Toward Performance-Based Acceptance of Asphalt Mixtures in Ontario: Industry (O-MAP) Preliminary Findings.

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The author(s) acknowledge all members of the OAPC's Ontario Asphalt Expert Task Group (OAETG), especially members of its Oversight Study Team (OST), The material donors and the participating industry laboratories, who have contributed to the success of this continuing research study aimed at understanding Ontario's Superpave mix performance.

ABSTRACT

Research efforts are being undertaken in North America, to improve methodology for designing asphalt mixes through incorporating reliable laboratory tests and procedures into material specifications. Some of these efforts have further demonstrated that implementing performance tests can improve the longevity of asphalt pavements and reduce risk of premature pavement deterioration. The Ontario Asphalt Pavement Council *(OAPC – A Council of Ontario Road Builders' Association, ORBA)* is particularly interested in this focus, as potential means of addressing concerns on premature cracking of asphalt mixes. Considering this, the Ontario Asphalt Expert Task Group (OAETG) – Ontario - Mix Asphalt Program (O-MAP) study, commissioned by the OAPC, has been conducted to examine issues and challenges related to the performance of typical Ontario Superpave asphalt mixtures.

Further to the industry's readiness to identify any issues and challenges involving performance of typical Ontario Superpave asphalt mixtures, this paper summarises the findings, recommendations, and next steps from round-one of O-MAP Testing. Throughout this round, two SP 12.5 mixes designed specifically for highest Traffic Category ("E") were studied. The evaluated mixes were Plant-Produced Lab Compacted (PP-LC) prepared using Performance Graded Asphalt Cement (PGAC) 70-28XJ, meeting Ontario Provincial Standard Specification (OPSS) 1101. The results indicated that the success of adopting performance testing in Ontario is reliant on the ability of both the owner-agency and industry to establish and meet performance criteria related to test methods including, but not limited to: Hamburg Wheel Tracking Device (HWTD), Semi-circular Bend Test (SCB), and Disk-Shaped Compact Tension (DCT) array of tests. The round-one results were further incorporated into Performance Space Diagram (PSD) to better characterize the mixes based on performance testing conducted.

Based on the identified study limitations and results analyzed and verified by the O-MAP's Oversight Study Team (OST), there are still areas requiring further investigation in order to better understand the factors that may affect the interpretation of results. To this end, different mix properties, testing parameters, testing equipment/fixtures, or a combination of all these factors, including the effect of changing height on the reliability of Superpave Gyratory Compactors (SGCs) used in the province, and their differences as a significant source of variation related to "within" and/or "interlaboratory" Coefficient of Variation (COV) should be further investigated.

1. INTRODUCTION

1.1 Study Background and Problem Statement

Currently, most agencies rely primarily on measuring volumetric properties to ensure good field performance. Notwithstanding, there are on-going initiatives, with considerable amounts of research efforts to develop and implement “asphalt performance tests” that can link laboratory-measured parameters to pavement performance. In North America, research efforts are also being undertaken to refine the asphalt mix design methodology, such that laboratory tests and procedures can be incorporated into material specifications. Some of these efforts have further demonstrated that implementing performance tests can improve the longevity of asphalt pavements and reduce risk of early pavement deterioration.

This focus is of particular interest to the industry in Ontario, due to concerns of premature cracking of Ontario roadways. As a result, since mid-2017, the Ministry of Transportation in Ontario has been involved with several research efforts aimed at developing an acceptance criterion for the performance of asphalt mixtures produced and placed on provincial roadways. Following-up on these efforts, as well as the need to have comparable industry data to adequately advance conversations and decisions should performance testing become a reality for contractual acceptance, the Ontario Asphalt Pavement Council *(OAPC – A Council of Ontario Road Builders’ Association, ORBA)*, in 2021/22, took leadership through the Ontario Asphalt Expert Task Group (OAETG), and developed the Ontario - Mix Asphalt Program (O-MAP). This mix-testing program is identified as an integral part of the OAETG’s five-year long-term plan ***(see Figure 1)**,* and in alignment with the overall vision and goals of the OAPC which entails dedication to quality and sustainable asphalt pavements, and paving techniques.

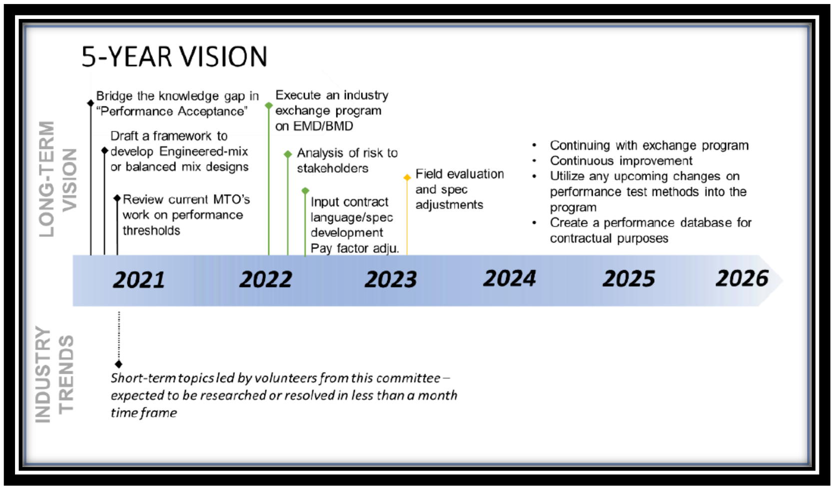


Figure 1. OAETG 5-Year Vision

1.2 Ontario's Path Forward in Adopting Performance Testing

Ontario's path towards implementing performance testing for paving with asphalt mixtures should be aimed at adopting a structured, simplified system that is flexible in approach, measurable and modifiable. Uniformity in practices is critical for business. It is imperative that stakeholders continue to question and evaluate performance strategies by ensuring that the approach for final implementation fits a unique situation. Currently, efforts are being built in consideration of the experiences of other jurisdictions with particular emphasis on test simplicity, factoring technician training, sample preparation protocols, sensitivity to mix design parameters, correlation to field performance, ease of data interpretation and analysis, and equipment availability. Central to this is the OAETG's continued focus on recovered asphalt testing, and pathways towards mix performance testing in Ontario. These efforts will assist the understanding of knowledge gaps and any future research needs for long-term pavement performance.

1.3 Research Scope and Objectives

Through the OAETG processes, detailed literature reviews for establishing mix performance-based specification were completed, highlighting the underlisted findings *[1, 2, 3, 4, 5, 6, 7]*:

- *Long term aging of asphalt mixes is recommended.*
- *Performance testing typically recommended for mixes placed on high volume roadways.*
- *Setting thresholds requires developing a performance cumulative database.*
- *Austroads uses 5% air voids for performance testing like Superpave5 concept.*
- *Adopting any of these tests takes a long time, so we are on the right track to start now.*

Resulting from several industry discussions, wherein, the members provided inputs on technical matters, and contractual implications of "Performance-Based" specification on asphalt mixtures, this study considered a framework around evaluation of practice-ready approaches to the design of asphalt mixtures using performance testing methods - specifically, testing methods that the Ministry of Transportation Ontario (MTO) has extensively studied. They include:

- Hamburg Wheel Tracking (HWT) Test,
- Semi-Circular Bending (SCB) I-FIT method, and
- Disc-Shaped Compact Tension (DCT) test.

In addition, the O-MAP performance testing study was expected to complement a prior recovered asphalt and performance study completed by the OAPC and the University of

Waterloo - Centre for Pavement and Transportation Technology (CPATT), and to further assist as follows:

- Bridge the knowledge gap in “Performance Testing Methods and Acceptance.”
- Aid an understanding of risks to quality assurance (QA) performance acceptance, such as inherent variability within test method – test variability, and variability due to mix properties (volumetrics variability).
- Evaluate any correlation or trends between Recovered Asphalt Cement (RAC) physical and chemical properties and outcome of performance testing.

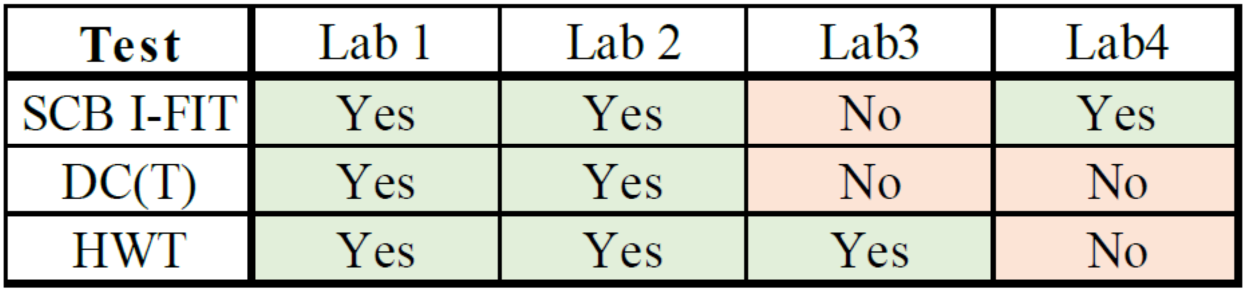
In O-MAP round-one, two SP12.5 mixes designed specifically for the highest Traffic Category (“E”) were studied. The evaluated mixes were Plant-Produced Lab Compacted (PP-LC) prepared using Performance Graded Asphalt Cement (PGAC) 70-28XJ, meeting Ontario Provincial Standard Specification (OPSS) 1101. The two traffic category E mixes (Mix A and Mix B) were distributed among four different laboratories. The properties of the mixes tested are as shown in **Table 1**.

Table 1. Mix Properties of the Mix Included in O-MAP Round 1

Mix Composition	**Mix A**	**Mix B**
% A.C Content	5.25	5.00
Aggregate Gradation ***(% Passing Sieve, mm)***		
- 25.0	100.0	100.0
- 19.0	100.0	100.0
- 12.5	97.5	97.1
- 9.5	89.5	81.7
- 6.7	77.2	-
- 4.75	65.0	54.4
- 2.36	46.3	39.8
- 1.18	34.6	32.7
- 0.600	25.2	26.6
- 0.300	15.4	17.4
- 0.150	7.5	8.2
- 0.075	5.1	3.3
Mix Properties		
- MSG (G_{mm})	2.724	2.810
- BRD@N_{des}	2.461	2.490
- BRD@N_{max}	2.564	2.594
- %G_{mm}@N_{ini}	89.2	89.0
- %G_{mm}@N_{des}	96.0	96.0
- %G_{mm}@N_{max}	96.6	96.8
Tensile Strength Ratio, ***80 % Minimum***	90.4	95.2

Table 2, illustrates the distribution, and performance tests completed. Three of the labs (Labs 1, 2, and 4) performed the SCB I-FIT test, three labs (Labs 1, 2, and 3) conducted the HWT test, and two labs (Labs 1 and 2) participated in DC(T) test. For statistical analysis of results, the analysis of variance (ANOVA) approach was performed on collected data from each performance-related test.

Table 2. Participating Labs and Performance Related Tests



Test	Lab 1	Lab 2	Lab3	Lab4
SCB I-FIT	Yes	Yes	No	Yes
DC(T)	Yes	Yes	No	No
HWT	Yes	Yes	Yes	No

It should be noted that, the study anticipated that, looking into these stiffer mix-types could provide data and supporting facts related to existing softening concerns and that, one-testing temperature doesn't fit all need.

1.4 Applicable Testing Documentations and References

The underlisted reference and testing documentations were applicable to this study:

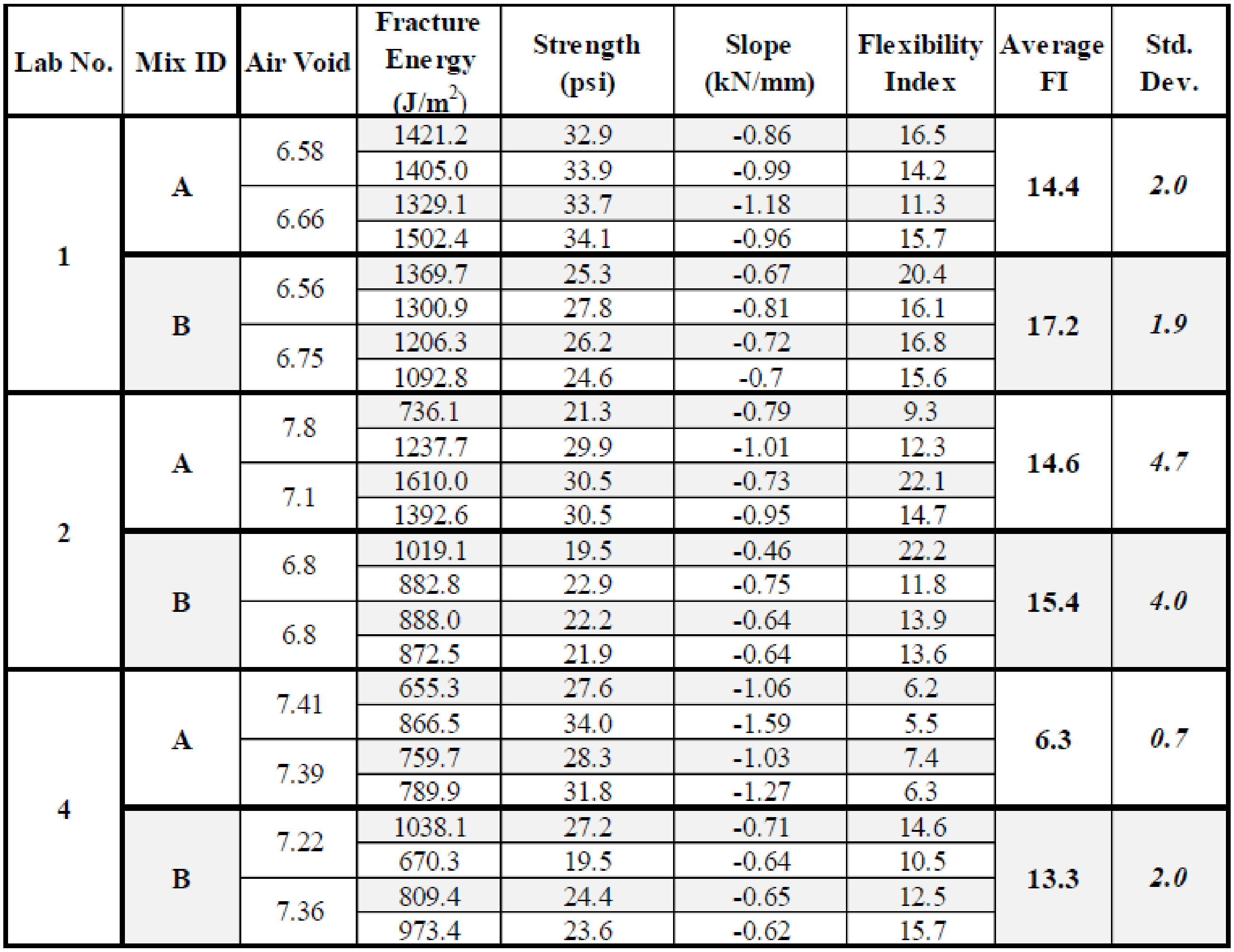
- Ministry of Transportation (MTO) Bituminous Section, 2022 Multiple Rounds of MTO Inter-Laboratory Correlation Program Instructions for *[8]:*
    - *Hamburg Wheel-Track (HWT)*
    - *Flexibility Index Test (FIT) Using Semi-Circular Bend (SCB) Geometry*
    - *Disk-Shaped Compact Tension (DCT)*
- American Association of State Highway and Transportation Officials (AASHTO) T324-19 *[9]*
- AASHTO R30 *[10]*
- AASHTO T312-19 *[11]*
- AASHTO T 393-21*[12]*
- American Society of Testing Materials (ASTM) D8044 *[13]*
- ASTM D7313 *[14]*

2. MIX TESTING RESULTS

2.1 Illinois Flexibility Index Test using Semi-Circular Bending Geometry (SCB FI)

SCB I-FIT is a monotonic bending test developed to predict the crack propagation properties of asphalt mixes at intermediate temperatures. For each mix, four parameters were reported, including fracture energy, strength, post-peak slope, and the calculated flexibility index (FI) parameter. Table 3, presents the collected data and average and standard deviation values for each set of mix-lab. To further investigate the impact of participating labs on the results, the analysis of variance method (ANOVA) was used. For this purpose, mix supplier and laboratory were considered the two impacting factors and student's t-tests were performed (α=0.05, representing a 95% confidence level).

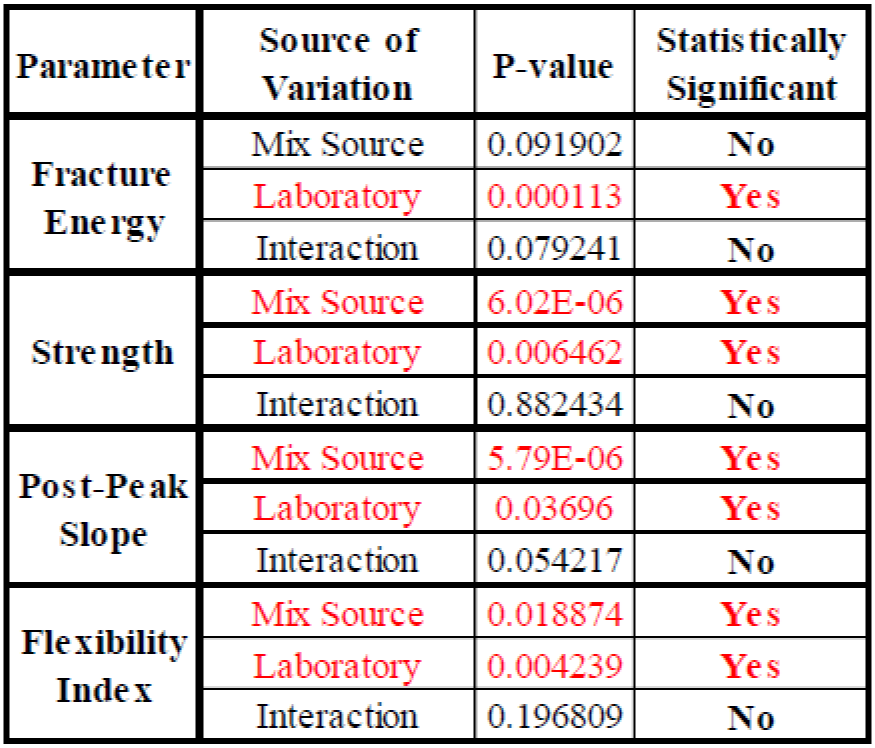
Table 3. Results of SCB I-FIT for Mix A&B from Participating Laboratories



Lab No.	Mix ID	Air Void	Fracture Energy (J/m^2)	Strength (psi)	Slope (kN/mm)	Flexibility Index	Average FI	Std. Dev.
1	A	6.58	1421.2	32.9	-0.86	16.5	**14.4**	***2.0***
			1405.0	33.9	-0.99	14.2		
		6.66	1329.1	33.7	-1.18	11.3		
			1502.4	34.1	-0.96	15.7		
	B	6.56	1369.7	25.3	-0.67	20.4	**17.2**	***1.9***
			1300.9	27.8	-0.81	16.1		
		6.75	1206.3	26.2	-0.72	16.8		
			1092.8	24.6	-0.7	15.6		
2	A	7.8	736.1	21.3	-0.79	9.3	**14.6**	***4.7***
			1237.7	29.9	-1.01	12.3		
		7.1	1610.0	30.5	-0.73	22.1		
			1392.6	30.5	-0.95	14.7		
	B	6.8	1019.1	19.5	-0.46	22.2	**15.4**	***4.0***
			882.8	22.9	-0.75	11.8		
		6.8	888.0	22.2	-0.64	13.9		
			872.5	21.9	-0.64	13.6		
4	A	7.41	655.3	27.6	-1.06	6.2	**6.3**	***0.7***
			866.5	34.0	-1.59	5.5		
		7.39	759.7	28.3	-1.03	7.4		
			789.9	31.8	-1.27	6.3		
	B	7.22	1038.1	27.2	-0.71	14.6	**13.3**	***2.0***
			670.3	19.5	-0.64	10.5		
		7.36	809.4	24.4	-0.65	12.5		
			973.4	23.6	-0.62	15.7		

Figure 2, visualizes the variability for each mix-lab combination and within each lab and mix for data presented in **Table 3**. As can be seen, all three participating labs determined higher FI values for Mix B compared to Mix A. However, one of the labs (lab 4) shows significantly lower FI values, specifically for Mix A. At the same time, the same lab results have less variability in predicting FI. **Table 4**, tabulates the results of the ANOVA analysis on SCB I-FIT test results, and **Figure 3**, visualizes the calculated F-values and $F_{Critical}$. This analysis suggests that lab impact is the primary source of variation in determining the fracture energy value, while no significant impact of mix source was observed. However, in assessing the strength of the mixes and post-peak slope, the impact of the mix source is the prominent impacting factor in data variation. In contrast, the impact of the operating lab is still significant. In determining FI, both factors (operating lab and mix source) significantly impact the calculated values. No statistically significant interaction between lab and mix source was observed in determining any of the parameters, which means all labs ranked mixes equally.

Table 4. ***ANOVA Analysis Results for SCB I-FIT Results and P-values Associated with Each Source of Variation***



Parameter	**Source of Variation**	**P-value**	**Statistically Significant**
Fracture Energy	Mix Source	0.091902	**No**
	Laboratory	0.000113	**Yes**
	Interaction	0.079241	**No**
Strength	Mix Source	6.02E-06	**Yes**
	Laboratory	0.006462	**Yes**
	Interaction	0.882434	**No**
Post-Peak Slope	Mix Source	5.79E-06	**Yes**
	Laboratory	0.03696	**Yes**
	Interaction	0.054217	**No**
Flexibility Index	Mix Source	0.018874	**Yes**
	Laboratory	0.004239	**Yes**
	Interaction	0.196809	**No**

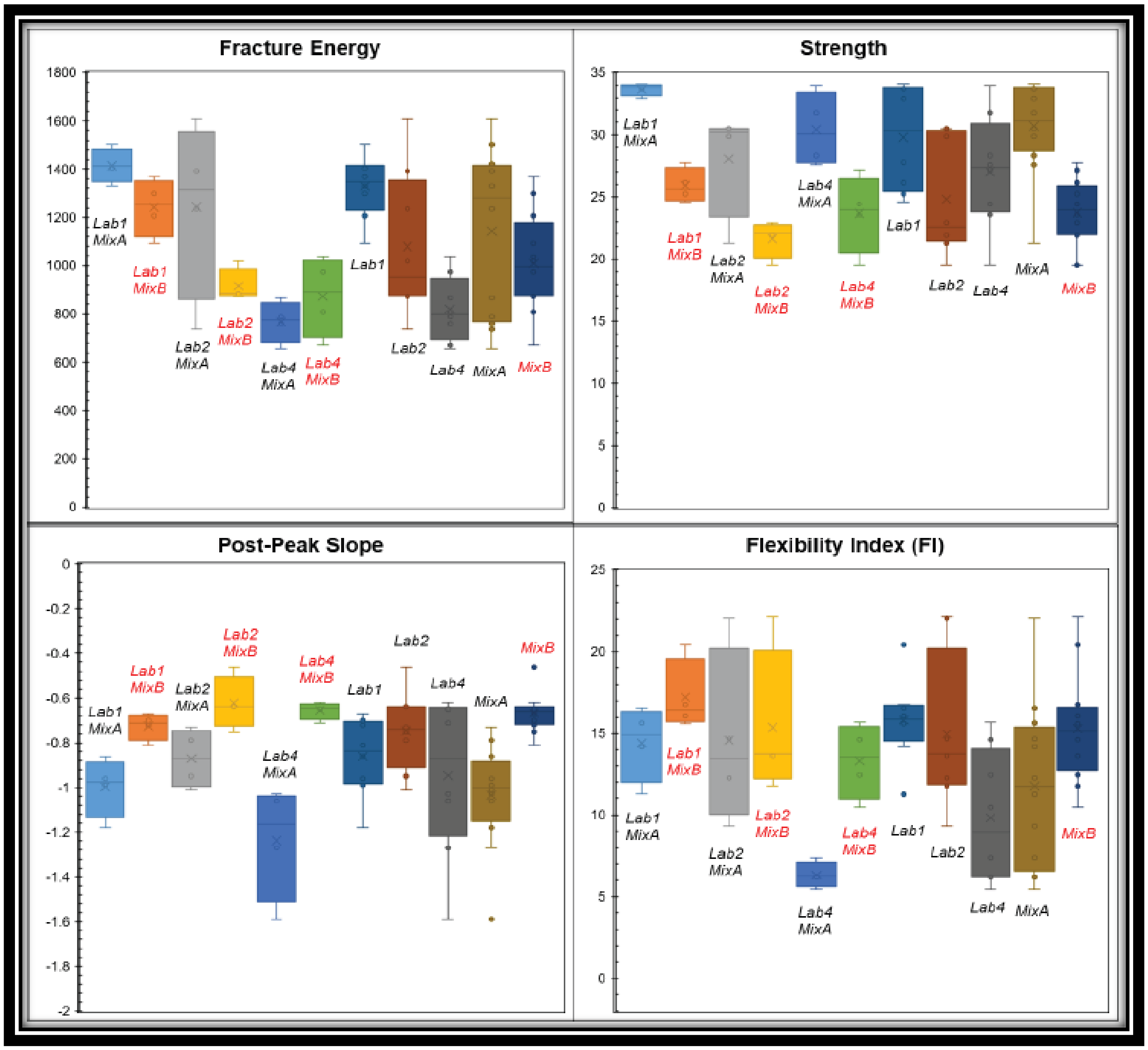


Figure 2. Box and Whisker diagrams for fracture energy, strength, post-peak slope, and flexibility index value for mixes A and B

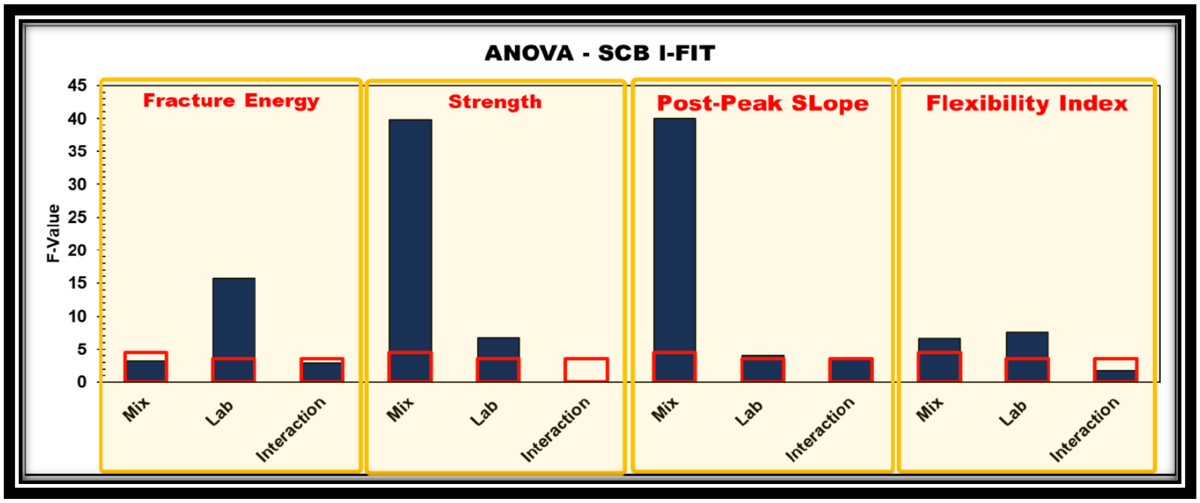


Figure 3. Graphical Representation of the Source of Variation for SCB Flexibility Index (FI) Parameters

SCB testing revealed that, the mixes are quite similar in performance although Mix A was found to pass or fail depending on the lab performing the testing. Mix B performed well when tested by all labs. It is unclear why one mix had greater variability than the other, but the mix was determined to play a much more prominent role in the variability (see following section) that any of the other variables. All things equal, a lower asphalt binder content typically results in worse performance (i.e., lower Flexibility Index) in the SCB at intermediate temperature, however, Mix B had a higher FI in all the labs that conducted the test, suggesting that other factors such as binder formulation and aggregate gradation may have impacts that could not be quantified through this small-scale study. This is significant since it shows that, it is possible that the difference in asphalt cement content in this scenario was not significant enough to play a role in performance test results. While the initial expectation was that these stiffer, polymer modified asphalt mixes would fail the cracking criteria, it is also understood that increasing the stiffness of materials reduces the resultant deflection for a given applied load, and this can aid in improving cracking resistance.

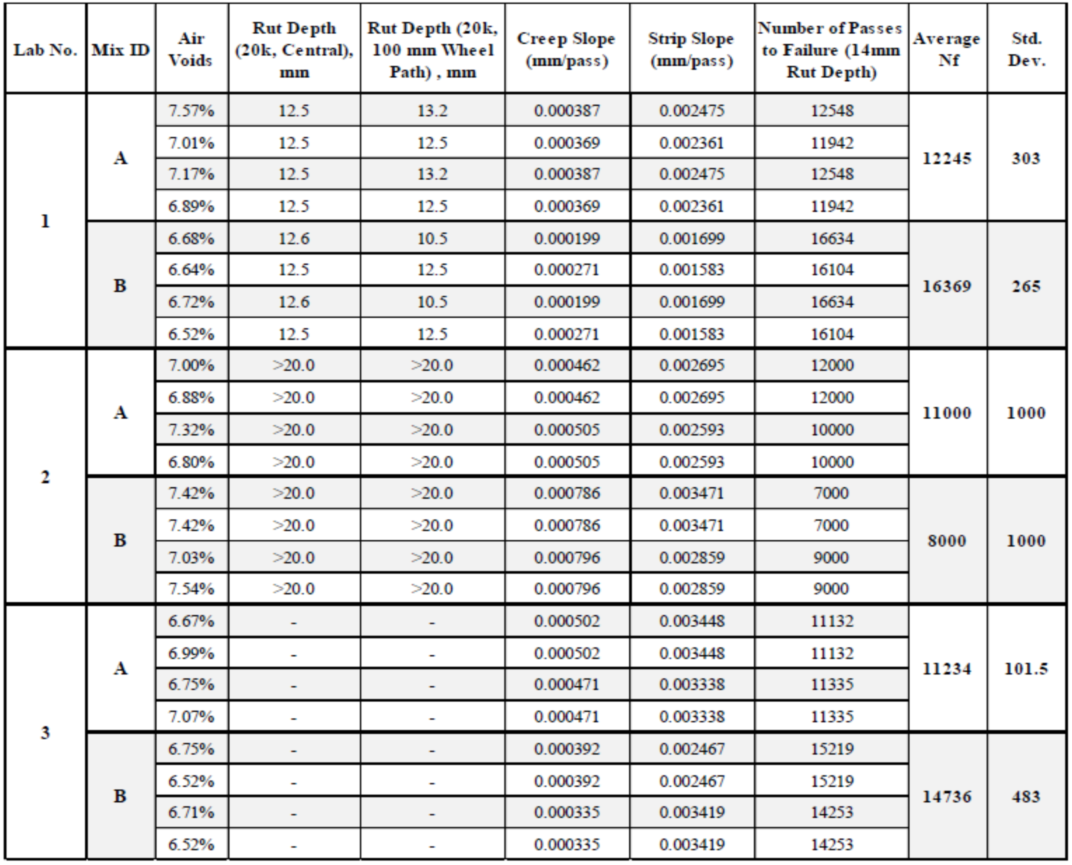
2.2 Hamburg Wheel Track Test (HWT)

The Hamburg wheel-track test evaluates the rutting susceptibility and stripping failure of asphalt mixes due to aggregate structure or inadequate binder stiffness (AASHTO T324). Using HWT data, various data could be calculated, including total rut depth (at a designated number of wheel passes), number of passes to failure N_f (for specified rut depth), creep slope (slope of the first portion of the rut curve), strip slope (slope of the second portion of the rut curve), number of passes to stripping inflection point (SIP).

Three of the participating labs (labs 1, 2, & 3) performed HWT on the mixes from both suppliers (Mixes A & B). Test temperature was selected at 50°C, as both mixes utilized PG 70-28XJ binders. **Table 5**, shows test results from these participating labs. ANOVA analysis was performed on collected data for three parameters (creep slope, strip slope, and the number of passes to failure) to evaluate the significance of each affecting factor (mix source and testing laboratory) on the final results ***(see Table 6)*****.** For the rut depth at 20k passes, two of the labs didn't report any number as both mixes passed the maximum value of 20 mm. The data variation within each combination of mix-lab, lab, and mix is provided in **Figure 4**.

One central observation from ANOVA is observing a more statistically significant impact of a testing lab compared to the mix source. One primary reason could be that very similar mixes were selected for this study (both mixes are SP12.5 FC2 using PG70-28XJ binders). As shown in **Table 5** and **Figure 5**, for all parameters, the interaction of factors (mix and lab) has significant importance on obtained results, which means the selection of testing lab is not only impacting the HWT results, but may alter it in the ranking of the mixes.

Table 5. Hamburg Wheel Track Test Results for Mixes A & B from Labs 1, 2, & 3



Lab No.	Mix ID	Air Voids	Rut Depth (20k, Central), mm	Rut Depth (20k, 100 mm Wheel Path) , mm	Creep Slope (mm/pass)	Strip Slope (mm/pass)	Number of Passes to Failure (14mm Rut Depth)	Average Nf	Std. Dev.
1	**A**	7.57%	12.5	13.2	0.000387	0.002475	12548	**12245**	**303**
		7.01%	12.5	12.5	0.000369	0.002361	11942		
		7.17%	12.5	13.2	0.000387	0.002475	12548		
		6.89%	12.5	12.5	0.000369	0.002361	11942		
	B	6.68%	12.6	10.5	0.000199	0.001699	16634	**16369**	**265**
		6.64%	12.5	12.5	0.000271	0.001583	16104		
		6.72%	12.6	10.5	0.000199	0.001699	16634		
		6.52%	12.5	12.5	0.000271	0.001583	16104		
2	**A**	7.00%	>20.0	>20.0	0.000462	0.002695	12000	**11000**	**1000**
		6.88%	>20.0	>20.0	0.000462	0.002695	12000		
		7.32%	>20.0	>20.0	0.000505	0.002593	10000		
		6.80%	>20.0	>20.0	0.000505	0.002593	10000		
	B	7.42%	>20.0	>20.0	0.000786	0.003471	7000	**8000**	**1000**
		7.42%	>20.0	>20.0	0.000786	0.003471	7000		
		7.03%	>20.0	>20.0	0.000796	0.002859	9000		
		7.54%	>20.0	>20.0	0.000796	0.002859	9000		
3	**A**	6.67%	-	-	0.000502	0.003448	11132	**11234**	**101.5**
		6.99%	-	-	0.000502	0.003448	11132		
		6.75%	-	-	0.000471	0.003338	11335		
		7.07%	-	-	0.000471	0.003338	11335		
	B	6.75%	-	-	0.000392	0.002467	15219	**14736**	**483**
		6.52%	-	-	0.000392	0.002467	15219		
		6.71%	-	-	0.000335	0.003419	14253		
		6.52%	-	-	0.000335	0.003419	14253		

Table 6. ANOVA analysis results for HWT test parameters and P-value associated with each source of variation

Parameter	Source of Variation	P-value	Statistically Significant
Rut Depth (Central)*	Mix Source	-	-
	Laboratory	-	-
	Interaction	-	-
Rut Depth (100mm Wheel Path)*	Mix Source	-	-
	Laboratory	-	-
	Interaction	-	-
Number of Passes to Failure	Mix Source	6.48E-05	Yes
	Laboratory	3.45E-10	Yes
	Interaction	1.38E-08	Yes
Creep Slope	Mix Source	2.00E-01	No
	Laboratory	4.26E-15	Yes
	Interaction	5.12E-13	Yes
Strip Slope	Mix Source	4.81E-02	Yes
	Laboratory	3.17E-07	Yes
	Interaction	4.22E-04	Yes

* Lack of appropriate data for ANOVA analysis

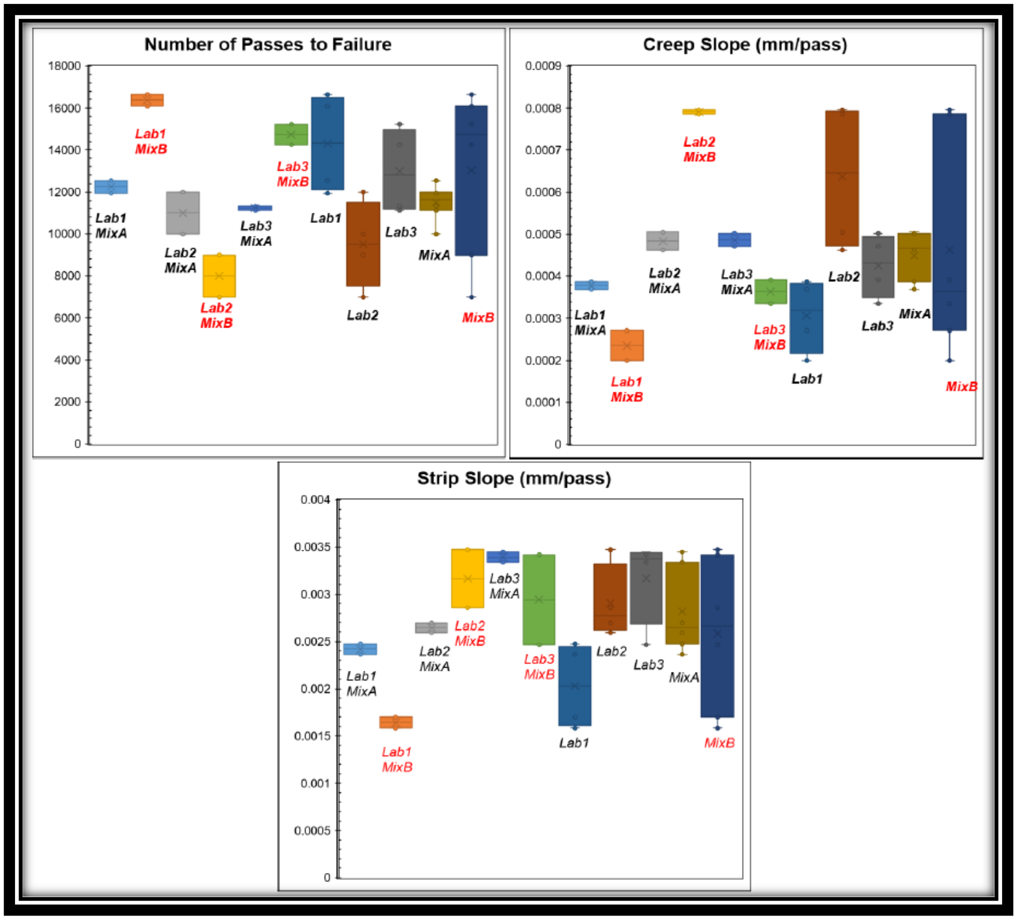


Figure 4. Box and Whisker diagrams for Nf, Creep Slope, and Strip Slope for mixes A and B

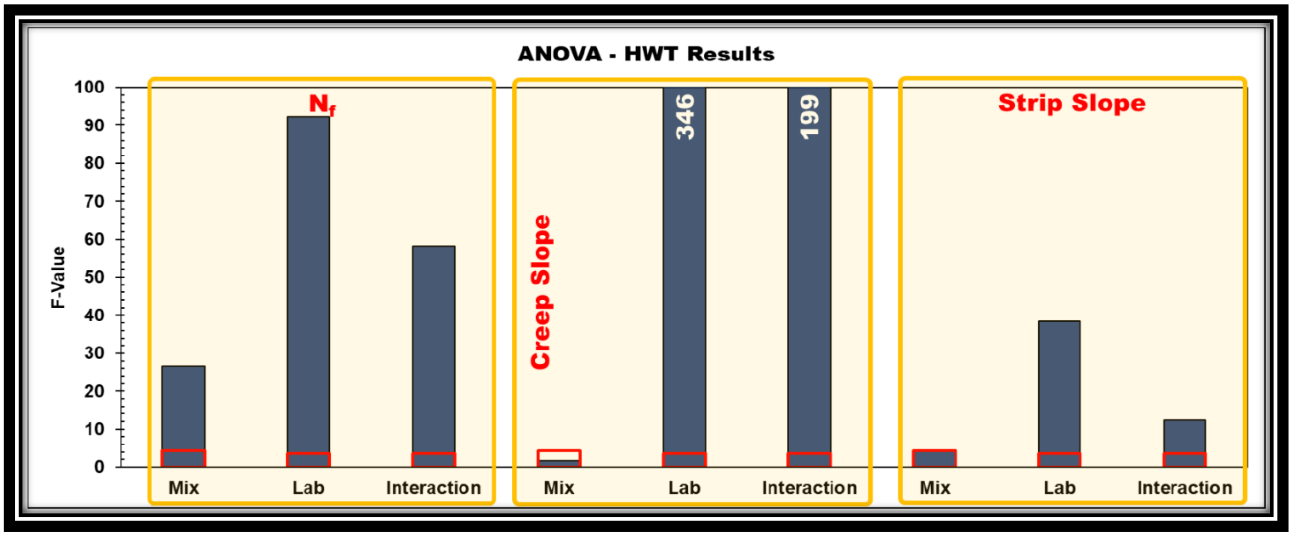


Figure 5. Graphical Representation of the Source of Variation for HWT Parameters

2.3 Disk-Shaped Compact Tension Test - DC(T)

The disk-shaped compact tension test or DC(T) was developed at the University of Illinois to predict the low temperature cracking properties of asphalt mixes by measuring the fracture energy (*Gf*) under crack mouth opening displacement (CMOD) control mode. Other than *Gf*, which is considered the fruit of this test, other parameters, including CMOD at failure, peak load, and time of peak load, are some additional outputs of this test. Two labs participated in DC(T) testing program (lab 1 and lab 2), performing the test at -18°C. Submitted results are presented in **Table 7**. **Figure 6** visualizes collected data for each combination of mix-lab, within each lab, and for each mix. **Table 8**, summarizes the ANOVA analysis of the DC(T) results, and Figure visualizes the same data. Although both mix type and testing laboratory significantly impact the fracture energy results, it can be seen in **Figure 7** that the impact of the mix source is considerably higher than that of the testing laboratory, and no interactions were observed. However, in determining the peak load, the impact of the testing laboratory is more important than the mixed source, and the interaction effect is significant. Interestingly, the mix source seems to be the only significant factor in the reported time of peak loads, and the testing laboratory does not significantly impact the results.

Table 7. Disk-shape compact tension test results for mixes A & B from labs 1 &2

Lab No.	Mix ID	Peak Load	Time of Peak Load	Fracture Energy (J/m^2)	Average Fracture Energy	Std. Dev.
1	A	3.17	25.91	1334	**1016.8**	**217.2**
		3.87	14.52	879.3		
		3.79	16.85	1089.8		
		3.61	14.25	764.2		
	B	3.99	27.04	1568.7	**1718.8**	**109.6**
		4.5	32.35	1827.5		
		4.25	27.72	1760.3		
		-	-	-		
2	A	2.92	12.97	625.6	**765.3**	**95.2**
		2.7	13.93	759.7		
		3.29	16.97	893.4		
		2.94	14.09	782.3		
	B	2.75	34.25	1354.9	**1315.5**	**251.1**
		3.03	27.53	1699.1		
		2.97	20.17	1020.4		
		2.98	19.21	1187.5		

Table 8. ANOVA analysis results for DC(T) data and P-values associated with each source of variation.

Parameter	Source of Variation	P-value	Statistically Significant
Fracture Energy	Mix Source	5.71E-05	Yes
	Laboratory	8.11E-03	Yes
	Interaction	4.77E-01	No
Peak Load	Mix Source	2.28E-02	Yes
	Laboratory	2.17E-06	Yes
	Interaction	1.42E-02	Yes
Time of Peak Load	Mix Source	5.33E-04	Yes
	Laboratory	1.54E-01	No
	Interaction	9.41E-01	No

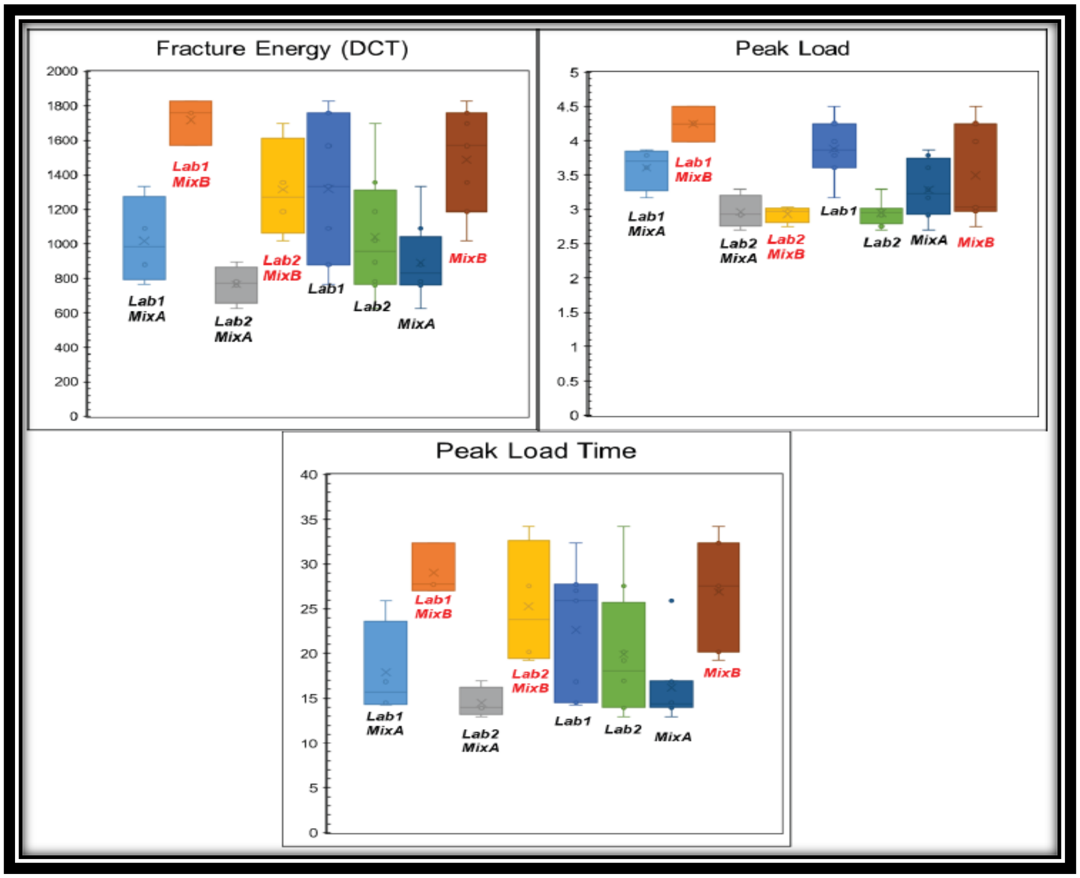


Figure 6. Box and Whisker diagrams for fracture energy, peak load, and time of peak load for mixes A and B

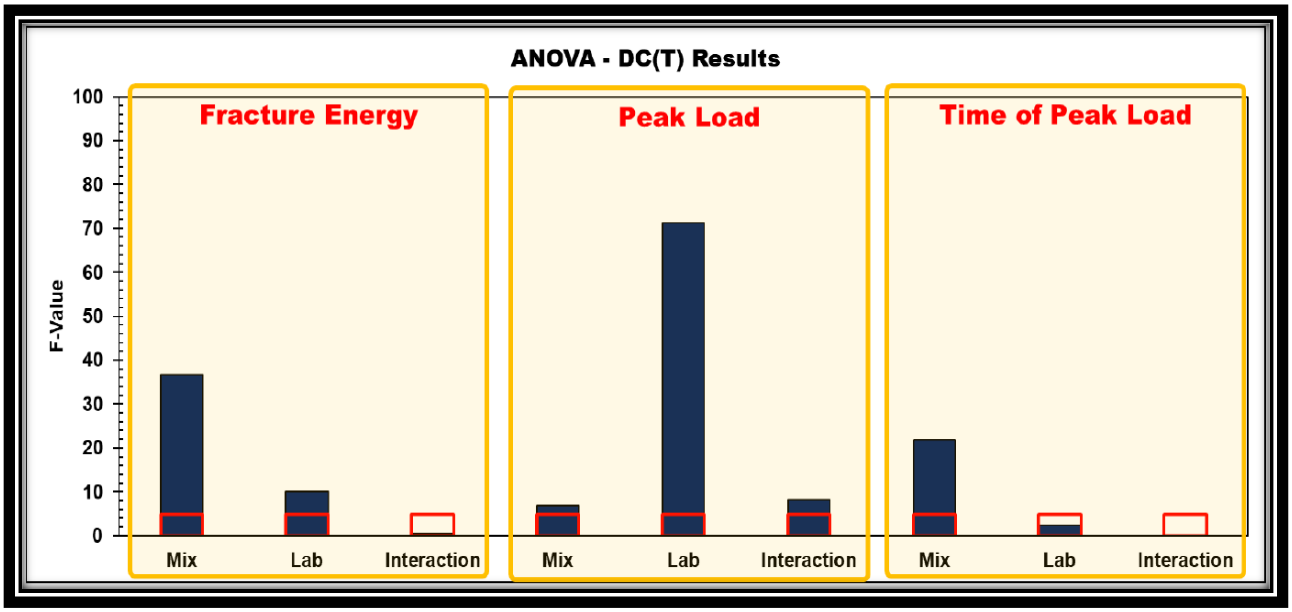
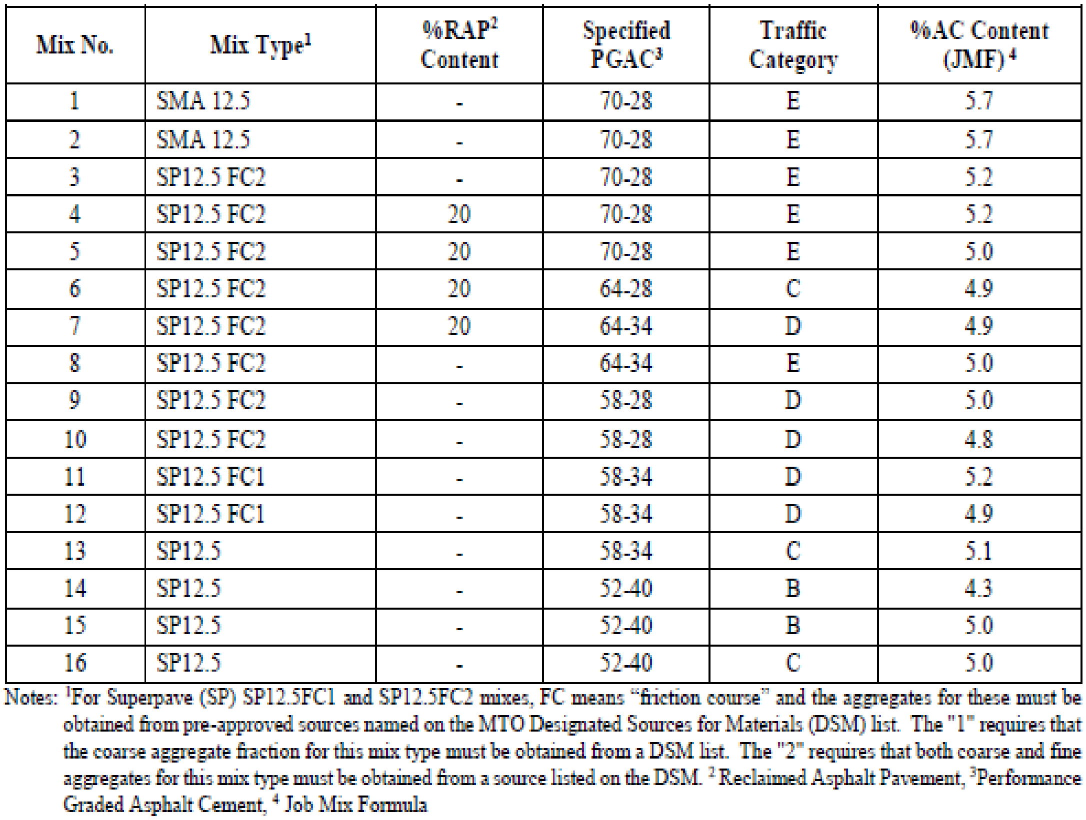


Figure 7. Graphical Representation of the Significance of the Source of Variation for DC(T) Parameters

3. DISCUSSIONS

The selection of these mixes was based on the idea that very stiff asphalt mixes, i.e., designed and produced with polymer modified asphalt such as PG 70-28XJ, would have issues with passing the set cracking criteria. Surprisingly, the mixes tested met the cracking criteria, but failed the rutting criteria, which is unexpected for a mix designed and produced with polymer modified PG 70-28XJ. This raised questions over whether this is a result to the mix design, testing parameters, PGAC formulation, or combination of all factors. The outcomes obtained from the HWT and SCB tests were utilized to construct a Performance Space Diagram (PSD). This diagram evaluates the response of a mixture to different loading conditions, specifically for rutting and fatigue distress. **Figure 8**, extracted from a paper authored by the Ministry of Transportation Ontario (MTO) and published in the Canadian Technical Asphalt Association Conference proceedings of the 2020s, illustrates the MTO's PSD. It was developed based on testing sixteen (16) representative asphalt mixes listed in **Table 9**, encompassing various types, traffic categories, and PGACs. This PSD was subsequently used to compare the performance of the mix tested by different laboratories in O-MAP Round-one with other benchmarked mixes in Ontario ***(see Figure 8)***.

Table 9. List of Sixteen (16) Mixes Used in MTO's Study in Developing PSD for Ontario Mixes



Mix No.	Mix Type[1]	%RAP[2] Content	Specified PGAC[3]	Traffic Category	%AC Content (JMF)[4]
1	SMA 12.5	-	70-28	E	5.7
2	SMA 12.5	-	70-28	E	5.7
3	SP12.5 FC2	-	70-28	E	5.2
4	SP12.5 FC2	20	70-28	E	5.2
5	SP12.5 FC2	20	70-28	E	5.0
6	SP12.5 FC2	20	64-28	C	4.9
7	SP12.5 FC2	20	64-34	D	4.9
8	SP12.5 FC2	-	64-34	E	5.0
9	SP12.5 FC2	-	58-28	D	5.0
10	SP12.5 FC2	-	58-28	D	4.8
11	SP12.5 FC1	-	58-34	D	5.2
12	SP12.5 FC1	-	58-34	D	4.9
13	SP12.5	-	58-34	C	5.1
14	SP12.5	-	52-40	B	4.3
15	SP12.5	-	52-40	B	5.0
16	SP12.5	-	52-40	C	5.0

Notes: [1]For Superpave (SP) SP12.5FC1 and SP12.5FC2 mixes, FC means "friction course" and the aggregates for these must be obtained from pre-approved sources named on the MTO Designated Sources for Materials (DSM) list. The "1" requires that the coarse aggregate fraction for this mix type must be obtained from a DSM list. The "2" requires that both coarse and fine aggregates for this mix type must be obtained from a source listed on the DSM. [2] Reclaimed Asphalt Pavement, [3]Performance Graded Asphalt Cement, [4] Job Mix Formula

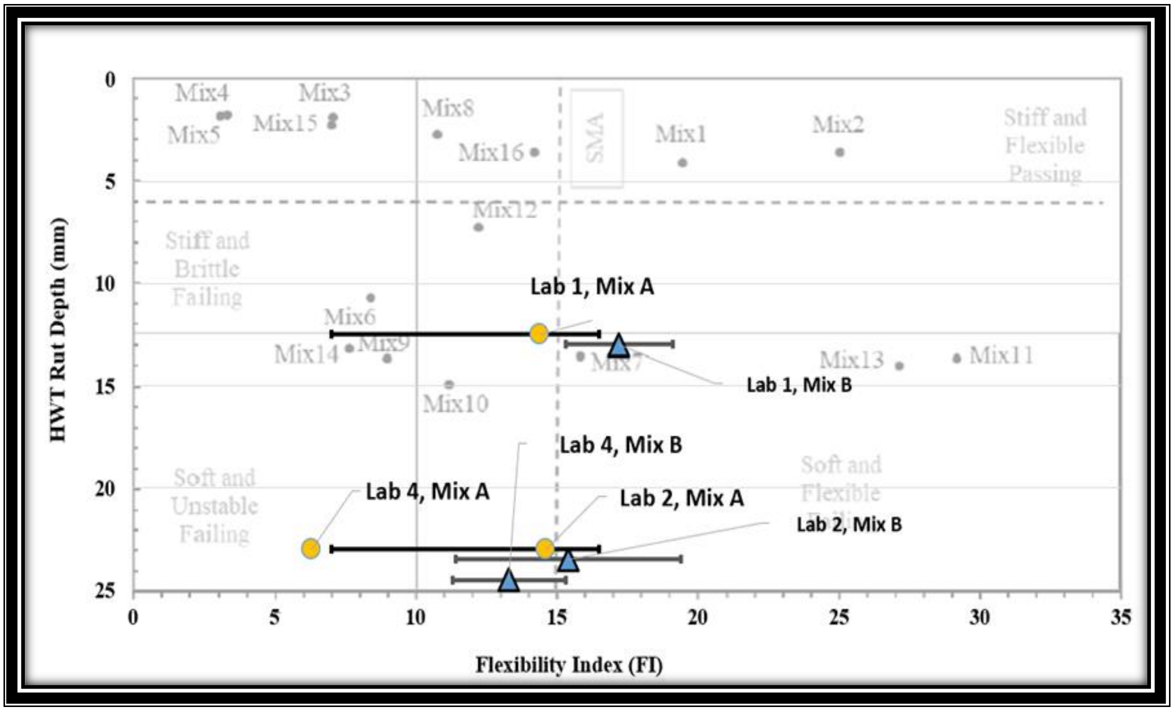


Figure 8. Results of OMAP Round 1 Superimposed Over Reference PSD Developed by the Ministry of Transportation Ontario After Evaluating Sixteen (16) Mixes of Conventional Mixes in Ontario in Terms Rutting Performance Versus Fatigue Cracking.

Most of the labs assessed the O-MAP Round-one mix(es) as unstable or flexible while being soft passing, when considering the average values of HWT and SCB. However, when accounting for one standard deviation from the average value (represented as error bars), there is still a significant degree of variability among the labs. The error bars indicate a 68% reliability level, assuming that the test results follow a normal distribution according to the three-sigma rule.

For three of the labs (Lab 1, 2, and 4), the error bars suggest a high probability of failing MTO's recommended thresholds for either HWT or HWT and SCB. This variability, if not properly understood, could have implications when applying the Balanced Mix Design (BMD) approach.

Furthermore, these mixes have not shown to be rutting in the field.

While it is surprising that none of the HWT samples passed the proposed criteria, two of the three labs which performed the test confirmed that Mix B had higher rutting resistance. This could be also somehow attributed to the lower asphalt binder content of Mix B. Both mixes are produced with polymer modified asphalt binder so it is possible that the differences are due to asphalt cement content, aggregate properties, or gradation, as such further verification is required. It was suggested that including asphalt mixes of different traffic categories would provide more valuable information to determining correlation with performance. It would be also wise to revisit the different approaches for interpreting the HWT results toward pass/fail criteria. This becomes, especially of importance if it is confirmed — through an expanded stage of the study — that the investigated mixes exhibit a good in-service rutting performance, but fail in the laboratory evaluation. Some U.S. agencies such as Iowa DOT and ILDOT have previously investigated the conditions for which each of the commonly used HWT parameters can be reliably used as a performance indicator.

The DCT testing favours Mix B, which becomes apparent when evaluating the low temperature binder properties. Although aggregate type and binder content do play a role in low temperature behaviour, the selection of the correct binder grade is still the primary factor which influences low temperature performance. This would suggest that binder specifications should take priority over low temperature testing of mixtures. Nonetheless, DCT, Bending Beam Rheometer test and ash content can be performed to assess the low temperature relaxation properties of the mix and to quantify the amount of deleterious additives in the asphalt binder, respectively.

3.1 Study Limitations

The primary limitation of this study was the small sample size selected for study due to financial constraints. The small sample size makes it difficult to establish meaningful trends about what is driving performance, which binder and mix properties are related as well as the true nature of the inter-laboratory variability. The sample size limitation has also prevented the team from performing additional detailed verification testing that was found to be informative upon reviewing the preliminary results obtained during this first phase of the study. This project is also impacted by inclusion of relatively large number of different mix properties. The mixes tested have different asphalt cement contents, different asphalt cement sources, different gradations, and different aggregate sources. These are all known through literature to have an impact on the different aspects mix performance being studied. The differences in binder formulation are also apparent and significant enough to impact the binder properties measured. The high degree of confounding factors makes it difficult to understand what is driving differences in test values. The success of adopting performance testing relies on the ability of contractors and agency to understand how to meet performance criteria. However, this small-scale round was trying to simply evaluate how Ontario industry is performance ready and establish an understanding of laboratory readiness for the purpose of performance testing. The ability of the asphalt expert group members to monitor and evaluate the field performance of these mixes will also help in achieving the long-term goals of the O-MAP and provide better insight about the ability of the different performance tests to characterize asphalt mixes to ensure the durability of asphalt pavements in Ontario.

CONCLUSIONS, AND RECOMMENDATIONS FOR FUTURE WORK

Testing in this study was performed on two SP12.5 traffic category “E” plant-produced mixes containing PG70-28XJ meeting OPSS 1101. The findings reinforce a fact that, the success of adopting performance testing in Ontario, is reliant on the ability of both the owner-agency and industry’s understanding of how to establish and meet the performance criteria. When the mixes were plotted on a Performance Space Diagram (PSD) used by MTO, the mix testing results suggest both mixes are “soft, failing” or “soft and unstable”. This contradicts multi-year field performance of these mixes, as tracked and reported by the mix donators. The HWT requires fabrication of 60 mm ± 1 mm thick specimens for testing purposes. Samples are fabricated using a Superpave Gyratory Compactor (SGC) compacting to height, while targeting a range of air voids controlled by the sample weight. Based on literature findings, it is believed that different SGCs can only maintain variability and repeatability in producing field representative samples if specimen height is maintained within 115 mm ± 5 mm *(height used in Superpave method of design, Level 1 “volumetrics only design”)*. Consequently, Further investigation is strongly recommended to understand the effect of changing height on reliability of SGCs used in the province and their differences could further introduce a significant source of variation related to “within” and/or “interlaboratory” coefficient of variation (COV).

Furthermore, based on the identified study limitations, several questions pertaining to effect of mix properties, testing parameters, PGAC formulation, testing equipment/fixture differences, or combination of all these factors should be investigated.

The study recommends developing experimental programs where a high degree of control can be exerted over variables of interest, and ability of segregating each variable effect on test’s COV. Certainly, study of sample height change on fabrication variability is the first and important variable to be considered.

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