ONTARIO ASPHALT EXPERT TASK GROUP (OAETG)

EXECUTIVE SUMMARY PREPARED FOR ORBA-OAPC MEMBERS

SUBJECT: OAETG Mix Asphalt Program (O-MAP) Round 2 – Results

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Introduction

The Mix Asphalt Program (MAP), created by the Ontario Asphalt Expert Task Group (OAETG), was designed with specific objectives in mind. These objectives include addressing the knowledge gap in performance testing experience within Ontario, understanding the risks associated with quality assurance acceptance by examining the sources of variability inherent to the performance tests of interest and inter-laboratory fabrication.

The OAETG selected the Hamburg Wheel Tracking (HWT) test, Semi-Circular Bend (SCB) Flexibility Index (FI) test, and Disk-Shaped Compact Tension (DCT) Test as the methods to be used in **Round 2** of the study. The testing focused on one mix obtained from the **MTO's Superpave Hot Mix Inter-Laboratory Testing Program [Round 4].** This summary presents important findings from the testing conducted thus far and utilizes the current work to provide suggestions for future projects.

Project Limitations

To provide context for the analysis presented in this summary, it is important to discuss the limitations associated with this project. The primary limitation stems from the small sample size used for the study, which was due to financial constraints. The limited number of samples makes it challenging to identify meaningful patterns regarding performance drivers, the relationship between binder and mix properties, and the true nature of inter-laboratory variability. Additionally, this project is affected by the inclusion of a relatively large number of different mix properties.

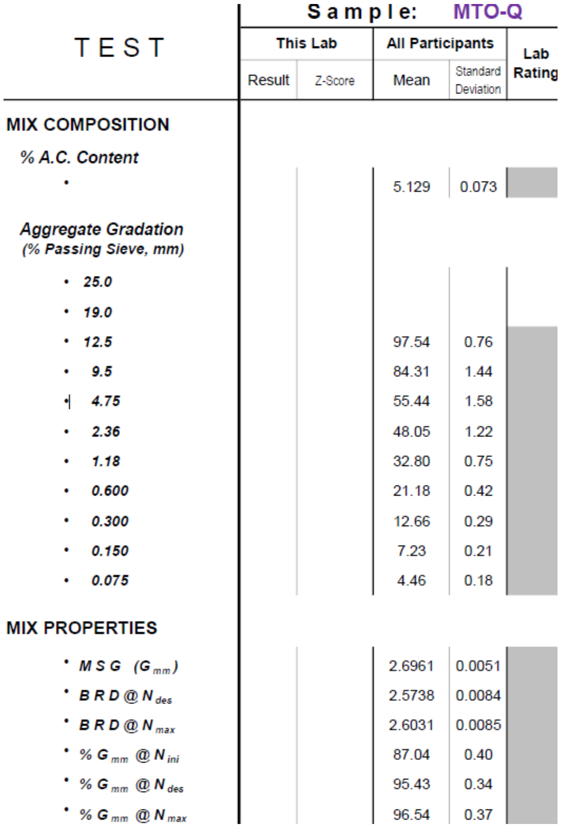
The specific design of the mix tested was unknown to the OAETG, with only the traffic category, extracted gradation, and extracted AC content being known physical properties. The grading of Recovered Asphalt Cement was not included in this round due to financial limitations. The presence of numerous confounding factors complicates the understanding of what influences the differences in test values. These limitations can be further tackled at the level of our joint MTO-OAPC Hot Mix Paving Technical Committee.

The success of implementing performance testing relies on contractors and agencies' ability to comprehend and meet performance criteria. However, this small-scale round aimed to evaluate the **preparedness of the Ontario industry in terms of performance and establish an understanding of laboratory readiness for performance testing, similar to the focus of O-MAP Round 1.**

Mix Testing Results

To ensure that a mix known to the Ministry was selected for future conversations and program’s transparency, the OAETG collaborated with PNJ Engineering Inc. (PNJ), with the permission of MTO, to collect a minimum of 20 boxes of loose mix during the correlation sample collection (Round 4, MTO-Q). PNJ was responsible for collecting all the boxes, which were then transferred to their laboratory in Mississauga. The samples were tagged by the OAETG chair, Sina Varamini, and the OAPC/ORBA Representative, Doubra Ambaiowei, before being distributed to the participating laboratories. Engtec Consulting Inc. provided an in-kind contribution by assisting in the distribution of samples to the labs.

The properties of the mix that was tested are provided below (Figure 1), as shared by MTO with OAPC/ORBA upon request. Overall, the mix indicates a heavy-duty mix, likely belonging to the FC2 category. The OAPC/ORBA has informed the OAETG that the Performance Grade Asphalt Cement (PGAC) for this mix is 70-28XJ, and it is possibly designed for traffic category "D".



TEST	Sample: MTO-Q				
	This Lab		All Participants		Lab Rating
	Result	Z-Score	Mean	Standard Deviation	
MIX COMPOSITION					
% A.C. Content					
•			5.129	0.073	
Aggregate Gradation (% Passing Sieve, mm)					
• *25.0*					
• *19.0*					
• *12.5*			97.54	0.76	
• *9.5*			84.31	1.44	
• *4.75*			55.44	1.58	
• *2.36*			48.05	1.22	
• *1.18*			32.80	0.75	
• *0.600*			21.18	0.42	
• *0.300*			12.66	0.29	
• *0.150*			7.23	0.21	
• *0.075*			4.46	0.18	
MIX PROPERTIES					
• MSG (G_{mm})			2.6961	0.0051	
• BRD @ N_{des}			2.5738	0.0084	
• BRD @ N_{max}			2.6031	0.0085	
• % G_{mm} @ N_{ini}			87.04	0.40	
• % G_{mm} @ N_{des}			95.43	0.34	
• % G_{mm} @ N_{max}			96.54	0.37	

Figure 1. Mix properties of the mix included in O-MAP Round 2 (Information provided by Gelu.V at the MTO)

Statistical Evaluation of Mix Performance Test Results

The mix was distributed to nine (9) different laboratories for performance testing, including the Disk-Shaped Compact Tension (DC(T)) test, Semi-Circular Bending (SCB FI) test, and Hamburg Wheel Tracking (HWT) test. Initially, IDEAL-type testing was also planned, but it was discovered that the labs assigned for IDEAL testing were not sufficiently familiar with data processing. Therefore, IDEAL testing was temporarily put on hold until the OAETG develops a spreadsheet to assist the labs in calculating the CT-index and RT-index.

Despite the small sample size, the collected data was analyzed using the Analysis of Variance (ANOVA) method, which yielded significant findings. These findings are presented through graphical representations that show the mean (average) and spread of the dataset, along with the associated standard deviation. These visualizations provide a clearer understanding of the variability in testing outcomes across the participating labs.

Figure 1 illustrates the range of measurements obtained by each lab for the Flexibility Index. The analysis reveals that, overall, the mix exhibits flexibility and meets the minimum threshold proposed by MTO, although the specific threshold may vary depending on the testing lab. Most labs passed the sample, while one lab failed the mix. It should be noted that Lab 2, despite passing the mix, still has a chance of failing according to MTO's threshold. This analysis highlights the presence of variability in the SCB test results that requires further investigation. This variability could be attributed to several factors, among others.

Variations in laboratory approaches for pre-conditioning the sample prior to compaction can contribute to the observed variability. Labs may employ different methods, such as a combination of microwave and conventional oven, or solely rely on an oven. Some labs might choose to superheat the oven to expedite reaching the compaction temperature. It is important to note that these steps are not specified in the AASHTO procedure for the test and are not controlled by LS methods. Additionally, there are differences in the testing equipment used for applying compressive force during the test. Some labs utilize screw-driven equipment, while others opt for hydraulically controlled equipment. The housing of testing equipment and fixtures also varies among labs. Some labs house the equipment and fixture within an environmental chamber, while others condition the samples in an external chamber. Furthermore, the type of cutting saw used for creating the notch in the samples can differ among labs, which can also contribute to variability in the test results.

The results of the Hamburg Wheel Rut test also demonstrated variability. **Figure 2** illustrates the variation observed among the labs when evaluating rut depth after 20,000 passes at the central point of the mold, equivalent to a 100mm wheelpath.

Figure 3 presents the DCT data, which exhibits relatively consistent results between the two labs capable of performing the DCT test. However, it is important to note that drawing definitive conclusions from these results is limited due to the restricted number of labs involved in the testing.

It should be highlighted that, in general, asphalt mixes in Ontario tend to exhibit soft-passing behavior when tested using DCT.

This can be attributed to the stringent requirements outlined in OPSS 1101 (MUNI & PROV), which mandates the use of binders that are typically softer than the -YY specifications required for the climate zone. As a result, the mixes developed in Ontario are softer than what the climate zone necessitates. Nevertheless, these softer mixes generally perform well in terms of Fracture Energy (FE) and meet the minimum requirement of 600 FE proposed by MTO.

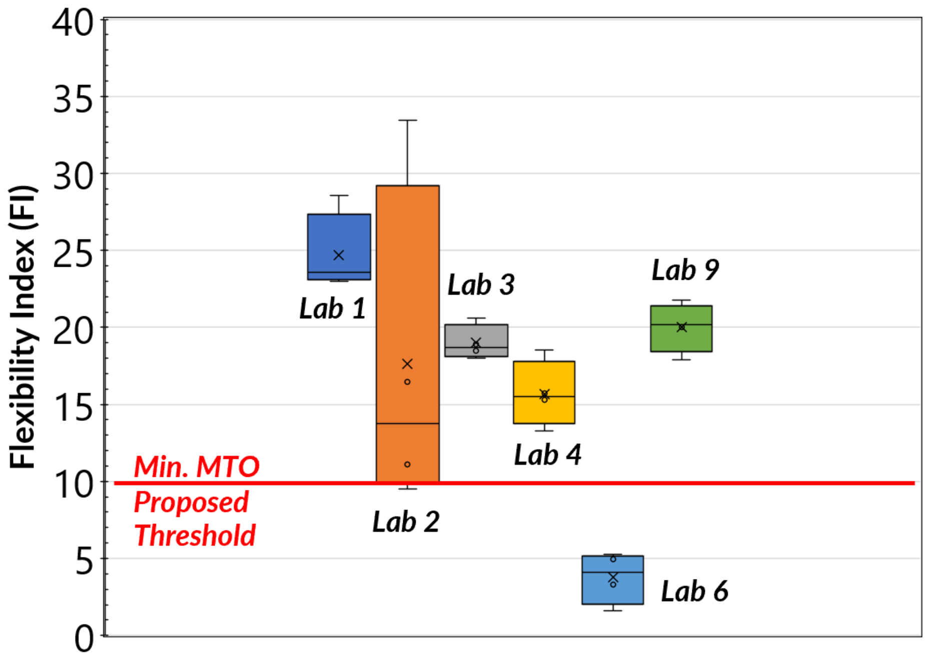


Figure 1 Graphical representation of SCB Results

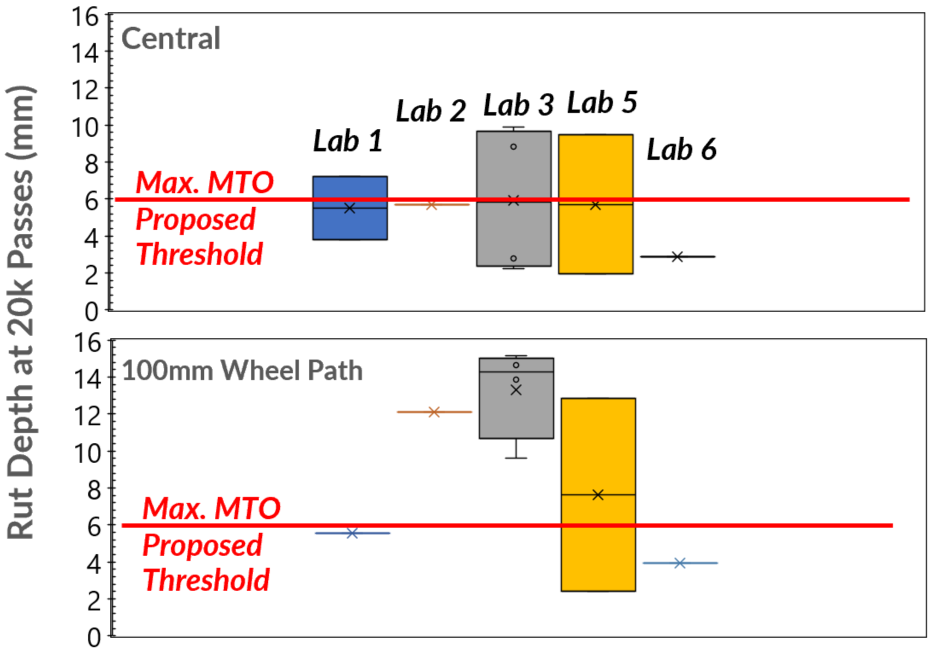


Figure 2 Graphical representation of HWT Results

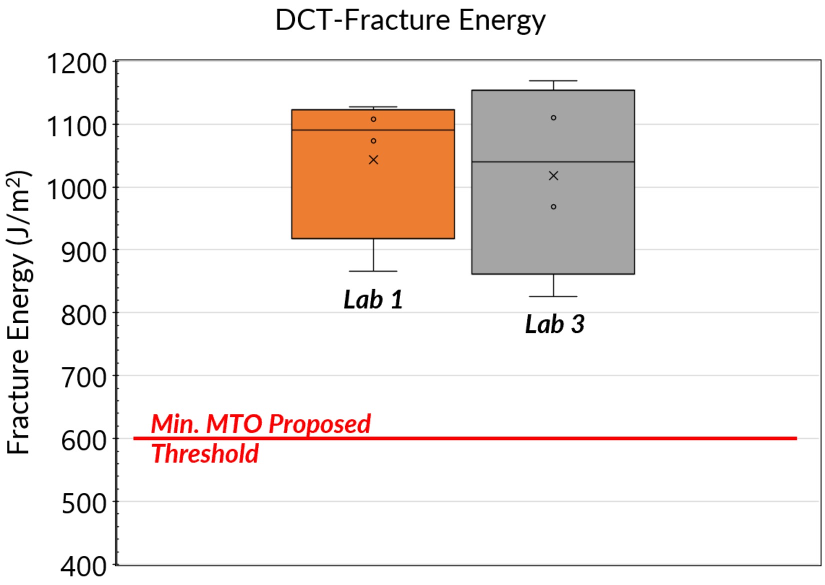


Figure 3 Graphical representation of DC(T)

<u>The data presented highlights a significant level of uncertainty in the results, suggesting that different laboratories may rank mixes differently depending on the specific test and parameters being examined</u>. This level of variability is similar to what was observed in Round 1 of O-MAP. It is evident that the laboratory itself plays a significant role in contributing to this variability, indicating a need for enhanced experience and training in testing methods.

This observation can be further supported by examining specific details from individual labs, such as the average notch length for SCB and other specimen parameters. To address these issues and reduce uncertainty, <u>future work should consider incorporating training programs for technicians or exploring alternative test methods that may have simpler preparation procedures.</u>

One approach to mitigate uncertainty in future projects could be to assign a single lab with the responsibility of preparing all the specimens. This would help standardize the preparation process and provide an opportunity to evaluate the factors driving differences in laboratory results.

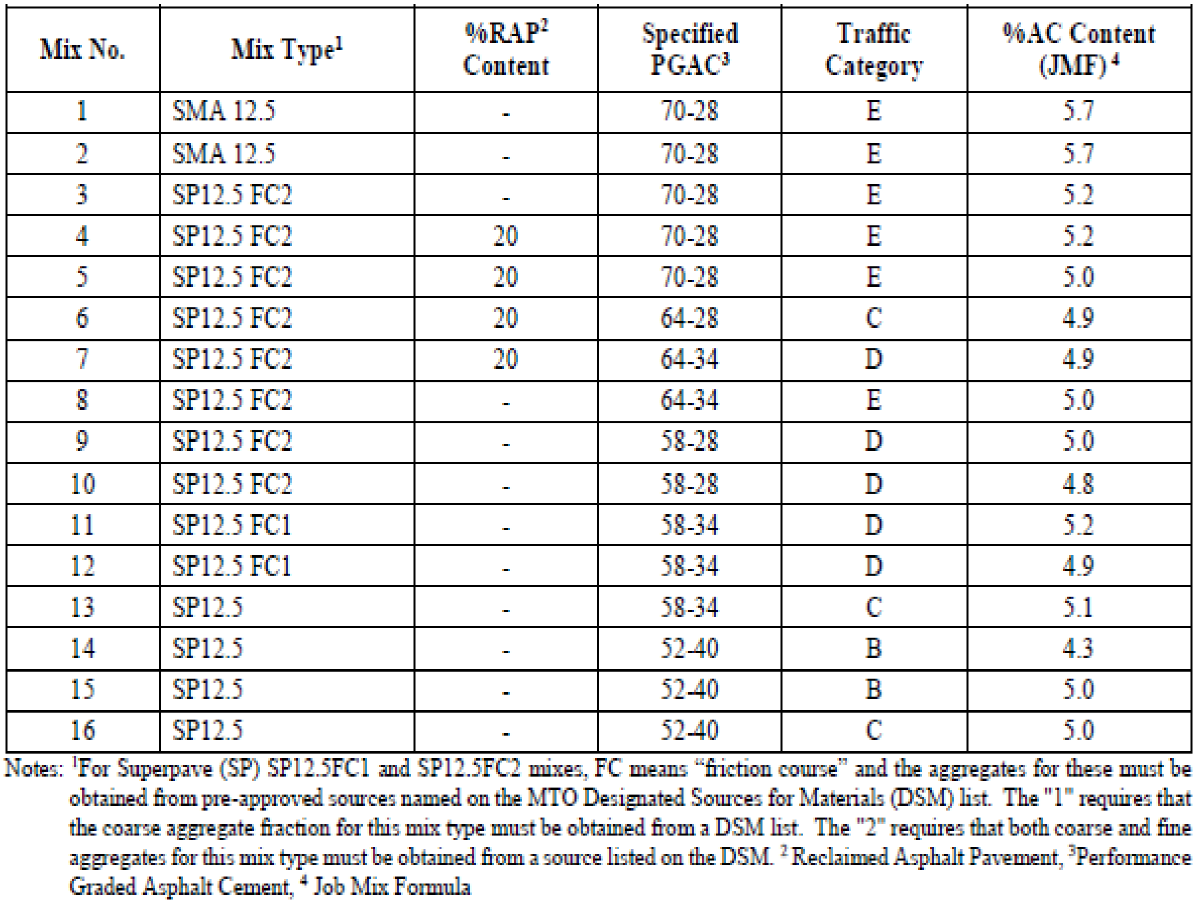
Performance Space Diagram (PSD)

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 4, 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 1, encompassing various types, traffic categories, and PGACs. This PSD was subsequently used to compare the performance of the mix tested by different laboratories in OMAP Round 2 with other benchmarked mixes in Ontario (Figure 4).

Most of the labs assessed the OMAP Round 2 mix as a well-balanced mixture when considering the average values of HWT and SCB, with the exception of Lab 6. 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 6), 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. For instance, Lab 6 might be a contractor's laboratory or a service provider hired by a contractor to implement BMD for a performance-verified or performance-based mix design. Lab 6's results might indicate a stiff and brittle mix that requires further performance balancing, while an independent quality assurance testing facility like Lab 9 may classify the mix as passing the stiffness and flexibility criteria. Unaware of this discrepancy, Lab 6's results could mislead the mix designer into increasing the asphalt content, for example, to enhance the SCB performance. However, this adjustment may result in excessive asphalt content, leading to instability, premature rutting, or bleeding in the mix. Consequently, the mix could be characterized as either failing the softness and flexibility criteria or failing due to softness and instability.

Table 1 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

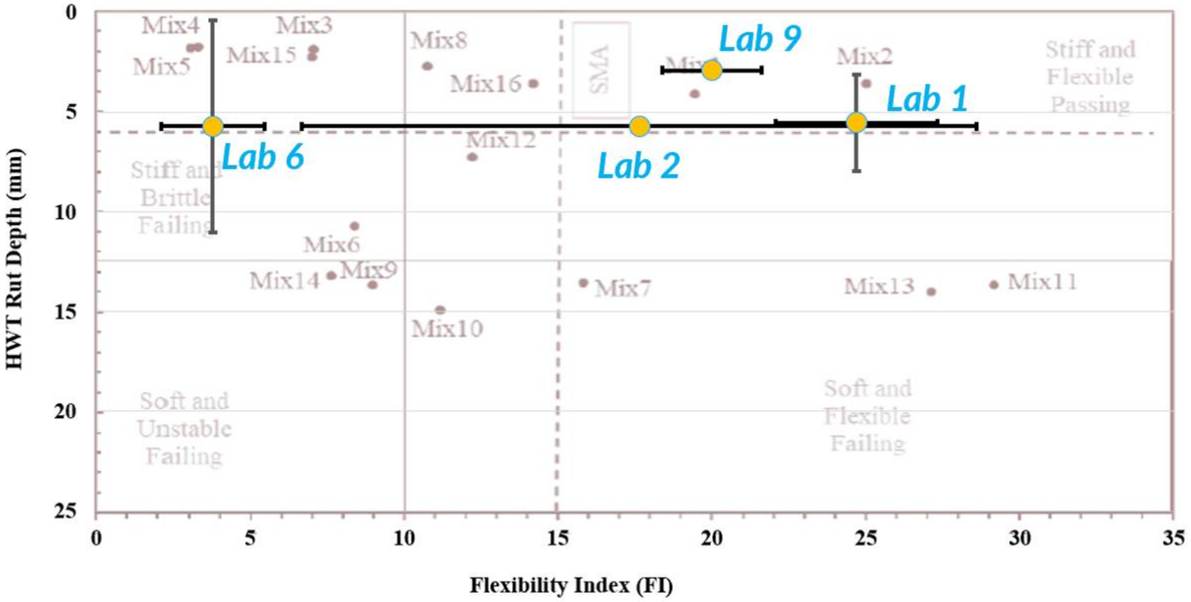


Figure 4 Results of OMAP Round 2 Superimposed Over Reference PSD Developed by the Ministry of Transportation Ontario After Evaluating Sixteen (16) Mixes of Conventional Mixes in Ontario in Terms Rutting Performance Versus Fatigue Cracking.

Recommendations for Future Work

Based on the discussions presented in this summary, the OAETG proposes several suggestions for future work. These suggestions aim to highlight multiple ideas that can contribute to the advancement of knowledge and practical applications. It is important to note that these ideas are considered essential for future experimental programs, but they are not listed in any order. Priorities may be adjusted as new information becomes available:

1. **Investigate the impact of different mix variables on performance.**
2. **Understand the differences in gyratory compactors and their relationship to specimen fabrication and testing variability.**
3. **Foster a shift within the industry towards a mix performance mindset.**
4. **Place greater emphasis on testing laboratory-produced mixes as part of the mix design stage.**
5. **Establish a performance test correction factor between laboratory and plant-produced mixes.**
6. **Explore a test method with simpler sample preparation, such as IDEAL CT & RT, for performance testing of quality assurance samples.**
7. **Examine the sensitivity of test results to temperature variations in performance testing.**

The OAETG recommends developing experimental programs in collaboration with the MTO, where a high level of control can be exerted over the mix variables of interest. Ideally, this plan would focus on laboratory testing, but also provide an opportunity to study the design phase of the process. Regardless of the agency's interest in plant-produced mixes, most design work begins with laboratory testing.

Understanding this phase of the process is crucial for comprehending how different variables influence performance for ORBA-OAPC contractor members. Once this understanding is established, it is important to study the differences between laboratory and plant-produced mixes. Contractors must ensure they can replicate laboratory mixes at the plant to avoid potential quality assurance issues in the future.

Collecting data on the key concepts outlined here is critical for enhancing the ability of ORBA-OAPC members to design, troubleshoot, and innovate mixes moving forward. The data collected will hold significant value when engaging in discussions with various agencies. However, it is essential to develop more extensive testing plans to maximize the value of the collected data.