	62	48	35	22	13	7	4.5	2.5
23	7/20/09	100	97	89	65	49	34	22	14	8	4.8	2.3
24	7/22/09	100	96	87	62	47	32	20	14	8	5.2	2.5
25	7/23/09	100	95	89	64	45	34	23	14	9	5.6	2.4
26	7/24/09	100	94	83	60	45	34	23	14	9	5.6	2.3
27	7/27/09	100	97	84	62	46	36	24	15	9	5.3	2.3
28	7/28/09	100	92	85	60	45	34	22	15	9	5.9	2.6
29	8/17/09	100	94	86	61	46	34	22	13	9	5.3	3.7
30	8/18/09	100	96	88	61	48	32	22	12	9	6.1	3.6
31	8/19/09	100	94	87	64	45	32	24	13	10	5.5	3.3
32												
33												
34												
35												

Aggregate Industries, West Central Region
Technical Services Department
Project: NH 0641-073
S.A. 16522
Location: SH 34 Bypass

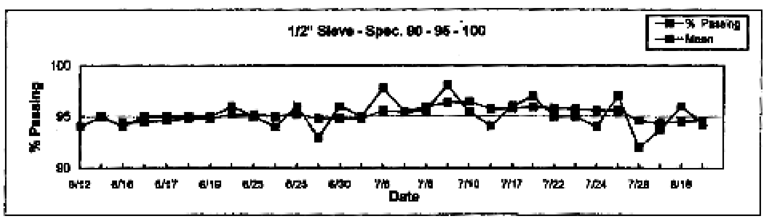
CDOT Mix Design # : 170947
Agg Ind Mix Design # : 64 (Greeley plant)
Grading: SX (100) , PG 64-28 (SGLP / Suncor)

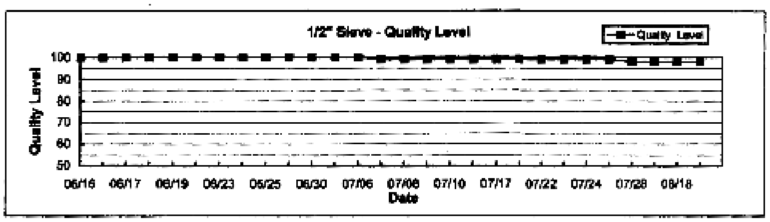
T upper = 100
T lower = 90

3/5/2012

1/2" Sieve

Test Number	Date	% Passing	Quality Level	Mean	s	Q upper	Q lower	P upper	P lower
1	06/12	94							
2	06/15	95							
3	06/16	94	100	94.33	0.58	9.81	7.51	100	100
4	06/16	95	100	94.50	0.58	9.53	7.79	100	100
5	06/17	95	100	94.60	0.55	9.86	8.40	100	100
6	06/18	95	100	94.80	0.45	11.63	10.73	100	100
7	06/19	95	100	94.80	0.45	11.63	10.73	100	100
8	06/22	96	100	95.20	0.45	10.73	11.63	100	100
9	06/23	95	100	95.20	0.45	10.73	11.63	100	100
10	06/24	94	100	95.00	0.71	7.07	7.07	100	100
11	06/25	96	100	95.20	0.84	5.74	6.22	100	100
12	06/26	93	100	94.80	1.30	3.99	3.68	100	100
13	06/30	96	100	94.80	1.30	3.99	3.68	100	100
14	07/01	95	100	94.80	1.30	3.99	3.68	100	100
15	07/06	98	100	95.56	1.75	2.53	3.17	100	100
16	07/07	95	99	95.44	1.73	2.63	3.14	99	100
17	07/08	96	99	95.96	1.09	3.71	5.47	99	100
18	07/09	96	99	96.36	1.45	2.49	4.39	99	100
19	07/10	95	99	96.48	1.37	2.58	4.73	99	100
20	07/16	94	99	95.72	1.46	2.93	3.92	99	100
21	07/17	96	99	95.77	1.31	3.23	4.40	99	100
22	07/20	97	99	95.94	1.28	3.16	4.63	99	100
23	07/22	95	99	95.83	1.23	3.38	4.72	99	100
24	07/23	95	99	95.73	1.19	3.60	4.83	99	100
25	07/24	94	99	95.56	1.25	3.56	4.46	99	100
26	07/27	97	99	95.60	1.34	3.28	4.17	99	100
27	07/28	92	98	94.60	1.82	2.97	2.53	99	99
28	08/17	94	98	94.34	1.84	3.06	2.36	99	99
29	08/18	96	98	94.54	1.98	2.76	2.30	99	99
30	08/19	94	98	94.58	1.97	2.76	2.33	99	99
31									





Technical Services Department
Project: NH 0641-073
S.A. 16522
Location: SH 34 Bypass

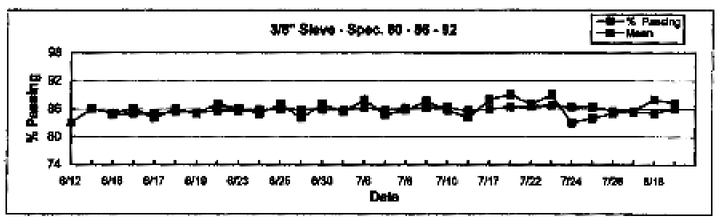
CDOT Mix Design # : 170947 AGGREGATE
Agg Ind Mix Design # : 64 (Greeley plant)
Grading: SX (100) , PG 64-28 (SGLP / Suncor)

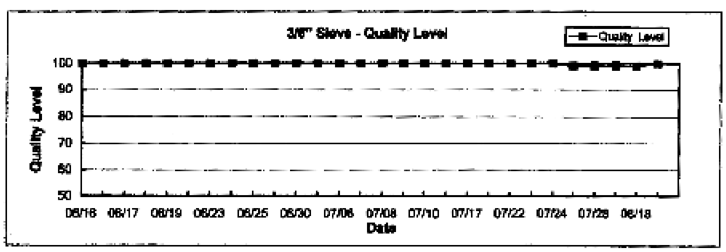
T upper = 92 3/6/2012
T lower = 80

3/8" Sieve

Test Number	Date	% Passing	Quality Level	Mean	s
1	06/12	83			
2	06/15	86			
3	06/16	85	100	84.67	1.53
4	06/16	86	100	85.00	1.41
5	06/17	84	100	84.80	1.30
6	06/18	86	100	85.40	0.89
7	06/19	85	100	85.20	0.84
8	06/22	87	100	85.60	1.14
9	06/23	86	100	85.60	1.14
10	06/24	85	100	85.80	0.84
11	06/25	87	100	86.00	1.00
12	06/26	84	100	85.80	1.30
13	06/30	87	100	85.80	1.30
14	07/01	86	100	85.68	1.31
15	07/06	88	100	86.26	1.56
16	07/07	85	100	85.80	1.62
17	07/08	86	100	86.14	1.29
18	07/09	88	100	86.26	1.41
19	07/10	86	100	86.32	1.37
20	07/16	84	100	85.58	1.33
21	07/17	88	100	85.97	1.55
22	07/20	89	100	86.40	1.82
23	07/22	87	100	86.48	1.70
24	07/23	89	100	86.76	1.80
25	07/24	83	100	86.36	2.07
26	07/27	84	99	86.40	2.79
27	07/28	85	99	85.60	2.41
28	08/17	86	99	85.32	2.26
29	08/18	88	99	85.12	1.89
30	08/19	87	100	85.96	1.65
31					

Q upper	Q lower	P upper	P lower
4.80	3.06	100	100
4.95	3.54	100	100
5.52	3.68	100	100
7.38	6.04	100	100
8.13	6.22	100	100
5.61	4.91	100	100
5.61	4.91	100	100
7.41	6.93	100	100
6.00	6.00	100	100
4.78	4.45	100	100
4.78	4.45	100	100
4.83	4.34	100	100
3.70	4.03	100	100
3.83	3.59	100	100
4.54	4.78	100	100
4.07	4.43	100	100
4.14	4.61	100	100
4.84	4.18	100	100
3.89	3.85	100	100
3.07	3.51	100	100
3.25	3.81	100	100
2.91	3.75	100	100
2.71	3.08	100	100
2.01	2.29	100	99
2.66	2.33	100	99
2.93	2.33	100	99
3.64	2.71	100	98
3.66	3.63	100	100





Technical Services Department
Project: NH 0641-073
S.A. 16522
Location: SH 34 Bypass

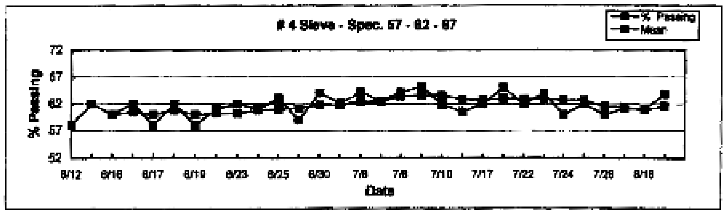
CDOT Mix Design # : 170947
Agg Ind Mix Design # : 64 (Greeley plant)
Grading: SX (100) , PG 64-28 (SGLP / Suncor)

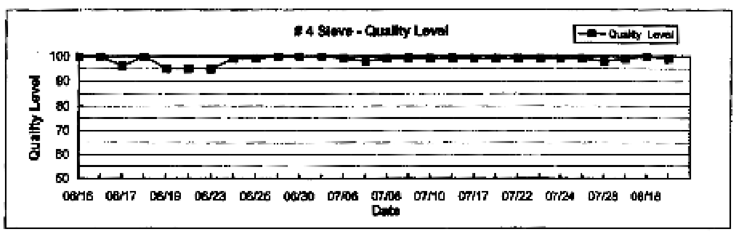
T upper = 67
T lower = 57

3/5/2012

4 Sieve

Test Number	Date	% Passing	Quality Level	Mean	s	Q upper	Q lower	P upper	P lower
1	06/12	56							
2	06/15	62							
3	06/16	60	100	60.00	2.00	3.50	1.50	100	100
4	06/16	62	100	60.60	1.91	3.39	1.83	100	100
5	06/17	58	96	60.00	2.00	3.50	1.50	100	96
6	06/18	62	100	60.80	1.79	3.47	2.12	100	100
7	06/19	58	95	60.00	2.00	3.50	1.50	100	95
8	06/22	61	95	60.20	2.05	3.32	1.56	100	95
9	06/23	62	95	60.20	2.05	3.32	1.56	100	95
10	06/24	61	99	60.80	1.64	3.77	2.31	100	99
11	06/25	63	99	61.00	1.87	3.21	2.14	100	99
12	06/26	59	100	61.20	1.48	3.91	2.83	100	100
13	06/30	64	100	61.60	1.82	2.70	2.50	100	100
14	07/01	62	100	61.62	1.93	2.69	2.50	100	100
15	07/06	64	99	62.46	2.11	2.16	2.58	99	100
16	07/07	63	98	62.36	2.09	2.22	2.57	99	99
17	07/08	64	99	63.36	1.00	3.63	6.36	99	100
18	07/09	65	99	63.62	1.29	2.63	5.14	99	100
19	07/10	62	99	63.56	1.38	2.49	4.76	99	100
20	07/16	61	99	62.82	1.86	2.25	3.13	99	100
21	07/17	62	99	62.68	1.70	2.54	3.35	99	100
22	07/20	65	99	63.01	1.78	2.24	3.38	99	100
23	07/22	62	99	62.89	1.69	2.44	3.49	99	100
24	07/23	64	99	63.01	1.62	2.46	3.71	99	100
25	07/24	60	99	62.71	1.80	2.38	3.17	99	100
26	07/27	62	99	62.65	1.72	2.63	3.28	99	100
27	07/28	60	98	61.60	1.67	3.23	2.75	99	98
28	08/17	61	99	61.44	1.66	3.34	2.67	100	99
29	08/18	61	100	60.84	0.65	7.22	4.50	100	100
30	08/19	64	99	61.60	1.42	3.80	3.24	100	99
31									





Aggregate Industries, West Central Region
Technical Services Department
Project: NH 0641-073
S.A. 16522
Location: SH 34 Bypass

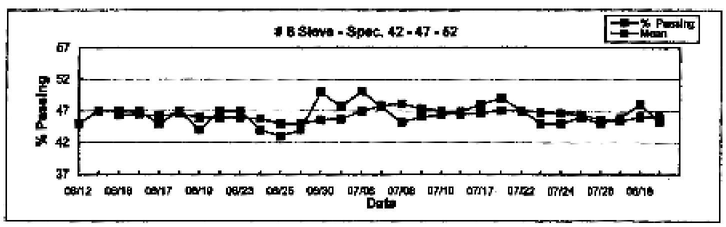
CDOT Mix Design # : 170947
Agg Ind Mix Design # : 64 (Greeley plant)
Grading: SX (100) , PG 64-28 (SGLP / Suncor)

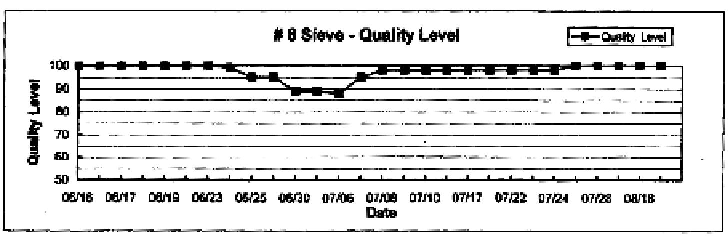
T upper = 52
T lower = 42

3/6/2012

8 Sieve

Test Number	Date	% Passing	Quality Level	Mean	s	Q upper	Q lower	P upper	P lower
1	06/12	45							
2	06/15	47							
3	06/16	47	100	46.33	1.15	4.91	3.75	100	100
4	06/16	47	100	46.50	1.00	5.50	4.50	100	100
5	06/17	45	100	46.20	1.10	5.28	3.83	100	100
6	06/18	47	100	46.60	0.89	6.04	5.14	100	100
7	06/19	44	100	46.00	1.41	4.24	2.83	100	100
8	06/22	47	100	46.00	1.41	4.24	2.83	100	100
9	06/23	47	100	46.00	1.41	4.24	2.83	100	100
10	06/24	44	99	45.80	1.64	3.77	2.31	100	99
11	06/25	43	95	45.00	1.87	3.74	1.60	100	95
12	06/26	44	95	45.00	1.87	3.74	1.60	100	95
13	06/30	50	89	45.60	2.88	2.22	1.25	99	90
14	07/01	48	89	45.74	2.98	2.10	1.25	99	90
15	07/06	50	88	46.96	3.32	1.52	1.49	94	94
16	07/07	48	95	47.88	2.48	1.66	2.37	96	99
17	07/08	45	98	48.12	2.03	1.91	3.02	98	100
18	07/09	46	98	47.34	1.87	2.50	2.86	99	99
19	07/10	46	98	47.06	1.89	2.60	2.68	99	99
20	07/16	47	98	46.44	0.90	6.20	4.85	99	99
21	07/17	48	98	46.70	1.02	5.18	4.59	99	99
22	07/20	49	98	47.03	1.28	3.90	3.94	99	99
23	07/22	47	98	47.03	1.18	4.21	4.25	99	99
24	07/23	45	98	46.80	1.30	4.01	3.71	99	99
25	07/24	45	98	46.62	1.35	3.99	3.43	99	99
26	07/27	46	100	46.40	1.67	3.35	2.63	100	100
27	07/28	45	100	45.60	0.89	7.16	4.02	100	100
28	08/17	46	100	45.39	0.52	12.69	6.46	100	100
29	08/18	48	100	45.96	1.23	4.91	3.25	100	100
30	08/19	45	100	46.02	1.19	5.03	3.36	100	100
31									





Technical Services Department
Project: NH 0641-073
S.A. 16522
Location: SH 34 Bypass

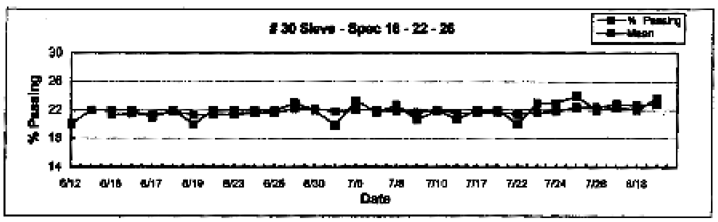
CDOT Mix Design # : 170947
Agg Ind Mix Design # : 64 (Greeley plant)
Grading: SX (100) , PG 64-28 (SGLP / Suncor)

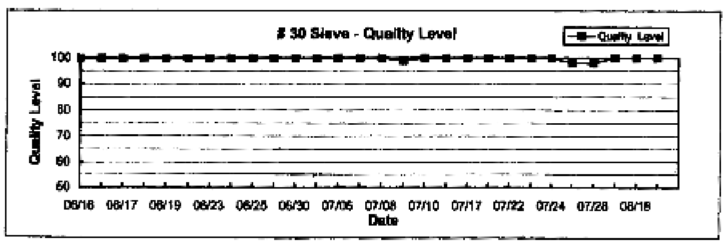
T upper = 26
T lower = 18

3/6/2012

30 Sieve

Test Number	Date	% Passing	Quality Level	Mean	s	Q upper	Q lower	P upper	P lower
1	06/12	20							
2	06/15	22							
3	06/16	22	100	21.33	1.15	4.04	2.89	100	100
4	06/16	22	100	21.50	1.00	4.50	3.50	100	100
5	06/17	21	100	21.40	0.89	5.14	3.80	100	100
6	06/18	22	100	21.80	0.45	9.39	8.60	100	100
7	06/19	20	100	21.40	0.89	5.14	3.80	100	100
8	06/22	22	100	21.40	0.89	5.14	3.80	100	100
9	06/23	22	100	21.40	0.89	5.14	3.80	100	100
10	06/24	22	100	21.60	0.89	4.92	4.02	100	100
11	06/25	22	100	21.60	0.89	4.92	4.02	100	100
12	06/26	23	100	22.20	0.45	8.50	9.39	100	100
13	06/30	22	100	22.20	0.45	8.50	9.39	100	100
14	07/01	20	100	21.76	1.18	3.60	3.19	100	100
15	07/06	23	100	22.02	1.37	2.90	2.93	100	100
16	07/07	22	100	21.96	1.38	2.93	2.87	100	100
17	07/08	23	100	21.90	1.33	3.09	2.94	100	100
18	07/09	21	99	21.62	1.44	3.03	2.51	100	99
19	07/10	22	100	22.04	1.03	3.85	3.93	100	100
20	07/16	21	100	21.62	0.88	5.10	4.01	100	100
21	07/17	22	100	21.60	0.81	5.43	4.44	100	100
22	07/20	22	100	21.98	0.75	5.75	4.85	100	100
23	07/22	20	100	21.45	0.91	4.99	3.78	100	100
24	07/23	23	100	21.82	1.00	4.39	3.63	100	100
25	07/24	23	100	21.76	1.04	4.09	3.63	100	100
26	07/27	24	98	22.40	1.52	2.37	2.90	99	99
27	07/28	22	98	22.40	1.52	2.37	2.90	99	99
28	08/17	22	100	22.88	0.76	4.13	6.45	100	100
29	08/18	22	100	22.68	0.84	3.93	5.55	100	100
30	08/19	24	100	22.82	0.96	3.31	5.02	100	100
31									





Technical Services Department
Project: NH 0641-073
S.A. 16522
Location: SH 34 Bypass

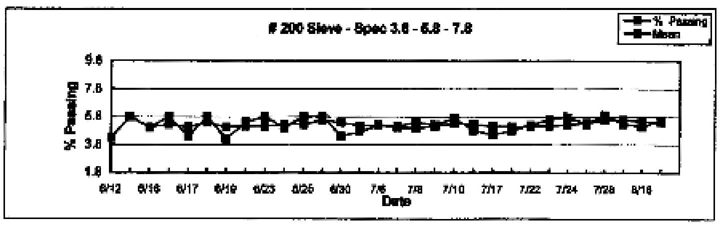
CDOT Mix Design # : 170947
Agg Ind Mix Design # : 64 (Greeley plant)
Grading: SX (100) , PG 64-28 (SGLP / Suncor)

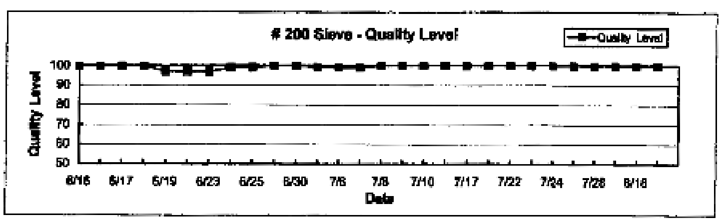
T upper = 7.8
T lower = 3.8

3/6/2012

200 Sieve

Test Number	Date	% Passing	Quality Level	Mean	s	Q upper	Q lower	P upper	P lower
1	6/12	4.3							
2	6/15	5.8							
3	6/16	5.0	100	5.03	0.75	3.69	1.64	100	100
4	6/16	5.8	100	5.23	0.72	3.58	1.97	100	100
5	6/17	4.4	100	5.06	0.73	3.77	1.73	100	100
6	6/18	5.8	100	5.36	0.64	3.62	2.44	100	100
7	6/19	4.2	97	5.04	0.76	3.66	1.65	100	97
8	6/22	5.4	97	5.12	0.77	3.48	1.72	100	97
9	6/23	5.8	97	5.12	0.77	3.48	1.72	100	97
10	6/24	5.0	99	5.24	0.67	3.82	2.15	100	99
11	6/25	5.8	99	5.24	0.67	3.82	2.15	100	99
12	6/26	5.8	100	5.56	0.36	6.26	4.82	100	100
13	6/30	4.4	100	5.36	0.64	3.82	2.44	100	100
14	7/1	4.7	99	5.14	0.64	4.16	2.10	100	99
15	7/6	5.2	99	5.18	0.63	4.13	2.16	100	99
16	7/7	5.1	99	5.04	0.53	5.19	2.33	100	99
17	7/8	5.4	100	4.98	0.40	7.03	2.87	100	100
18	7/9	5.2	100	5.12	0.26	10.35	5.10	100	100
19	7/10	5.7	100	5.32	0.24	10.39	6.37	100	100
20	7/16	4.8	100	5.24	0.34	7.62	4.28	100	100
21	7/17	4.5	100	5.12	0.43	6.30	3.09	100	100
22	7/20	4.8	100	5.07	0.41	6.70	3.12	100	100
23	7/22	5.2	100	5.09	0.38	7.16	3.39	100	100
24	7/23	5.6	100	5.14	0.39	6.74	3.41	100	100
25	7/24	5.8	100	5.21	0.43	6.09	3.31	100	100
26	7/27	5.3	100	5.34	0.38	6.39	4.00	100	100
27	7/28	5.9	100	5.56	0.30	7.35	5.77	100	100
28	8/17	5.3	100	5.58	0.28	8.00	6.41	100	100
29	8/18	5.1	100	5.48	0.35	6.64	4.81	100	100
30	8/19	5.5	100	5.42	0.30	7.85	5.34	100	100
31									





845 Navajo Street
Denver, CO 80204
303.975.9959, Fax: 303.975.9969

PRODUCTION SAMPLE TEST REPORT

HOT MIX ASPHALT

REPORT DATE: August 7, 2009
MIX DESIGN NO.: 251809
GYRATIONS, INITIAL - DESIGN: 8 - 100
DATE SAMPLED: August 3, 2009
DATE RECEIVED: August 3, 2009
DATE TESTED: August 4, 2009
SAMPLED BY: Client
SAMPLE LOCATION: Delivered

PROJECT: US 34 Bypass Crumb Rubber
WesTest PROJECT NO.: 258809
CLIENT: Aggregate Industries
John Cheever
1705 S. Acoma Street
Denver, CO 80223

MATERIAL DESCRIPTION: SX (100) PG 64-28 TB
SAMPLE NO.: 1

AGGREGATE PROPERTIES (CP - 31A & 31B)

Sieve Size	Sample Percent Passing	Job Mix Formula	CDOT Grading Specification	Production Gradation Tolerance
1 - 1/2"				
1"				
3/4"				
1/2"				
3/8"				
#4				
#8				
#16				
#30				
#50				
#100				
#200				

MIX PROPERTIES

Test Procedure		Production Sample Results	Mix Design Tolerance / Target
ASPHALT CEMENT CONTENT (%)			
	Nuclear Method (CP 85)	5.16*	5.3 - 5.9
	Ignition Method (CP-L 5120)**	5.38	
THEORETICAL MAXIMUM SPECIFIC GRAVITY (CP 51)		2.457	2.439
THEORETICAL MAXIMUM DENSITY (PCF)		152.9	151.8
VOIDS IN TOTAL MIX (%) (CP-L 5115)			
	$N_{INITIAL}$ GYRATIONS (INFORMATION ONLY)	11.1	
	N_{DESIGN} GYRATIONS	4.6	2.7 - 5.1
TEST DATA @ N_{DESIGN} GYRATIONS			
	BULK SPECIFIC GRAVITY (CP 44)	2.344	2.344
	VOIDS IN MINERAL AGGREGATE (%) (CP 48)	14.5	13.7 - 16.1
	VOIDS FILLED WITH ASPHALT (%)	68.3	73.8
	HVEEM STABILITY (CP-L 5106)	47	30 Min.
	COMPACTION TEMPERATURE (°F)	300	300

LOTTMAN MOISTURE SENSITIVITY TEST RESULTS (CP-L 5109, Method B)

AVERAGE SPECIMEN VOID CONTENT (%)	7.5	6.0 - 8.0
AVERAGE SATURATION (%)	86	
AVERAGE DRY TENSILE STRENGTH (PSI)	80	30 Min.
AVERAGE CONDITIONED TENSILE STRENGTH (PSI)	63	
TENSILE STRENGTH RATIO (%)	79	70 Min.

* Denotes deviation from specification.
** Uncorrected ignition burn

REVIEWED BY:

PRODUCTION SAMPLE TEST REPORT

HOT MIX ASPHALT

WesTest
SPECIALISTS TO THE PAVING INDUSTRY
845 Navajo Street
Denver, CO 80204
303.975.9959, Fax: 303.975.9969

REPORT DATE: August 7, 2009
MIX DESIGN NO.: 251809
GYRATIONS, INITIAL - DESIGN: 8 - 100
DATE SAMPLED: August 4, 2009
DATE RECEIVED: August 5, 2009
DATE TESTED: August 5-6, 2009
SAMPLED BY: Client
SAMPLE LOCATION: Delivered

PROJECT: US 34 Bypass Crumb Rubber
WesTest PROJECT NO.: 258809
CLIENT: Aggregate Industries
John Cheever
1705 S. Acoma Street
Denver, CO 80223

MATERIAL DESCRIPTION: SX (100) PG 64-28 TB
SAMPLE NO.: 3

AGGREGATE PROPERTIES (CP - 31A & 31B)

Sieve Size	Sample Percent Passing	Job Mix Formula	CDOT Grading Specification	Production Gradation Tolerance
1 - 1/2"				
1"				
3/4"				
1/2"				
3/8"				
#4				
#8				
#16				
#30				
#50				
#100				
#200				

MIX PROPERTIES

Test Procedure		Production Sample Results	Mix Design Tolerance / Target
ASPHALT CEMENT CONTENT (%)			
	Nuclear Method (CP 85)	5.19*	5.3 - 5.9
THEORETICAL MAXIMUM SPECIFIC GRAVITY (CP 51)		2.441	2.439
THEORETICAL MAXIMUM DENSITY (PCF)		151.9	151.8
VOIDS IN TOTAL MIX (%) (CP-L 5115)			
	$N_{INITIAL}$ GYRATIONS (INFORMATION ONLY)	10.9	
	N_{DESIGN} GYRATIONS	4.2	2.7 - 5.1
TEST DATA @ N_{DESIGN} GYRATIONS			
	BULK SPECIFIC GRAVITY (CP 44)	2.339	2.344
	VOIDS IN MINERAL AGGREGATE (%) (CP 48)	14.7	13.7 - 16.1
	VOIDS FILLED WITH ASPHALT (%)	71.6	73.8
	HVEEM STABILITY (CP-L 5106)		
	COMPACTION TEMPERATURE (°F)	300	300

LOTTMAN MOISTURE SENSITIVITY TEST RESULTS (CP-L 5109, Method B)

AVERAGE SPECIMEN VOID CONTENT (%)		
AVERAGE SATURATION (%)		
AVERAGE DRY TENSILE STRENGTH (PSI)		
AVERAGE CONDITIONED TENSILE STRENGTH (PSI)		
TENSILE STRENGTH RATIO (%)		

* Denotes deviation from specification.

REVIEWED BY:

PRODUCTION SAMPLE TEST REPORT

HOT MIX ASPHALT

845 Navajo Street
Denver, CO 80204
303.975.9959, Fax: 303.975.9969

REPORT DATE: August 19,2009
MIX DESIGN NO.: 251909
GYRATIONS, INITIAL - DESIGN: 8 - 100
DATE SAMPLED: August 10, 2009
DATE RECEIVED: August 12, 2009
DATE TESTED: August 13, 2009
SAMPLED BY: Client
SAMPLE LOCATION: Delivered

PROJECT: US 34 Bypass Crumb Rubber
WesTest PROJECT NO.: 256609
CLIENT: Aggregate Industries
John Cheever
1705 S. Acoma Street
Denver, CO 80223

MATERIAL DESCRIPTION: SX (100) PG 64-28 WP
SAMPLE NO.: 1-WP

AGGREGATE PROPERTIES (CP - 31A & 31B)

Sieve Size	Sample Percent Passing	Job Mix Formula	CDOT Grading Specification	Production Gradation Tolerance
1 - 1/2"				
1"				
3/4"				
1/2"				
3/8"				
#4				
#8				
#16				
#30				
#50				
#100				
#200				

MIX PROPERTIES

Test Procedure		Production Sample Results	Mix Design Tolerance / Target
ASPHALT CEMENT CONTENT (%)			
	Nuclear Method (CP 85)	5.91	5.8 - 6.4
THEORETICAL MAXIMUM SPECIFIC GRAVITY (CP 51)		2.421	2.417
THEORETICAL MAXIMUM DENSITY (PCF)		150.7	150.4
VOIDS IN TOTAL MIX (%) (CP-L 5115)			
	$N_{INITIAL}$ GYRATIONS (INFORMATION ONLY)	10.9	
	N_{DESIGN} GYRATIONS	4.4	3.1 - 5.5
TEST DATA @ N_{DESIGN} GYRATIONS			
	BULK SPECIFIC GRAVITY (CP 44)	2.314	2.313
	VOIDS IN MINERAL AGGREGATE (%) (CP 48)	16.3	15.3 - 17.7
	VOIDS FILLED WITH ASPHALT (%)	72.8	73.9
	HVEEM STABILITY (CP-L 5106)	37	30 min.
	COMPACTION TEMPERATURE (°F)	300	300
LOTTMAN MOISTURE SENSITIVITY TEST RESULTS (CP-L 5109, Method B)			
AVERAGE SPECIMEN VOID CONTENT (%)		6.9	6.0 - 8.0
AVERAGE SATURATION (%)		86	
AVERAGE DRY TENSILE STRENGTH (PSI)		86	30 min.
AVERAGE CONDITIONED TENSILE STRENGTH (PSI)		84	
TENSILE STRENGTH RATIO (%)		98	70 min.

* Denotes deviation from specification.

REVIEWED BY:

WesTest

845 Navajo Street
Denver, CO 80204
303.975.9959, Fax: 303.975.9969

PRODUCTION SAMPLE TEST REPORT

HOT MIX ASPHALT

REPORT DATE: August 17, 2009
MIX DESIGN NO.: 251909
GYRATIONS, INITIAL - DESIGN: 8 - 100
DATE SAMPLED: August 11, 2009
DATE RECEIVED: August 12, 2009
DATE TESTED: August 14, 2009
SAMPLED BY: Client
SAMPLE LOCATION: Sta. 61+ 50, 221.47 tons

PROJECT: US 34 Bypass Crumb Rubber
WesTest PROJECT NO.: 258809
CLIENT: Aggregate Industries
John Cheever
1705 S. Acoma Street
Denver, CO 80223

MATERIAL DESCRIPTION: SX (100) PG 64-28 WP
SAMPLE NO.: 3-WP

AGGREGATE PROPERTIES (CP - 31A & 31B)

Sieve Size	Sample Percent Passing	Job Mix Formula	CDOT Grading Specification	Production Gradation Tolerance
1 - 1/2"				
1"				
3/4"				
1/2"				
3/8"				
#4				
#8				
#16				
#30				
#50				
#100				
#200				

MIX PROPERTIES

Test Procedure		Production Sample Results	Mix Design Tolerance / Target
ASPHALT CEMENT CONTENT (%)			
	Nuclear Method (CP 85)	6.27	5.8 - 6.4
THEORETICAL MAXIMUM SPECIFIC GRAVITY (CP 51)		2.412	2.417
THEORETICAL MAXIMUM DENSITY (PCF)		150.1	150.4
VOIDS IN TOTAL MIX (%) (CP-L 5115)			
	$N_{INITIAL}$ GYRATIONS (INFORMATION ONLY)	11.2	
	N_{DESIGN} GYRATIONS	4.6	3.1 - 5.5
TEST DATA @ N_{DESIGN} GYRATIONS			
	BULK SPECIFIC GRAVITY (CP 44)	2.301	2.313
	VOIDS IN MINERAL AGGREGATE (%) (CP 48)	17.0	15.3 - 17.7
	VOIDS FILLED WITH ASPHALT (%)	73.0	73.9
	HVEEM STABILITY (CP-L 5106)		
	COMPACTION TEMPERATURE (°F)	300	300

LOTTMAN MOISTURE SENSITIVITY TEST RESULTS (CP-L 5109, Method B)

AVERAGE SPECIMEN VOID CONTENT (%)		
AVERAGE SATURATION (%)		
AVERAGE DRY TENSILE STRENGTH (PSI)		
AVERAGE CONDITIONED TENSILE STRENGTH (PSI)		
TENSILE STRENGTH RATIO (%)		

* Denotes deviation from specification.

REVIEWED BY:

NUCLEAR A.C. GAUGE CALIBRATION

PROJECT NO.: 258809
CLIENT: Aggregate Industries
PROJECT: US 34 - Bypass
MIX NO.: WT 251809, CDOT 180610TB
A.C. BRAND / GRADE: Wright PG 64-28 TB
OPTIMUM A.C.: 5.6
BASE WEIGHT: 7000 g
CALIBRATION NO.: 25881

DATE: 08/03/09
GAUGE NO.: 6

	A.C. CONTENT				
	4.60%		**5.60%**		**6.60%**
10% 3/4" Rock - 35th Ave.	672.6		665.5		658.5
17% 1/2" Rock - 35th Ave.	1143.4		1131.4		1119.4
35% Crusher Fines - Distel	2354.0		2329.3		2304.6
22% Class 7 - 83rd Ave.	1479.7		1464.1		1448.6
15% Concrete Sand - 83rd Ave.	1008.9		998.3		987.7
1% Lime - Pete Lien	67.3		66.6		65.8
100% TOTAL AGG. WT.	6725.7		6655.2		6584.7
A.C.	324.3		394.8		465.3
TOTAL MIX WT	7050.0		7050.0		7050.0
GAUGE COUNT					
DEVIATION					

CORRELATION FACTOR

A1: ______

A2: ______

A3: ______

COMMENTS:

\\Motherwestest\Aggregate Industries\2009\258809 - US 34 Bypass Crumb Rubber\25881 Nuc AC Calibration

NUCLEAR A.C. GAUGE CALIBRATION

PROJECT NO.: 258809 **DATE:** 08/03/09
CLIENT: Aggregate Industries **GAUGE NO.:** 6
PROJECT: US 34 - Bypass
MIX NO.: WT 251909, CDOT 180610WP
A.C. BRAND / GRADE: Ecopath PG 64-28 WP
OPTIMUM A.C.: 6.1
BASE WEIGHT: 7000 g
CALIBRATION NO.: 25882

	A.C. CONTENT		
	5.10%	**6.10%**	**7.10%**
10% **3/4" Rock - 35th Ave.**	669.0	662.0	654.9
17% **1/2" Rock - 35th Ave.**	1137.4	1125.4	1113.4
35% **Crusher Fines - Distel**	2341.7	2317.0	2292.3
22% **Class 7 - 83rd Ave.**	1471.9	1456.4	1440.9
15% **Concrete Sand - 83rd Ave.**	1003.6	993.0	982.4
1% **Lime - Pete Lien**	66.9	66.2	65.5
100% **TOTAL AGG. WT.**	6690.5	6620.0	6549.5
A.C.	359.6	430.1	500.6
TOTAL MIX WT	7050.0	7050.0	7050.0
GAUGE COUNT			
DEVIATION			

CORRELATION FACTOR
A1: ______
A2: ______
A3: ______

COMMENTS:

\\Mother\westest\Aggregate Industries\2009\258809 - US 34 Bypass Crumb Rubber\25882 Nuc AC Calibration

Crumb Rubber Control Site -- Passing Lane

6/4/2009

Equivalent Water Permeability Calculations Using ROMUS Air Permeameter Data

Viscosity of air	1.84E-05	kg/m*s	
Atmospheric Pressure	101353	Pa	
Volume of air Chamber	0.02186	m^3	0.02186
Density of water	1000	kg/m^3	
Viscosity of water	0.001	kg/m*s	

Test Sample	NMAS	Voids	Gradation	$L^{(1)}$ (m)	A (m^2)	t_1 (sec)	t_2 (sec)	t_3 (sec)	t_4 (sec)	k_{w1} (10^{-5}cm/s)	k_{w2} (10^{-5}cm/s)	k_{w3} (10^{-5}cm/s)	k_{w4} (10^{-5}cm/s)	k_{avg} (10^{-5}cm/s)	$k_{overall}$ (10^{-5}cm/s)
STA 61+60	SX			0.025	0.01824	0.714	0.839	1.038	1.442	138	144	150	152	146	147
STA 61+60	SX			0.025	0.01824	0.762	0.893	1.103	1.877	129	136	141	131	134	134
STA 61+60	SX			0.025	0.01824	0.794	0.939	1.169	1.927	124	129	133	114	126	123
STA 51+60	SX			0.025	0.01824	0.797	0.949	1.179	1.905	124	127	132	115	125	123
STA 61+10	SX			0.025	0.01824	0.65	0.756	0.85	1.671	152	160	164	131	152	146
STA 61+10	SX			0.025	0.01824	0.666	0.776	0.969	1.616	148	156	161	136	150	148
STA 61+10	SX			0.025	0.01824	0.663	0.779	0.967	1.619	149	155	161	136	150	148
STA 61+30	SX			0.025	0.01824	0.644	0.747	0.928	1.315	153	162	168	167	162	164
STA 61+30	SX			0.025	0.01824	0.667	0.777	0.962	1.627	148	155	162	135	150	147
STA 61+30	SX			0.025	0.01824	0.654	0.758	0.94	1.281	151	159	166	171	162	164
STA 61+30	SX			0.025	0.01824	0.656	0.773	0.961	1.642	150	156	162	134	151	147
STA 61+30	SX			0.025	0.01824	0.661	0.778	0.952	1.649	149	155	164	133	150	147
STA 61+30	SX			0.025	0.01824	0.674	0.776	0.968	1.613	146	155	161	138	150	147

(1) Thickness of specimen or layer

Crumb Rubber: Terminal Blend

7/20/2009

Equivalent Water Permeability Calculations Using ROMUS Air Permeameter Data

Viscosity of air	1.84E-05 kg/m*s	
Atmospheric Pressure	101353 Pa	
Volume of air Chamber	0.02186 m^3	0.02186
Density of water	1000 kg/m^3	
Viscosity of water	0.001 kg/m*s	

Test Sample	NMAS	Voids	Gradation	$L^{(1)}$ (m)	A (m^2)	t_1 (sec)	t_2 (sec)	t_3 (sec)	t_4 (sec)	k_{w1} (10^{-5}cm/s)	k_{w2} (10^{-5}cm/s)	k_{w3} (10^{-5}cm/s)	k_{w4} (10^{-5}cm/s)	k_{avg} (10^{-5}cm/s)	$k_{overall}$ (10^{-5}cm/s)
STA 129+70	SX			0.025	0.01824	1.001	1.190	1.498	2.356	99	101	104	93	99	99
STA 129+70	SX			0.025	0.01824	1.02	1.22	1.53	2.277	97	99	102	96	98	98
STA 129+70	SX			0.025	0.01824	1.034	1.23	1.539	2.245	95	98	101	98	98	98
STA 130+00	SX			0.025	0.01824	2.516	3.09	4.025	5.66	39	39	39	39	39	39
STA 130+00	SX			0.025	0.01824	2.626	3.267	4.196	6.022	38	37	37	36	37	37
STA 130+00	SX			0.025	0.01824	2.653	3.276	4.253	5.828	37	37	37	37	37	37
STA 130+45	SX			0.025	0.01824	1.391	1.669	2.094	2.911	71	72	74	75	73	74
STA 130+45	SX			0.025	0.01824	1.426	1.731	2.189	3.138	69	70	72	70	70	70
STA 130+45	SX			0.025	0.01824	1.463	1.754	2.221	3.427	67	69	70	64	68	67
STA 130+45	SX			0.025	0.01824	1.489	1.789	2.271	3.319	66	66	69	66	67	67

(1) Thickness of specimen or layer

Crumb Rubber: Terminal Blend

7/20/2009

Equivalent Water Permeability Calculations Using ROMU SAir Permeameter Data

Viscosity of air	1.84E-05	kg/m*s	
Atmospheric Pressure	101353	Pa	
Volume of air Chamber	0.02186	m^3	0.02186
Density of water	1000	kg/m^3	
Viscosity of water	0.001	kg/m*s	

Test Sample	NMAS	Voids	Gradation	$L^{(1)}$ (m)	A (m^2)	t_1 (sec)	t_2 (sec)	t_3 (sec)	t_4 (sec)	k_{w1} (10^{-5}cm/s)	k_{w2} (10^{-5}cm/s)	k_{w3} (10^{-5}cm/s)	k_{w4} (10^{-5}cm/s)	k_{avg} (10^{-5}cm/s)	$k_{overall}$ (10^{-5}cm/s)
STA 129+70	SX			0.025	0.01824	1.001	1.190	1.498	2.356	99	101	104	93	99	99
STA 129+70	SX			0.025	0.01824	1.02	1.22	1.53	2.277	97	99	102	96	98	98
STA 129+70	SX			0.025	0.01824	1.034	1.23	1.539	2.245	95	98	101	98	98	98
STA 130+00	SX			0.025	0.01824	2.516	3.09	4.025	5.66	39	39	39	39	39	39
STA 130+00	SX			0.025	0.01824	2.626	3.257	4.196	6.022	38	37	37	36	37	37
STA 130+00	SX			0.025	0.01824	2.653	3.276	4.253	5.928	37	37	37	37	37	37
STA 130+45	SX			0.025	0.01824	1.391	1.669	2.094	2.911	71	72	74	75	73	74
STA 130+45	SX			0.025	0.01824	1.426	1.731	2.189	3.138	69	70	72	70	70	70
STA 130+45	SX			0.025	0.01824	1.463	1.754	2.221	3.427	67	69	70	64	68	67
STA 130+45	SX			0.025	0.01824	1.489	1.789	2.271	3.319	66	66	69	66	67	67

(1) Thickness of specimen or layer

Crumb Rubber Control Site -- Driving Lane

7/20/2009

Equivalent Water Permeability Calculations Using ROMU SAir Permeameter Data

Viscosity of air	1.84E-05	kg/m*s	
Atmospheric Pressure	101353	Pa	
Volume of air Chamber	0.02186	m^3	0.02186
Density of water	1000	kg/m^3	
Viscosity of water	0.001	kg/m*s	

Test Sample	NMAS	Voids	Gradation	$L^{(1)}$ (m)	A (m^2)	t_1 (sec)	t_2 (sec)	t_3 (sec)	t_4 (sec)	K_{w1} (10^{-5} cm/s)	K_{w2} (10^{-5} cm/s)	K_{w3} (10^{-5} cm/s)	K_{w4} (10^{-5} cm/s)	K_{ave} (10^{-5} cm/s)	$K_{overall}$ (10^{-5} cm/s)
STA 20+30	SX			0.025	0.01824	0.590	0.675	0.820	1.139	187	179	190	193	182	184
STA 20+30	SX			0.025	0.01824	0.607	0.696	0.847	1.469	163	174	184	149	167	164
STA 20+30	SX			0.025	0.01824	0.616	0.712	0.862	1.43	180	170	181	153	166	164
STA 20+30	SX			0.025	0.01824	0.626	0.72	0.879	1.397	158	168	177	157	166	164
STA 20+40	SX			0.025	0.01824	0.498	0.569	0.679	1.091	199	216	229	201	211	210
STA 20+40	SX			0.025	0.01824	0.504	0.569	0.686	1.068	196	212	226	206	210	210
STA 20+40	SX			0.025	0.01824	0.514	0.578	0.704	1.031	192	209	221	213	209	210
STA 20+40	SX			0.025	0.01824	0.517	0.588	0.711	1.011	191	206	219	217	208	210
STA 20+30	SX			0.025	0.01824	0.48	0.542	0.659	1.147	206	223	236	191	214	210
STA 20+30	SX			0.025	0.01824	0.492	0.552	0.675	1.11	201	219	231	198	212	210
STA 20-30	SX			0.025	0.01824	0.502	0.562	0.69	1.076	197	215	226	204	210	210
STA 20−30	SX			0.025	0.01824	0.507	0.574	0.699	1.051	195	210	223	209	209	210

(1) Thickness of specimen or layer

Crumb Rubber Control Site – Passing Lane 7/17/2009

Equivalent Water Permeability Calculations Using ROMUS Air Permeameter Data

Viscosity of air	1.84E-05	kg/m*s	
Atmospheric Pressure	101353	Pa	
Volume of air Chamber	0.02186	m^3	0.02186
Density of water	1000	kg/m^3	
Viscosity of water	0.001	kg/m*s	

Test Sample	NMAS	Voids	Gradation	$L^{(1)}$ (m)	A (m^2)	t_1 (sec)	t_2 (sec)	t_3 (sec)	t_4 (sec)	k_{w1} (10^{-4}cm/s)	k_{w2} (10^{-4}cm/s)	k_{w3} (10^{-4}cm/s)	k_{w4} (10^{-4}cm/s)	k_{2-4} (10^{-4}cm/s)	$k_{overall}$ (10^{-4}cm/s)
STA 25+00	SX			0.025	0.01824	2.407	2.842	3.614	4.496	41	42	44	49	44	45
STA 25+00	SX			0.025	0.01824	2.464	2.941	3.639	5.014	40	41	43	44	42	42
STA 25+00	SX			0.025	0.01824	2.51	2.998	3.698	4.864	39	40	42	45	42	42
STA 25+00	SX			0.025	0.01824	2.549	3.049	3.731	5.129	39	40	42	43	41	41
STA 25+00	SX			0.025	0.01824	2.526	3.015	3.685	4.845	39	40	42	45	42	42
STA 24+80	SX			0.025	0.01824	2.345	2.79	3.415	4.718	42	43	46	47	44	45
STA 24+80	SX			0.025	0.01824	2.386	2.834	3.422	4.623	41	43	46	47	44	45
STA 24+80	SX			0.025	0.01824	2.38	2.833	3.446	4.609	41	43	45	48	44	45
STA 24+80	SX			0.025	0.01824	2.4	2.867	3.492	4.511	41	42	45	49	44	45
STA 24+70	SX			0.025	0.01824	4.657	5.442	6.666	8.581	21	22	23	26	23	23
STA 24+70	SX			0.025	0.01824	4.525	5.249	6.612	8.458	22	23	24	26	24	24
STA 24+70	SX			0.025	0.01824	4.489	5.241	6.532	8.7	22	23	24	25	24	24
STA 24+70	SX			0.025	0.01824	4.328	5.124	6.31	7.973	23	24	25	26	25	25

(1) Thickness of specimen or layer

ECOPATH®

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480 9910314

Rubber Plant Daily Report

Operator: Gary Kritner Day #: 3 + 4
Sheet #: 2 Date: 8/11/2009 + 8/12
Plant Location: Agg Industries Greeley Co.
Customer Name: Agg Industries
Project Location: Bypass 34
Project Number: ABO9135

Blend Data

Blend	Start Time	Stop Time	AC Temp	Tons AC	Tons Rubber	Tons Blend	% Rubber	Visc at ~~350~~ 275 °F
5	7:00	7:25	290°	5.86	.64	6.5	9.8%	1400
				4.11	.39	4.5	8.69%	
				9.97	1.03	11.0		

Virgin Asphalt

	Type (PG)	BOL	Qty (Tns)
1	58-28	???	9.97
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Total delivered today	9.97
Total delivered previous	55.73
Total delivered to date	65.70
Total used today	9.97
Total used previous	55.73
Total used to date	65.70
Balance	0

Crumb Rubber

	BOL	Qty (lbs)	# Bags
1			
2			
3			
4			
5			
6			
Total delivered today		0	0
Total delivered previous		38379	17
Total delivered to date		38 379	17
Total used today		2060	0
Total used previous		11040	6
Total used to date		13100	6
Balance		25 279	11

Asphalt Rubber Binder

	Qty (Tns)	# Bags
Total delivered today	11.00	
Total delivered previous	61.25	
Total delivered to date	72.25	
Total used today	57.64	
Total used previous	14.61	
Total used to date	72.25	
Balance	0	

Tanks

		Tank 1	Tank 2	Tank 3
VI	Inches		93."	
	Volume		11897.5	
	Density		7.84	
	Total Tons		46.64	
VI	Inches			
	Volume			
	Density		Empty	
	Total Tons			

Fuel

	Qty (Gal)
Total delivered today	0
Total delivered previous	300.0
Total delivered to date	300.0

Quantity of asphalt rubber binder ordered: 56. T Signature, Job title, & date: ____

Additional quantity: ____ Signature, Job title, & date: ____

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Rubber Plant Daily Report

Operator: Gary Kriner Day #: 1 + #2
Sheet #: 1 Date: 8/9 + 10/2009
Plant Location: Agg Industries Greeley Co
Customer Name: Agg Industries /
Project Location: Bypass 34
Project Number: AB09135

Blend Data

Blend	Start Time	Stop Time	AC Temp	Tons AC	Tons Rubber	Tons Blend	% Rubber	Visc at ~~350~~ 275 °F	
1	11:30	2:30	323°	28.20	2.78	30.98	8.97%	1500	8/10
2	10:00	11:45	305°	27.53	2.74	30.27	9.05%	1400	8/11
				55.73	5.52	61.25			

[illegible]

	Type (PG)	BOL	Qty (Tns)
1	58-28	0743404	28.20
2	58-28	0743444	27.57
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Total delivered today	55.73
Total delivered previous	-0-
Total delivered to date	55.73
Total used today	55.73
Total used previous	-0-
Total used to date	55.73
Balance	-0-

Crumb Rubber

	BOL	Qty (lbs)	# Bags
1	AE7066 Lot 3330	38 379	17
2			
3			
4			
5			
6			
Total delivered today		38379	17
Total delivered previous		-0-	-0-
Total delivered to date		38379	17
Total used today		11040	6
Total used previous		-0-	-0-
Total used to date		11040	6
Balance		27339	11

Asphalt Rubber Blend

	Qty (Tns)	# Bags
Total delivered today	61.25	
Total delivered previous	-0-	
Total delivered to date	61.25	
Total used today	14.61	
Total used previous	-0-	
Total used to date	14.61	
Balance	46.64	

		Tank 1	Tank 2	~~Tank 3~~
.M	Inches			
	Volume			
	Density			
	Total Tons			
M	Inches		93"	
	Volume		11897.5	
	Density		7.84	
	Total Tons		46.64	

[illegible]

	Qty (Gal)
Total delivered today	300.0
Total delivered previous	——
Total delivered to date	300.0

Quantity of asphalt rubber ordered: ____________ Signature, Job title, & date: ____________

Additional quantity: ____________ Signature, Job title, & date: ____________

Colorado Department of Transportation

PROJECT PRODUCED HOT MIX ASPHALT

Sample No: 1
Field Sheet No: 14979
Date Received: 8/10/2009 13:36:00
Sample Desc: 1st 10K / IAT, FS# 14979
Remarks: Final Report

Project No: NH0341-073
Location: US34-BYPASS RESURFACING 71
SubAcct. No: 16522
Mix Design: New
Region: 04
Tested By: R4 Lab

SuperPave Item 403

Form 43 Date: 7/28/2009
Form 43 No: 180610WP
Grading: SX
N(des): 100

Refinery: ECOPATH
Binder: PG 64-28WP
Contractor: Aggregate Industries
Pit: 35th Ave (LaFarge), Distel, 83rd

Voids Properties

Excluded Specimen No: 0

	Specimen:	Status	Specifications
% AC:	6.37	Pass	6.10 +/- 0.3
Max Sp. Gr.:	2.415	Inside Band	2.417 +/- 0.01

	Specimen 1:	Specimen 2:	Specimen 3:	Average	Status	Specifications
Bulk SG:	2.299	2.288	2.288	2.292		
Ht. N (Design):	63.1	63.1	63.1	63.1		
Voids @ N(des):	4.9	5.3	5.3	5.1	Pass	3.90 +/ 1.2
VMA @ N(des):	17.2	17.6	17.6	17.5	Pass	15.3 - 17.7
VFA @ N(des):	72.1	70.1	70.1	70.8	Pass	65 - 75

Gradation Results

Testing: Voids Acceptance **Aggregate Correction:** No

	Job Mix		Test Results	
Sieve mm (in)	% Pass Min	% Pass Max	Status	% Pass
37.5 (1 1/2)			N/A	100
25.0 (1)			N/A	100
19.0 (3/4)	100.00		N/A	100
12.5 (1/2)	90.00	100.00	Pass	94
9.5 (3/8)	80.00	92.00	Pass	86
4.75 - #4	57.00	67.00	Pass	60
2.36 - #8	42.00	52.00	Pass	46
1.18 - #16			N/A	33
600 mic. - #30	18.00	26.00	Pass	21
300 mic. - #50			N/A	13
150 mic. - #100			N/A	9
75 mic. - #200	3.80	7.80	Pass	5.9

Aggregate Properties

N(des): 100 **Gradation By:** BC

	Test Result	Status	Job Mix
Angularity T 304:	44.1	Fail	45.0
Bulk SG of Aggregate:	2.6		
Bulk SG of Fine Aggregate:	2.596		

Stability Results

Excluded Specimen No: 0
Stability Compacted By: BC
Stabilometer Run By: BC

		Status
Specimen 1:	28	
Specimen 2:	28	
Specimen 3:	29	
Average:	28	Fail

Lottman Results

Lottman Compacted By: BC
Lottman Loads By: BC

	Average	Status	Job Mix
Wet Avg. T.S.:	76.4		
Dry Avg. T.S.:	83.6	Pass	30
% Voids:	5.7		
% Saturation:	95		
T.S. Retained:	91	Pass	70

Colorado Department of Transportation

PROJECT PRODUCED HOT MIX ASPHALT

Sample No:	2	**Project No:**	NH0341-073
Field Sheet No:	14980	**Location:**	US34-BYPASS RESURFACING 71
Date Received:	8/11/2009 09:51:00	**SubAcct. No:**	16522
Sample Desc:	Test #2, FS# 14980	**Mix Design:**	New
Remarks:	Final Report	**Region:**	04
		Tested By:	R4 Lab

SuperPave Item 403

Form 43 Date:	7/28/2009	**Refinery:**	ECOPATH
Form 43 No:	180610WP	**Binder:**	PG 64-28WP
Grading:	SX	**Contractor:**	Aggregate Industries
N(des):	100	**Pit:**	35th Ave (LaFarge), Distel, 83rd

Voids Properties

Excluded Specimen No: 0

	Specimen:	Status	Specifications
% AC:	6.31	Pass	6.10 +/- 0.3
Max Sp. Gr.:	2.413	Inside Band	2.417 +/- 0.01

	Specimen 1:	Specimen 2:	Specimen 3:	Average	Status	Specifications
Bulk SG:	2.296	2.294	2.296	2.295		
Ht. N (Design):	63.3	63.2	63.2	63.2		
Voids @ N(des):	4.9	4.9	4.9	4.9	Pass	3.90 +/- 1.2
VMA @ N(des):	17.3	17.3	17.3	17.3	Pass	15.3 - 17.7
VFA @ N(des):	71.9	71.6	71.9	71.8	Pass	65 - 75

Gradation Results

Testing: Voids Acceptance **Aggregate Correction:** No

	Job Mix		Test Results	
Sieve mm (in)	% Pass Min	% Pass Max	Status	% Pass
37.5 (1 1/2)			N/A	
25.0 (1)			N/A	100
19.0 (3/4)	100.00		N/A	100
12.5 (1/2)	90.00	100.00	Pass	95
9.5 (3/8)	80.00	92.00	Pass	87
4.75 - #4	57.00	67.00	Pass	66
2.36 - #8	42.00	52.00	Pass	52
1.18 - #16			N/A	37
600 mic. - #30	18.00	26.00	Pass	24
300 mic. - #50			N/A	16
150 mic. - #100			N/A	10
75 mic. - #200	3.80	7.80	Pass	6.7

Aggregate Properties

N(des): 100 **Gradation By:** BC

AC Method: AC Nuclear Gauge

	Test Result	Status	Job Mix
Angularity T 304:	44.4	Fail	45.0
Bulk SG of Aggregate:	2.6		
Bulk SG of Fine Aggregate:	2.596		

Stability Results

Excluded Specimen No: 0

Stability Compacted By: BC

Stabilometer Run By: BC

		Status
Specimen 1:	30	
Specimen 2:	31	
Specimen 3:	31	
Average:	31	Pass

Lottman Results

Lottman Compacted By:

Lottman Loads By:

	Average	Status	Job Mix
Wet Avg. T.S.:			
Dry Avg. T.S.:		N/A	30
% Voids:	0.0		
% Saturation:			
T.S. Retained:	0	N/A	70

Colorado Department of Transportation

PROJECT PRODUCED HOT MIX ASPHALT

Sample No: 3
Field Sheet No: 14981
Date Received: 8/11/2009 10:43:00
Sample Desc: Test #3, FB# 14981
Remarks: Final Report

Project No: NH0341-073
Location: US34-BYPASS RESURFACING 71
SubAcct. No: 16522
Mix Design: New
Region: 04
Tested By: R4 Lab

SuperPave Item 403

Form 43 Date: 7/28/2009
Form 43 No: 180610WP
Grading: SX
N(des): 100

Refinery: ECOPATH
Binder: PG 64-28WP
Contractor: Aggregate Industries
Pit: 35th Ave (LaFarge), Distel, 83rd

Voids Properties

Excluded Specimen No: 0

	Specimen:	Status	Specifications
% AC:	6.25	Pass	6.10 +/- 0.3
Max Sp. Gr.:	2.412	Inside Band	2.417 +/- 0.01

	Specimen 1:	Specimen 2:	Specimen 3:	Average	Status	Specifications
Bulk SG:	2.329	2.328	2.331	2.329		
Ht. N (Design):	62.9	63.0	62.7	62.9		
Voids @ N(des):	3.5	3.5	3.4	3.4	Pass	3.90 +/- 1.2
VMA @ N(des):	16.0	16.1	16.0	16.0	Pass	15.3 - 17.7
VFA @ N(des):	78.4	78.3	78.9	78.5	Fail	65 - 75

Gradation Results

Testing: No Gradation Testing **Aggregate Correction:** No

	Job Mix		Test Results	
Sieve mm (in)	% Pass Min	% Pass Max	Status	% Pass
37.5 (1 1/2)			N/A	+
25.0 (1)			N/A	0
19.0 (3/4)	100.00		N/A	0
12.5 (1/2)	90.00	100.00	N/A	0
9.5 (3/8)	80.00	92.00	N/A	0
4.75 - #4	57.00	67.00	N/A	0
2.36 - #8	42.00	52.00	N/A	0
1.18 - #16			N/A	0
600 mic. - #30	18.00	26.00	N/A	0
300 mic. - #50			N/A	0
150 mic. - #100			N/A	0
75 mic. - #200	3.80	7.80	N/A	0.0

Aggregate Properties

N(des): 100 **Gradation By:** BC

AC Method: AC Nuclear Gauge

	Test Result	Status	Job Mix
Angularity T 304:	.0	N/A	45.0
Bulk SG of Aggregate:	2.6		
Bulk SG of Fine Aggregate:	2.596		

Stability Results

Excluded Specimen No: 0
Stability Compacted By: BC
Stabilometer Run By: BC

		Status
Specimen 1:	32	
Specimen 2:	32	
Specimen 3:	31	
Average:	32	Pass

Lottman Results

Lottman Compacted By:
Lottman Loads By:

	Average	Status	Job Mix
Wet Avg. T.S.:			
Dry Avg. T.S.:		N/A	30
% Voids:	0.0		
% Saturation:			
T.S. Retained:	0	N/A	70

CDOT Form #380 01/2007

Colorado Department of Transportation

PROJECT PRODUCED HOT MIX ASPHALT

Sample No:	3	**Project No:**	NH0341-073
Field Sheet No:	14981	**Location:**	US34 BYPASS RESURFACING 71
Date Received:	8/11/2009 10:43:00	**SubAcct. No:**	16522
Sample Desc:	Test #3, FS# 14981	**Mix Design:**	New
Remarks:	Final Report	**Region:**	04
		Tested By:	R4 Lab

SuperPave Item 403

Form 43 Date:	7/28/2009	**Refinery:**	ECOPATH
Form 43 No:	160610WP	**Binder:**	PG 64-28WP
Grading:	SX	**Contractor:**	Aggregate Industries
N(des):	100	**Pit:**	35th Ave (LaFarge), Distel, 83rd

Voids Properties

Excluded Specimen No: 0

	Specimen:	Status	Specifications
% AC:	6.25	Pass	6.10 +/- 0.3
Max Sp. Gr.:	2.412	Inside Band	2.417 +/- 0.01

	Specimen 1:	Specimen 2:	Specimen 3:	Average	Status	Specifications
Bulk SG:	2.329	2.328	2.331	2.329		
Ht. N (Design):	62.9	63.0	62.7	62.9		
Voids @ N(des):	3.5	3.5	3.4	3.4	Pass	3.90 +/- 1.2
VMA @ N(des):	16.0	16.1	16.0	16.0	Pass	15.3 - 17.7
VFA @ N(des):	78.4	78.3	78.9	78.5	Fail	65 - 75

Gradation Results

Testing: No Gradation Testing **Aggregate Correction:** No

	Job Mix		Test Results	
Sieve mm (in)	% Pass Min	% Pass Max	Status	% Pass
37.5 (1 1/2)			N/A	+
25.0 (1)			N/A	0
19.0 (3/4)	100.00		N/A	0
12.5 (1/2)	90.00	100.00	N/A	0
9.5 (3/8)	80.00	92.00	N/A	0
4.75 - #4	57.00	67.00	N/A	0
2.36 - #8	42.00	52.00	N/A	0
1.18 - #16			N/A	0
600 mic. - #30	18.00	26.00	N/A	0
300 mic. - #50			N/A	0
150 mic. - #100			N/A	0
75 mic. - #200	3.80	7.80	N/A	0.0

Aggregate Properties

N(des): 100 **Gradation By:** BC

AC Method: AC Nuclear Gauge

	Test Result	Status	Job Mix
Angularity T 304:	.0	N/A	45.0
Bulk SG of Aggregate:	2.6		
Bulk SG of Fine Aggregate:	2.598		

Stability Results

Excluded Specimen No: 0

Stability Compacted By: BC

Stabilometer Run By: BC

		Status
Specimen 1:	32	
Specimen 2:	32	
Specimen 3:	31	
Average:	32	Pass

Lottman Results

Lottman Compacted By:

Lottman Loads By:

	Average	Status	Job Mix
Wet Avg. T.S.:			
Dry Avg. T.S.:		N/A	30
% Voids:	0.0		
% Saturation:			
T.S. Retained:	0	N/A	70

CDOT Form #380 01/2007

Colorado Department of Transportation
PROJECT PRODUCED HOT MIX ASPHALT

Sample No: 136 HQ
Field Sheet No: 14979
Date Received: 8/11/2009 14:14:14
Sample Desc: 1st 10K, Lott, IAT, FS # 14979
Remarks: C.F applied

Project No: NH0341-073
Location: US34-BYPASS RESURFACING 71
SubAcct. No: 16522
Mix Design: New
Region: 04
Tested By: HQ Lab

SuperPave Item 403

Form 43 Date: 7/28/2009
Form 43 No: 180610WP
Grading: SX
N(des): 100

Refinery: ECOPATH
Binder: PG 64-28WP
Contractor: Aggregate Industries
Pit: 35th Ave (LaFarge). Distel, 63rd

Voids Properties

Excluded Specimen No: 0

	Specimen:	Status	Specifications
% AC:	6.42	Fail	6.10 +/- 0.3
Max Sp. Gr.:	2.427	Outside Band	2.417 +/- 0.01

	Specimen 1:	Specimen 2:	Specimen 3:	Average	Status	Specifications
Bulk SG:	2.295	2.306	2.300	2.301		
Ht. N (Design):	63.9	63.9	64.0	63.9		
Voids @ N(des):	5.5	4.9	5.2	5.2	Fail	3.90 +/- 1.2
VMA @ N(des):	17.4	16.9	17.2	17.2	Pass	15.3 - 17.7
VFA @ N(des):	68.7	71.0	69.5	69.7	Pass	65 - 75

Gradation Results

Testing: Voids Acceptance **Aggregate Correction:** No

Sieve mm (in)	Job Mix % Pass Min	Job Mix % Pass Max	Test Results Status	Test Results % Pass
37.5 (1 1/2)			N/A	
25.0 (1)			N/A	100
19.0 (3/4)	100.00		N/A	100
12.5 (1/2)	90.00	100.00	Pass	95
9.5 (3/8)	80.00	92.00	Pass	86
4.75 - #4	57.00	67.00	Pass	65
2.36 - #8	42.00	52.00	Pass	50
1.18 - #16			N/A	36
600 mic. - #30	18.00	26.00	Pass	23
300 mic. - #50			N/A	14
150 mic. - #100			N/A	9
75 mic. - #200	3.80	7.80	Pass	5.8

Aggregate Properties

N(des): 100 **Gradation By:** Lopez, Darcie L
AC Method: Pyrolysis Oven

	Test Result	Status	Job Mix
Angularity T 304:	.0	N/A	45.0
Bulk SG of Aggregate:	2.6		
Bulk SG of Fine Aggregate:	2.596		

Stability Results

Excluded Specimen No: 0
Stability Compacted By: Kinnes, Paul
Stabilometer Run By: Kinnes, Paul

		Status
Specimen 1:	31	
Specimen 2:	29	
Specimen 3:	29	
Average:	30	Pass

Lottman Results

Lottman Compacted By: Kinnes, Paul
Lottman Loads By: Kinnes, Paul

	Average	Status	Job Mix
Wet Avg. T.S.:	71.7		
Dry Avg. T.S.:	82.5	Pass	30
% Voids:	6.3		
% Saturation:	84		
T.S. Retained:	87	Pass	70

Colorado Department of Transportation

PROJECT PRODUCED HOT MIX ASPHALT

Sample No:	118 HQ	**Project No:**	NH0341-073
Field Sheet No:	14976	**Location:**	US34-BYPASS RESURFACING 71
Date Received:	8/3/2009 15:00:00	**SubAcct. No:**	16522
Sample Desc:	Info only / Research, FS# 14976	**Mix Design:**	New
Remarks:	C.F applied	**Region:**	04
		Tested By:	HQ Lab

SuperPave Item 403

Form 43 Date:	7/28/2009	**Refinery:**	WRIGHT
Form 43 No:	190610TB	**Binder:**	PG 64-28TB
Grading:	SX	**Contractor:**	Aggregate Industries
N(des):	100	**Pit:**	35th Ave (LaFarge), Distel, 83rd

Voids Properties

Excluded Specimen No: 0

	Specimen:	Status	Specifications
% AC:	5.58	Pass	5.60 +/- 0.3
Max Sp. Gr.:	2.454	Outside Band	2.439 +/- 0.01

	Specimen 1:	Specimen 2:	Specimen 3:	Average	Status	Specifications
Bulk SG:	2.353	2.357	2.359	2.357		
Ht. N (Design):	64.3	64.5	64.4	64.4		
Voids @ N(des):	4.1	3.9	3.9	4.0	Pass	3.90 +/- 1.2
VMA @ N(des):	14.5	14.4	14.3	14.4	Pass	13.7 - 15.1
VFA @ N(des):	71.8	72.6	73.0	72.5	Pass	65 - 75

Gradation Results

Testing: Voids Acceptance **Aggregate Correction:** No

	Job Mix		Test Results	
Sieve mm (in)	% Pass Min	% Pass Max	Status	% Pass
37.5 (1 1/2)			N/A	
25.0 (1)			N/A	100
19.0 (3/4)	100.00		N/A	100
12.5 (1/2)	90.00	100.00	Pass	98
9.5 (3/8)	80.00	92.00	Pass	90
4.75 - #4	57.00	67.00	Pass	65
2.36 - #8	42.00	52.00	Pass	50
1.18 - #16			N/A	37
600 mic. - #30	18.00	26.00	Pass	25
300 mic. - #50			N/A	16
150 mic. - #100			N/A	10
75 mic. - #200	3.80	7.80	Pass	6.6

Aggregate Properties

N(des): 100 **Gradation By:** Lam, Johnny

AC Method: Pyrolysis Oven

	Test Result	Status	Job Mix
Angularity T 304:	.0	N/A	45.0
Bulk SG of Aggregate:	2.6		
Bulk SG of Fine Aggregate:	2.596		

Stability Results

Excluded Specimen No: 0

Stability Compacted By: Lopez, Darcie L

Stabilometer Run By: Lam, Johnny

		Status
Specimen 1:	39	
Specimen 2:	40	
Specimen 3:	40	
Average:	39	Pass

Lottman Results

Lottman Compacted By: Lopez, Darcie L

Lottman Loads By: Lopez, Darcie L

	Average	Status	Job Mix
Wet Avg. T.S.:	63.6		
Dry Avg. T.S.:	73.2	Pass	30
% Voids:	7.3		
% Saturation:	90		
T.S. Retained:	87	Pass	70

Colorado Department of Transportation

PROJECT PRODUCED HOT MIX ASPHALT

Sample No: 118 HQ
Field Sheet No: 14976
Date Received: 8/3/2009 15:00:00
Sample Desc: Info only / Research, FS# 14976
Remarks: C.F applied

Project No: NH0341-073
Location: US34-BYPASS RESURFACING 71
SubAcct. No: 16522
Mix Design: New
Region: 04
Tested By: HQ Lab

SuperPave Item 403

Form 43 Date: 7/28/2009
Form 43 No: 190610TB
Grading: SX
N(des): 100

Refinery: WRIGHT
Binder: PG 64-28TB
Contractor: Aggregate Industries
Pit: 35th Ave (LaFarge), Distel, 83rd

Voids Properties

Excluded Specimen No: 0

	Specimen:	Status	Specifications
% AC:	5.58	Pass	5.60 +/- 0.3
Max Sp. Gr.:	2.454	Outside Band	2.439 +/- 0.01

	Specimen 1:	Specimen 2:	Specimen 3:	Average	Status	Specifications
Bulk SG:	2.353	2.357	2.359	2.357		
Ht. N (Design):	64.3	64.5	64.4	64.4		
Voids @ N(des):	4.1	3.9	3.9	4.0	Pass	3.90 +/- 1.2
VMA @ N(des):	14.5	14.4	14.3	14.4	Pass	13.7 - 15.1
VFA @ N(des):	71.8	72.6	73.0	72.5	Pass	65 - 75

Gradation Results

Testing: Voids Acceptance **Aggregate Correction:** No

	Job Mix		Test Results	
Sieve mm (in)	% Pass Min	% Pass Max	Status	% Pass
37.5 (1 1/2)			N/A	
25.0 (1)			N/A	100
19.0 (3/4)	100.00		N/A	100
12.5 (1/2)	90.00	100.00	Pass	98
9.5 (3/8)	80.00	92.00	Pass	90
4.75 - #4	57.00	67.00	Pass	65
2.36 - #8	42.00	52.00	Pass	50
1.18 - #16			N/A	37
600 mic. - #30	18.00	26.00	Pass	25
300 mic. - #50			N/A	16
150 mic. - #100			N/A	10
75 mic. - #200	3.80	7.80	Pass	5.6

Aggregate Properties

N(des): 100 **Gradation By:** Lam, Johnny

AC Method: Pyrolysis Oven

	Test Result	Status	Job Mix
Angularity T 304:	.0	N/A	45.0
Bulk SG of Aggregate:	2.6		
Bulk SG of Fine Aggregate:	2.596		

Stability Results

Excluded Specimen No: 0
Stability Compacted By: Lopez, Darcie L
Stabilometer Run By: Lam, Johnny

		Status
Specimen 1:	39	
Specimen 2:	40	
Specimen 3:	40	
Average:	39	Pass

Lottman Results

Lottman Compacted By: Lopez, Darcie L
Lottman Loads By: Lopez, Darcie L

	Average	Status	Job Mix
Wet Avg. T.S.:	63.6		
Dry Avg. T.S.:	73.2	Pass	30
% Voids:	7.3		
% Saturation:	90		
T.S. Retained:	87	Pass	70

Colorado Department of Transportation

PROJECT PRODUCED HOT MIX ASPHALT

Sample No: 126 HQ
Field Sheet No: 14977
Date Received: 8/6/2009 09:11:00
Sample Desc: IAT, FS# 14977
Remarks: C.F applied

Project No: NH0341-073
Location: US34-BYPASS RESURFACING 71
SubAcct. No: 16522
Mix Design: New
Region: 04
Tested By: HQ Lab

SuperPave Item 403

Form 43 Date: 7/28/2009
Form 43 No: 180610TB
Grading: SX
N(des): 100

Refinery: WRIGHT
Binder: PG 64-28TB
Contractor: Aggregate Industries
Pit: 35th Ave (LaFarge), Distel, 83rd

Voids Properties

Excluded Specimen No: 0

	Specimen:	Status	Specifications
% AC:	5.49	Pass	5.60 +/- 0.3
Max Sp. Gr.:	2.452	Inside Band	2.439 +/- 0.01

	Specimen 1:	Specimen 2:	Specimen 3:	Average	Status	Specifications
Bulk SG:	2.356	2.358	2.354	2.356		
Ht. N (Design):	64.1	64.2	64.4	64.2		
Voids @ N(des):	3.9	3.8	4.0	3.9	Pass	3.90 +/- 1.2
VMA @ N(des):	14.4	14.3	14.4	14.4	Pass	13.7 - 15.1
VFA @ N(des):	72.8	73.1	72.4	72.8	Pass	65 - 75

Gradation Results

Testing: Voids Acceptance **Aggregate Correction:** No

	Job Mix		Test Results	
Sieve mm (in)	% Pass Min	% Pass Max	Status	% Pass
37.5 (1 1/2)			N/A	
25.0 (1)			N/A	100
19.0 (3/4)	100.00		N/A	100
12.5 (1/2)	90.00	100.00	Pass	98
9.5 (3/8)	80.00	92.00	Pass	89
4.75 - #4	57.00	67.00	Pass	65
2.36 - #8	42.00	52.00	Pass	51
1.18 - #16			N/A	37
600 mic. - #30	18.00	26.00	Pass	25
300 mic. - #50			N/A	16
150 mic. - #100			N/A	10
75 mic. - #200	3.80	7.80	Pass	6.2

Aggregate Properties

N(des): 100 **Gradation By:** Lam, Johnny

AC Method: Pyrolysis Oven

	Test Result	Status	Job Mix
Angularity T 304:	.0	N/A	45.0
Bulk SG of Aggregate:	2.6		
Bulk SG of Fine Aggregate:	2.596		

Stability Results

Excluded Specimen No: 0
Stability Compacted By: Lopez, Darcie L
Stabilometer Run By: Kinnes, Paul

		Status
Specimen 1:	39	
Specimen 2:	40	
Specimen 3:	39	
Average:	39	Pass

Lottman Results

Lottman Compacted By: Lopez, Darcie L
Lottman Loads By: Lopez, Darcie L

	Average	Status	Job Mix
Wet Avg. T.S.:	78.6		
Dry Avg. T.S.:	88.7	Pass	30
% Voids:	7.1		
% Saturation:	90		
T.S. Retained:	89	Pass	70

Colorado Department of Transportation

PROJECT PRODUCED HOT MIX ASPHALT

Sample No: 3
Field Sheet No: 14978
Date Received: 8/4/2009 11:11:00
Sample Desc: Test #3, FS# 14978
Remarks: Final Report

Project No: NH0341-073
Location: US34-BYPASS RESURFACING 71
SubAcct. No: 16522
Mix Design: New
Region: 04
Tested By: R4 Lab

SuperPave Item 403

Form 43 Date: 7/28/2009
Form 43 No: 180610TB
Grading: SX
N(des): 100

Refinery: WRIGHT
Binder: PG 64-28TB
Contractor: Aggregate Industries
Pit: 35th Ave (LaFarge), Distel, 83rd

Voids Properties

Excluded Specimen No: 0

	Specimen:	Status	Specifications
% AC:	5.40	Pass	5.60 +/- 0.3
Max Sp. Gr.:	2.447	Inside Band	2.439 +/- 0.01

	Specimen 1:	Specimen 2:	Specimen 3:	Average	Status	Specifications
Bulk SG:	2.366	2.365	2.361	2.364		
Ht. N (Design):	63.8	63.8	64.0	63.9		
Voids @ N(des):	3.3	3.3	3.5	3.4	Pass	3.90 +/- 1.2
VMA @ N(des):	13.9	13.9	14.1	14.0	Pass	13.7 - 15.1
VFA @ N(des):	76.1	76.1	75.0	75.7	Fail	65 - 75

Gradation Results

Testing: Voids Acceptance **Aggregate Correction:** No

	Job Mix		Test Results	
Sieve mm (in)	% Pass Min	% Pass Max	Status	% Pass
37.5 (1 1/2)			N/A	
25.0 (1)			N/A	100
19.0 (3/4)	100.00		N/A	100
12.5 (1/2)	90.00	100.00	Pass	96
9.5 (3/8)	80.00	92.00	Pass	86
4.75 - #4	57.00	67.00	Pass	63
2.36 - #8	42.00	52.00	Pass	50
1.18 - #16			N/A	38
600 mic. - #30	18.00	26.00	Pass	24
300 mic. - #50			N/A	15
150 mic. - #100			N/A	10
75 mic. - #200	3.80	7.80	Pass	6.7

Aggregate Properties

N(des): 100 **Gradation By:** DKB

AC Method: AC Nuclear Gauge

	Test Result	Status	Job Mix
Angularity T 304:	44.0	Fail	45.0
Bulk SG of Aggregate:	2.6		
Bulk SG of Fine Aggregate:	2.596		

Stability Results

Excluded Specimen No: 0
Stability Compacted By: DKB
Stabilometer Run By: BC

		Status
Specimen 1:	43	
Specimen 2:	43	
Specimen 3:	43	
Average:	43	Pass

Lottman Results

Lottman Compacted By:
Lottman Loads By:

	Average	Status	Job Mix
Wet Avg. T.S.:			
Dry Avg. T.S.:		N/A	30
% Voids:	0.0		
% Saturation:			
T.S. Retained:	0	N/A	70

CDOT Form 4080 01/2007

Colorado Department of Transportation

PROJECT PRODUCED HOT MIX ASPHALT

Sample No: 2
Field Sheet No: 14977
Date Received: 8/4/2009 11:10:00
Sample Desc: Test #2, FS# 14977
Remarks: Final Report

Project No: NH0341-073
Location: US34-BYPASS RESURFACING 71
SubAcct. No: 16522
Mix Design: New
Region: 04
Tested By: R4 Lab

SuperPave Item 403

Form 43 Date: 7/28/2009
Form 43 No: 180610TB
Grading: SX
N(des): 100

Refinery: WRIGHT
Binder: PG 64-28TB
Contractor: Aggregate Industries
Pit: 35th Ave (LaFarge), Distel, 83rc

Voids Properties

Excluded Specimen No: 0

	Specimen:	Status	Specifications
% AC:	5.26	Fail	5.60 +/- 0.3
Max Sp. Gr.:	2.449	Inside Band	2.439 +/- 0.01

	Specimen 1:	Specimen 2:	Specimen 3:	Average	Status	Specifications
Bulk SG:	2.376	2.374	2.376	2.376		
Ht. N (Design):	63.5	63.6	63.5	63.5		
Voids @ N(des):	3.0	3.1	3.0	3.0	Pass	3.90 +/- 1.2
VMA @ N(des):	13.4	13.5	13.4	13.4	Fail	13.7 - 15.1
VFA @ N(des):	77.8	77.4	77.9	77.7	Fail	65 - 75

Gradation Results

Testing: Voids Acceptance **Aggregate Correction:** No

	Job Mix		Test Results	
Sieve mm (in)	% Pass Min	% Pass Max	Status	% Pass
37.5 (1 1/2)			N/A	
25.0 (1)			N/A	100
19.0 (3/4)	100.00		N/A	100
12.5 (1/2)	90.00	100.00	Pass	96
9.5 (3/8)	80.00	92.00	Pass	87
4.75 - #4	57.00	67.00	Pass	64
2.36 - #8	42.00	52.00	Pass	51
1.18 - #16			N/A	37
600 mic. - #30	16.00	26.00	Pass	25
300 mic. - #50			N/A	16
150 mic. - #100			N/A	10
75 mic. - #200	3.60	7.60	Pass	7.1

Aggregate Properties

N(des): 100 **Gradation By:** DKB

AC Method: AC Nuclear Gauge

	Test Result	Status	Job Mix
Angularity T 304:	44.0	Fail	45.0
Bulk SG of Aggregate:	2.6		
Bulk SG of Fine Aggregate:	2.596		

Stability Results

Excluded Specimen No: 0
Stability Compacted By: DKB
Stabilometer Run By: BC

		Status
Specimen 1:	42	
Specimen 2:	41	
Specimen 3:	43	
Average:	42	Pass

Lottman Results

Lottman Compacted By:
Lottman Loads By:

	Average	Status	Job Mix
Wet Avg. T.S.:			
Dry Avg. T.S.:		N/A	30
% Voids:	0.0		
% Saturation:			
T.S. Retained:	0	N/A	70

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Asphalt Cement Results and Final Quantity - PG 64-

Subaccount: **16522PG64-28**
Project: NH 0341-073
Location: US 34 Bypass Resurfacing 71st - 8th Ave.
Region: 4
Grade: PG64-28
Refinery: SUNCOR, Denver

Colorado Department of Transportation
Bituminous Unit 303-398-6530
4670 Holly St., Unit A
Denver, Co. 80216

Test Methods: AASHTO ASTM

FS#	Lot#	# of Cans	Samp#	IAT	Date Samp	Spec Grav	Brook Visc	DSR	Duct	Tough	Tenac	LOH	RTFO DSR	RTFO Duct	BBR S	BBR m	Dir Tens
AASHTO Specification							Max 3pa-s	Min 1.00 kPa	Min 50	Min 110lb	Min 75lb	Max loss 1.00	Min 2.20 kPa	Min 20	Max 300 MPa	Min 0.300	Min 1.0
44106	1	0	1	Y	6/16/2009			1.66	60.0	190.0	174.0		3.23	35.0	123	.355	
37698	1	7	2		6/16/2009			1.66	60.0	210.0	194.0		3.20	41.0	122	.358	
44118	2	0	2	Y	6/18/2009			1.75	60.0	249.0	231.0		3.32	33.0	137	.352	
37699	2	7	13		7/9/2009			1.55		150.0	138.0						
37700	3	7	16		7/17/2009			1.56		150.0	136.0						
37673	4	2	1		8/19/2009			1.69	60.0	213.0	197.0		3.24	34.0	135	.347	

Asphalt Cement Results Crumb Rubber Research PG 64-28TB

Subaccount: **16522PG64-28TB**
Project: NH 0341-073
Location: US 34 Bypass Resurfacing 71st to 8th Ave.
Region: 4
Grade: 64-28TB
Refinery: Wright , Channelview, TX

Colorado Department of Transportation
Bituminous Unit 303-398-6530
4670 Holly St., Unit A
Denver, Co. 80216

Test Methods: AASHTO-ASTM

FS#	Lot#	# of Cans	Samp#	IAT	Date Samp	Spec Grav	Brook Visc	DSR	Duct	Tough	Tenac	LOH	RTFO DSR	RTFO Duct	BBR S	BBR m	Dir Tens
AASHTO Specification							Max 3pa-s	Min 1.00 kPa	Min 50	Min 110ilp	Min 75ilp	Max loss 1.00	Min 2.20 kPa	Min 20	Max 300 MPa	Min 0.300	Min 1.0
44114	1	0	1	Y	8/4/2009			2.10	28.5 *	102.0 *	2.1 *		3.48	16.3 *	117	.365	
1	1	0	1		8/3/2009			2.01	29.5 *	115.0	2.0 *		3.35	16.5 *	[illegible]	[illegible]	
37671	1	3	2		8/4/2009			2.08	28.3 *	103.0 *	1.9 *		3.49	16.0 *	124	.358	

Total number of QA samples on this project: 3
Total number of IAT samples on this project: 1
Total tons of Mix / Binder covered: 1460

Final pay quantity: ______________ ***tons of Mix / Binder***

BBR S, BBR m, were tested at -24C

Approved by: ______________________________

Distribution: Region Materials Engineer
Region Documentation Unit
Project File

Asphalt Cement Results Crumb Rubber PG 64-28 WP

Subaccount:	**16522PG64-28WP**
Project:	NH 0341-073
Location:	US 34 Bypass Resurfacing 71st - 8th Ave.
Region:	4
Grade:	64-28WP
Refinery:	EcoPath

Colorado Department of Transportation
Bituminous Unit 303-398-6530
4670 Holly St., Unit A
Denver, Co. 80216

Test Methods: AASHTO ASTM

FS#	Lot#	# of Cans	Samp#	IAT	Date Samp	Spec Grav	Brook Visc	DSR	Duct	Tough	Tenac	LOH	RTFO DSR	RTFO Duct	BBR S	BBR m	Dir Tens
AASHTO Specification							Max 3pa-s	Min 1.00 kPa	Min 50	Min 110i/p	Min 75i/p	Max loss 1.00	Min 2.20 kPa	Min 20	Max 300 MPa	Min 0.300	Min 1.0
37672	1	3	1		8/10/2009			2.06	6.0 *	40.0 *	5.0 *		4.47	3.0 *	195	.308	
44116	1	0	1	Y	8/10/2009			1.91	6.0 *	22.0 *	3.0 *		4.86	4.0 *	192	.308	

Total number of QA samples on this project: 3
Total number of IAT samples on this project: 1
Total tons of Mix / Binder covered: 1079

Final pay quantity: ______________ *tons of Mix / Binder*

Approved by: ______________________

Distribution: Region Materials Engineer
Region Documentation Unit
Project File

Subaccount: **16522PG64-28WP**   * *denotes deviation from standard PG 64-28 specs*
Wednesday, August 26, 2009

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