OAPC – CPATT Study: Performance Testing Update

OAPC – 2021 Asphalt Technical Symposium (ATS) Webinar
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- Bachelors of Engineering – Materials Engineering
  - McMaster University
- Began career in a Mix Design Lab in 2006
- Master of Applied Science - Civil Engineering (2011)
- Managed QC, QMS, and Corporate Research & Mix Design Lab for Miller Paving Limited (6 years)
- Currently Canadian Regional Engineer for the Asphalt Institute, since January 2018

Background

Asphalt binders specified based on their properties in an original state

- Performance Graded by AASHTO or ASTM

What about properties of in-situ asphalt mixtures?

- Research
- Forensic investigation
- Evaluate properties of blended asphalt binder with RAP
- Predict performance

Background

Agencies are looking for ways to evaluate the properties of the blended asphalt binder (i.e., new binder and old binder from RAP).

Options:

1. Solvent extraction-recovery testing on the asphalt mixture
2. Asphalt mix performance testing

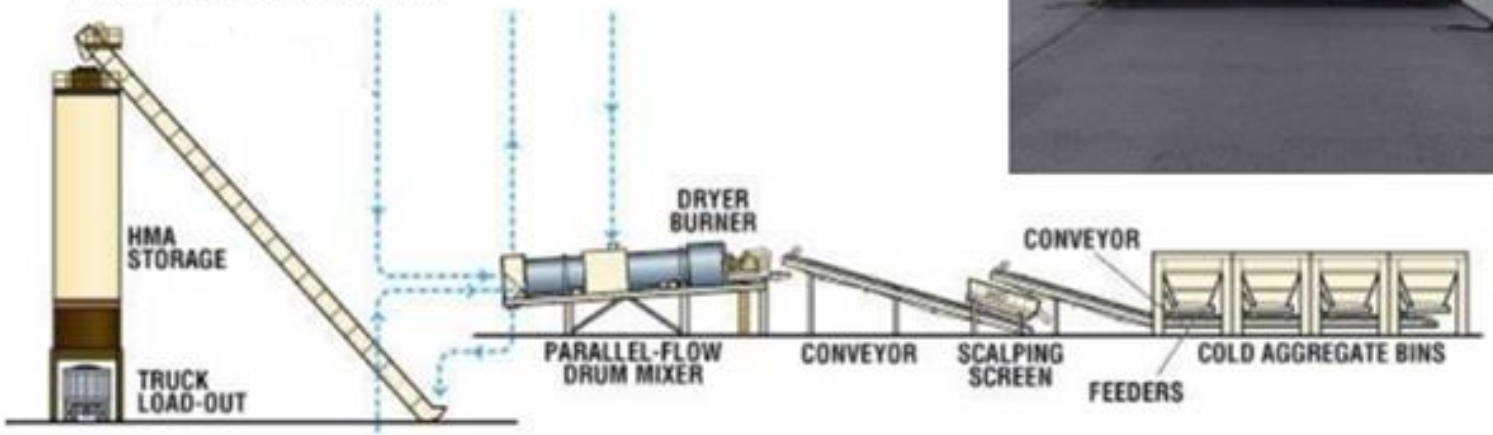
Objectives

1. Evaluate the inter-laboratory standard deviation of the test methods utilized for acceptance of asphalt binders in Ontario.
2. Evaluate the asphalt binders and mixes using recent test methods that have been verified through field performance.

Methodology - Sampling

SAMPLE 'D'
ASPHALT MIX
PAVING SITE

SAMPLE 'C'
ASPHALT MIX
HMA PRODUCTION PLANT



SAMPLE 'A'
ASPHALT CEMENT
SUPPLIER'S TERMINAL

SAMPLE 'B'
ASPHALT CEMENT
HMA PRODUCTION PLANT

Methodology – Materials

ID	Asphalt Mix Class	PG Grade	RAP Content
1-0708	12.5FC2	70-28	0
2-0809	12.5FC2	70-28	15
3-0915	12.5	58-34	15
4-1003	12.5	58-34	0
6-1006	**12.5**	**58-28**	**0**
7-1010	12.5FC2	64-28	0
8-1031	12.5FC1	58-34	0

Methodology – Testing Part I

Test Description	Test Method/Standard
Extraction of Asphalt Cement and Analysis of Extracted Aggregate	MTO LS 282
Recovery of Asphalt from Solution by Abson or Rotary Evaporator	MTO LS 284
Ash Content	MTO LS 227
Grading or Verifying the Performance Grade of an Asphalt Binder	AASHTO R 29
Multiple Stress Creep Recovery Test of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)	AASHTO T 350
Performance Grade of Physically Aged Asphalt Cement using Extended Bending Beam Rheometer (ExBBR)	MTO LS 308
Asphalt Cement's Resistance to Ductile Failure Using Double Edge Notched Tension (DENT) Test	MTO LS 299
Accelerated Aging of Asphalt using Pressure Aging Vessel Protocols	MTO LS 228

Results - ILS

The t test is used to test the hypothesis that there is no statistically significant difference in the means of the two groups: tank asphalt and recovered asphalt.

The null hypothesis symbolically is: H_o: $\mu_{tank} = \mu_{recovered}$

p value less than 0.05 means there is less than 5% chance a result in the sample occurred by chance, therefore the results are statistically significant, and reject the null hypothesis that there is no difference.

Results - ILS

The null hypothesis symbolically is: H_o: $\mu_{tank} = \mu_{recovered}$

PGAC Grade	RAP	Mix ID	p values						
			Ash	PG High	PG Low	MSCR Jnr	Grade Loss	LTLG	CTOD
58-34	0	8-1031	0.02	0.11	0.65	0.45	0.25	0.97	0.01
58-34	0	4-1003	0.01	0.04	0.86	0.72	0.48	0.08	0.00
58-34	15	3-0915	0.00	0.00	0.09	0.94	0.40	0.02	0.00
58-28	0	6-1006	0.00	0.83	0.41	0.21	0.28	0.28	0.24
64-28	0	7-1010	0.01	0.23	0.03	0.59	0.57	0.02	0.06
70-28	0	1-0708	0.00	0.03	0.26	0.40	0.58	0.26	0.20
70-28	15	2-0809	0.00	0.04	0.11	0.76	0.89	0.02	0.04

Results - ILS

The significance level is 5 percent (p value 0.05)

PGAC Grade	RAP	Mix ID	p values						
			Ash	PG High	PG Low	MSCR Jnr	Grade Loss	LTLG	CTOD
58-34	0	8-1031	**0.02**	0.11	0.65	0.45	0.25	0.97	**0.01**
58-34	0	4-1003	**0.01**	**0.04**	0.86	0.72	0.48	0.08	**0.00**
58-34	15	3-0915	**0.00**	**0.00**	0.09	0.94	0.40	**0.02**	**0.00**
58-28	0	6-1006	**0.00**	0.83	0.41	0.21	0.28	0.28	0.24
64-28	0	7-1010	**0.01**	0.23	**0.03**	0.59	0.57	**0.02**	0.06
70-28	0	1-0708	**0.00**	**0.03**	0.26	0.40	0.58	0.26	0.20
70-28	15	2-0809	**0.00**	**0.04**	0.11	0.76	0.89	**0.02**	**0.04**

Results - ILS

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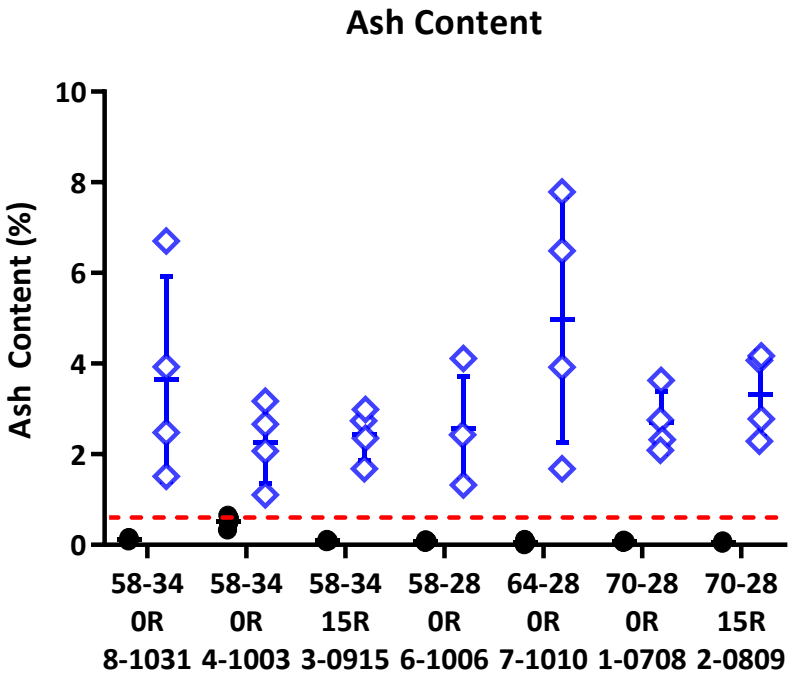
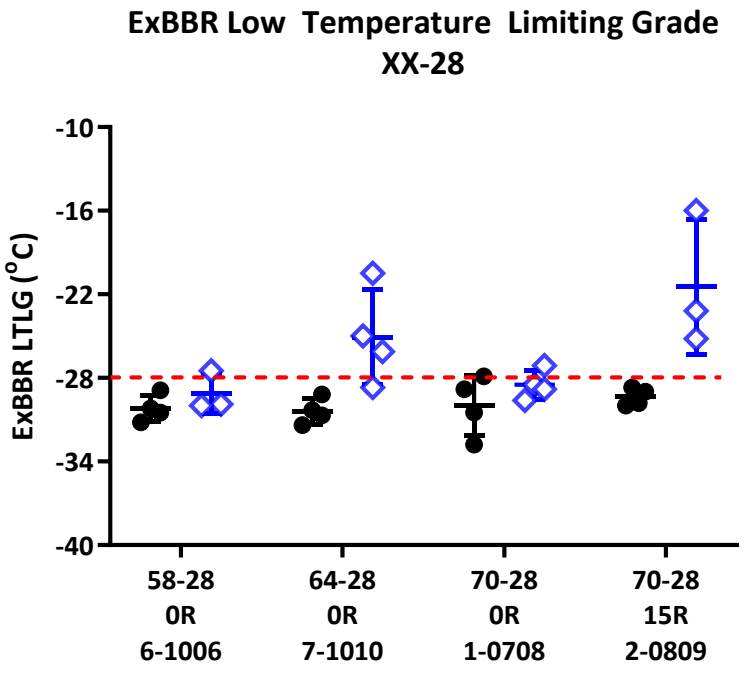
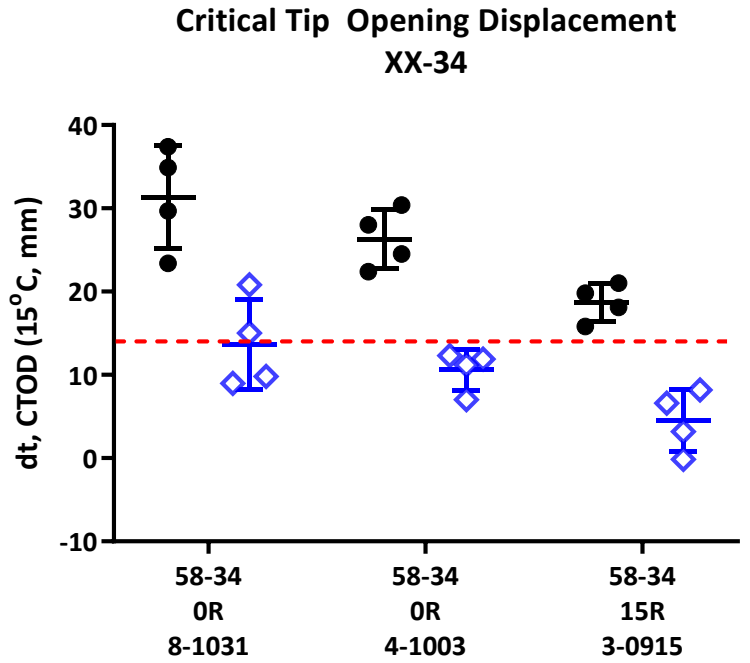
- Tank Asphalt
- Recovered Asphalt



There is a statistically significant difference in test results for tank and recovered asphalt when testing for ash content.



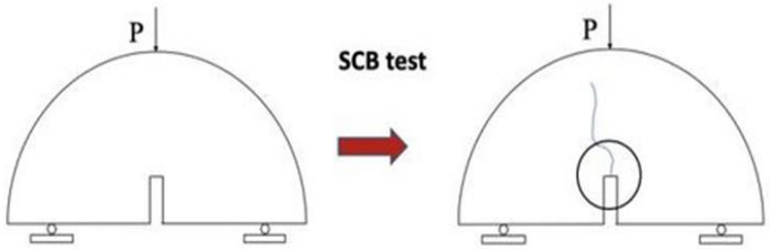
There is a statistically significant difference in test results for LTLG for: PG 64-28, PG 58-28, and PG 70-28 when 15 percent RAP is incorporated.



There is a statistically significant difference in test results for CTOD when RAP is incorporated in the mix and recovered for testing.

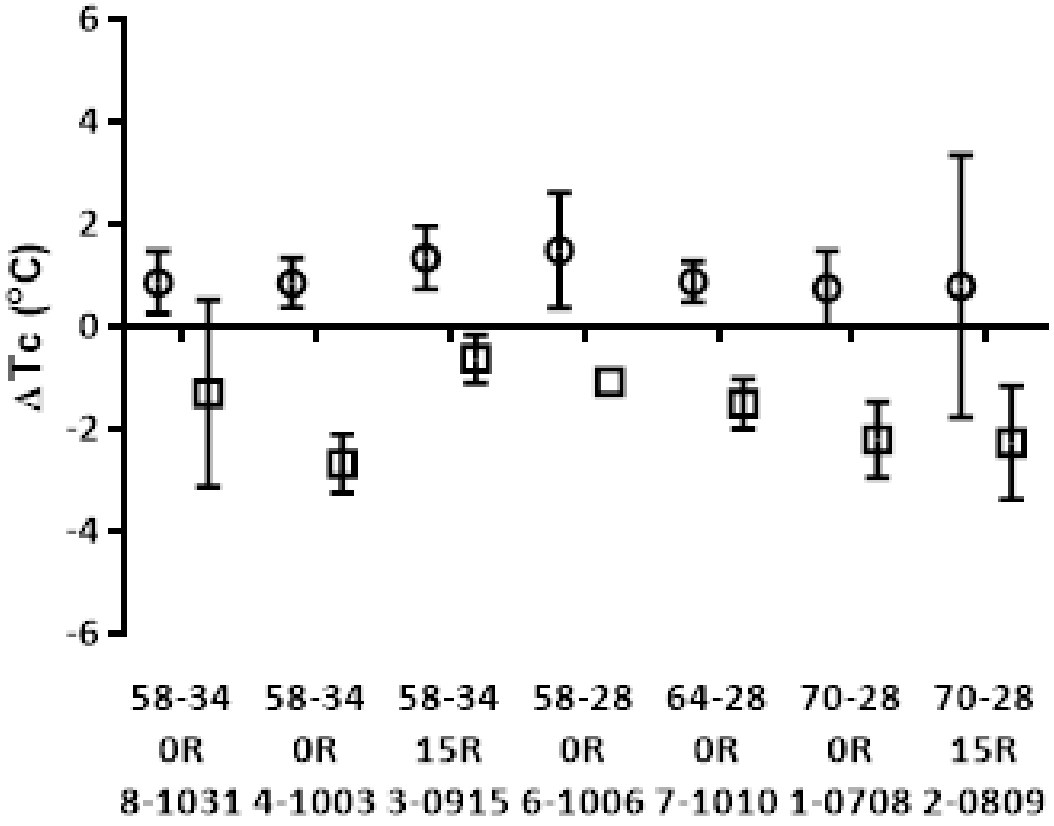
Methodology – Testing Part II

- Delta Tc
- Flow Number
- Illinois Flexibility Index Test



Results – Delta Tc

ΔT_c is calculated using values from the Bending Beam Rheometer (BBR) test included in the PG system, by subtracting the BBR m-critical temperature from the BBR stiffness-critical temperature: $\Delta T_c = (T_{s\text{-}critical} - T_{m\text{-}critical})$



ΔTc becoming worse (more negative) with extended aging, which supports the understanding of the impact of oxidation on the asphalt properties.

% of change in ΔT_c between the 20 and 40 hours is not consistent for all the asphalt binder grades

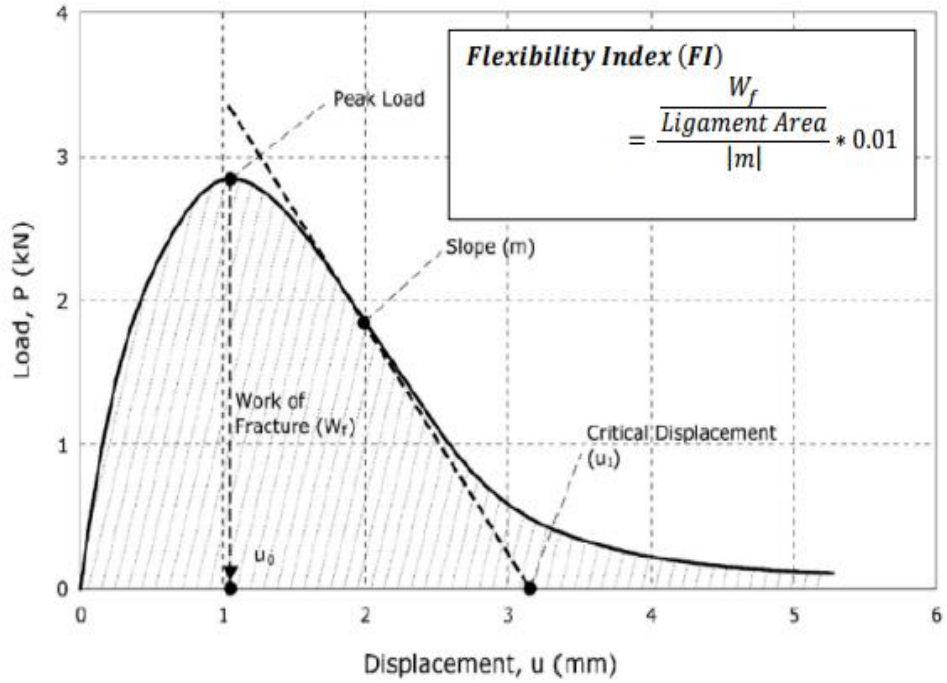
Results – AMPT Flow Number

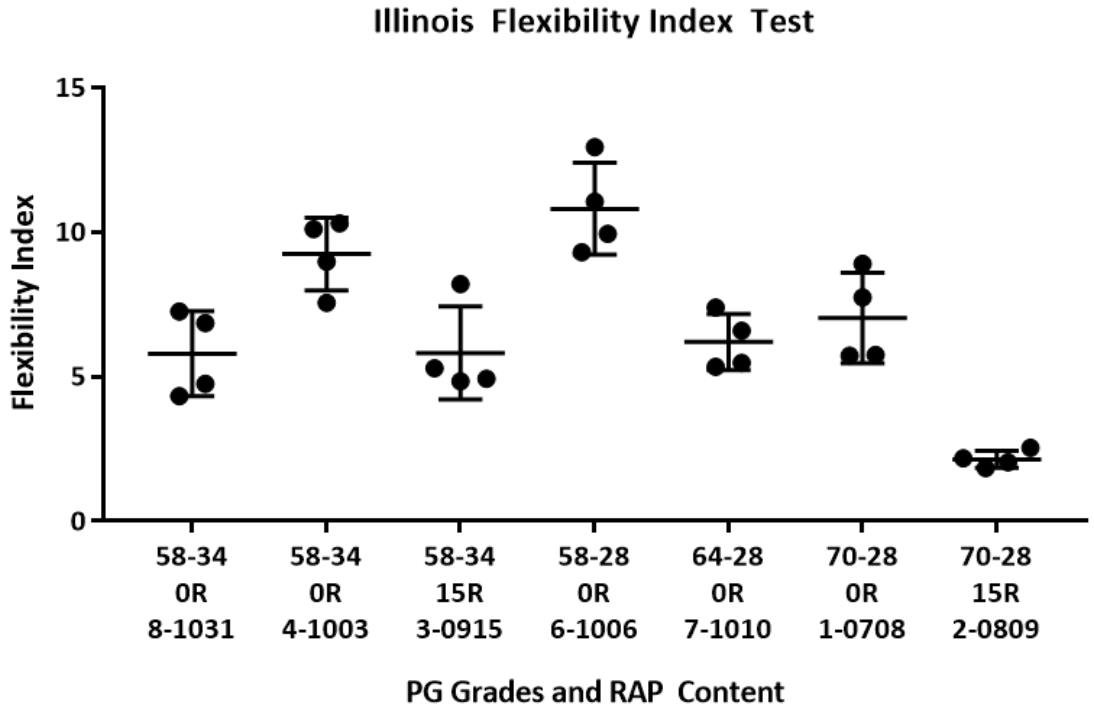
Sample ID	58-34 8-1031	**58-34 4-1003**	**58-34 3-0915***	**58-28 6-1006**	64-28 7-1010	**70-28 1-0708**	**70-28 2-0809***
Flow Number (FN)	67	**28**	**109**	**78**	136	**2659**	**3119**
Min	32	25	78	60	123	1680	440
Max	112	35	162	96	144	4190	4732
StDev	41	6	46	18	11	1342	2336
COV	60	20	43	23	8	51	75

The Flow Number values trend in the manner expected, i.e., higher FN values correspond to mixtures that are more resistant to rutting.

Results – I-FIT Flexibility Index

The I-FIT test quantifies the cracking resistance of asphalt mixtures using the Flexibility Index (FI), at intermediate temperature.





Sample ID	58-34 8-1031	58-34 4-1003	58-34 3-0915*	58-28 6-1006	64-28 7-1010	70-28 1-0708	70-28 2-0809*
Average FI	5.8	9.2	5.8	10.8	6.2	7.0	2.2
Min	4.3	7.6	4.9	9.3	5.3	5.7	1.8
Max	7.3	10.3	8.2	12.9	7.4	8.9	2.5
StDev	1.5	1.3	1.6	1.6	1.0	1.6	0.3
COV	25	14	27	15	16	22	14

Results – Correlation Table – Tank Asphalt

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TANK ASPHALT	RAP	Ash	PG High	PG Low	MSCR Jnr	MSCR %Rec 3.2kPa	Grade Loss (20Hr)	Grade Loss (40Hr)	LTLG (20Hr)	LTLG (40Hr)	CTOD	Delta Tc (20Hr)	Delta Tc (40Hr)	Flexibility Index	Flow Number
RAP															
Ash	-0.3														
PG High	0.3	-0.3													
PG Low	0.1	-0.9	0.3												
MSCR Jnr	-0.3	-0.1	-0.7	0.2											
MSCR %Rec 3.2kPa	0.3	0.1	0.8	-0.1	-1.0										
Grade Loss (20Hr)	0.4	-0.1	0.6	0.2	-0.6	0.7									
Grade Loss (40Hr)	0.2	-0.2	0.2	0.2	0.0	0.1	0.4								
LTLG (20Hr)	0.5	-0.9	0.1	0.6	0.1	-0.1	0.0	0.4							
LTLG (40Hr)	0.5	-0.8	0.1	0.5	0.0	-0.1	0.0	0.5	1.0						
CTOD	-0.4	0.7	-0.5	-0.8	0.1	-0.2	-0.7	-0.3	-0.4	-0.3					
Delta Tc (20Hr)	-0.4	0.4	-1.0	-0.4	0.8	-0.8	-0.6	-0.1	-0.2	-0.2	0.5				
Delta Tc (40Hr)	0.2	-0.4	-0.3	0.1	0.2	-0.4	-0.6	0.0	0.7	0.7	0.4	0.2			
Flexibility Index	-0.7	0.4	-0.7	-0.2	0.7	-0.6	-0.3	0.1	-0.5	-0.4	0.2	0.8	-0.3		
Flow Number	0.4	-0.3	0.9	0.4	-0.5	0.6	0.6	0.3	0.2	0.2	-0.6	-0.9	-0.3	-0.6	

-1 = a perfect negative linear correlation between two variables

0 = no linear correlation between two variables

1 = a perfect positive linear correlation between two variables

Results – Correlation Table – Recovered Asphalt

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RECOVERED ASPHALT	RAP	Ash	PG High	PG Low	MSCR Jnr	MSCR %Rec 3.2kPa	Grade Loss (20Hr)	Grade Loss (40Hr)	LTLG (20Hr)	LTLG (40Hr)	CTOD	Delta Tc (20Hr)	Delta Tc (40Hr)	Flexibility Index	Flow Number
RAP															
Ash	0.2														
PG High	0.3	0.5													
PG Low	0.3	0.4	0.5												
MSCR Jnr	-0.3	-0.2	-0.7	0.0											
MSCR %Rec 3.2kPa	0.1	-0.2	0.5	-0.2	-0.8										
Grade Loss (20Hr)	0.1	0.7	0.5	0.3	-0.3	0.0									
Grade Loss (40Hr)	-0.3	0.4	0.1	0.0	-0.1	-0.1	0.3								
LTLG (20Hr)	0.4	0.5	0.5	0.8	-0.1	-0.2	0.4	0.2							
LTLG (40Hr)	0.1	0.7	0.5	0.6	-0.2	-0.1	0.6	0.5	0.8						
CTOD	-0.3	-0.6	-0.5	-0.6	0.1	0.2	-0.8	-0.3	-0.6	-0.6					
Delta Tc (20Hr)	-0.5	-0.5	-0.5	-0.8	0.2	0.1	-0.3	-0.1	-0.7	-0.6	0.5				
Delta Tc (40Hr)	0.1	-0.7	-0.5	-0.2	0.3	0.0	-0.6	-0.5	-0.4	-0.8	0.6	0.3			
Flexibility Index	-0.7	-0.2	-0.6	-0.4	0.6	-0.5	0.0	0.0	-0.4	-0.2	0.1	0.5	0.0		
Flow Number	0.4	0.1	0.8	0.4	-0.5	0.6	0.2	-0.1	0.3	0.1	-0.2	-0.3	0.0	-0.6	

-1 = a perfect negative linear correlation between two variables

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Summary

The significant increase in ash content, coupled with the difference in aging for lab aging versus plant production, produced rheological properties that show the recovered asphalt was stiffer and less representative of the tank asphalt, namely: the recovered asphalt had higher PG high temperatures, higher PG low temperatures, higher LTLG, higher Grade Loss, and lower CTOD results.

Summary

The physical properties of recovered binder have shown to be statistically different from the physical property tests on tank asphalt.

Summary

The alternate tests included in the study: Delta Tc, AMPT Flow number, and I-FIT Flexibility Index correlated well with other measured parameters with verified field performance.

Thank you. Questions?

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