Newfoundland Labrador

Government of Newfoundland and Labrador
Transportation and Infrastructure
Materials Engineering Division

January 5, 2023

Mr. Corey Grandy
Deputy Minister of Transportation and Infrastructure
Government of Newfoundland Labrador
Confederation Building, 5th Floor West Block
St. John's, NL A1B 4J6

Dear Mr. Grandy:

Please find enclosed a report detailing the results of a trial project completed in 2017 to analyze the effect of different Performance grade binders and Marshall air voids on pavement performance.

The report provides details of the project including the original design and construction data and post construction data. It also summarizes some preliminary performance conclusions and lessons learned. It is important to note that the report only includes post construction data up to 2021. The automatic road analyzer vehicle that collects rutting and roughness data was unavailable in the fall of 2021. A new system for data collection was purchased in the spring of 2022, however with advancements in technology the new system measures smaller rut depths (is more accurate). Correlating this new data with the older data then becomes more challenging as the increase in data collected will drive the average down over the sections. In addition, due to failing infrastructure, a culvert was replaced within one of the trial sections in 2022.

This project only analyzed two parameters of an asphalt mix design, Performance Grade binders and Marshall air void contents, however there are other parameters that are essential to the development of a quality asphalt mix. Polymer modified binders have been used in high traffic environments since 2010 by the Department. Through continuous bi-yearly rut depth monitoring there has been an improved pavement life expectancy of functional mill and fill projects. Materials Engineering continues to monitor and analyze data and ensure necessary hot mix asphalt design changes are made to reflect the needs of the varying environmental and traffic conditions encountered in the province. It is highly recommended to continue the use of polymer modified binders and existing industry recommended volumetric principals to design asphalt pavements in Newfoundland and Labrador.

Sincerely,

LBennett

Laura Bennett, P.Eng.
Manager of Materials Engineering

TRANSPORTATION AND INFRASTRUCTURE

127-16 THP

TRIAL WEAR PROJECT

SUMMARY OF RESULTS

ABSTRACT

In response to a Construction industry request, a trial project was initiated with the objective to analyze asphalt mix designs with different Performance Grade binders at varying Marshall air void contents.

The materials utilized and the asphalt mixes produced met the requirements of the Department of Transportation and Infrastructures specifications, with the exception of those mixes produced targeting 1% Marshall air voids. Industry recommended guidelines state it is not advisable to produce mixtures with very low Marshall air voids or extremely low in-place air voids as it opens up an array of potential quality issues including plastic deformation and friction concerns.

While only a short period of time (in terms of overall expected service life) has elapsed since initial construction the following report summarizes and discusses the data collected for these areas. Preliminary trends show polymer modified binders at 2.5% Marshall Air Voids, to outperform conventional binder grades, which is expected due to their improved performance characteristics and historical success within the industry. The utilization of polymer modified binders on high traffic roadways has been required by the Department of Transportation and Infrastructure for numerous years. There also appears to be an increase in rut depth associated with the conventional binder grades and areas with low air voids. It appears decreasing Marshall air voids are associated with increased rut depth.

However, the selection of the trial areas did not offer a continuous straight path and it does become difficult to analyze data on curved sections of roadways as roadway users drive the curve radius' differently. As such data analysis can be more difficult as the trial sections do not have similar geometry.

This project was intended to analyze two parameters of an asphalt mix design. However, there are more parameters that are essential to the development of a quality asphalt mix and unfortunately there is no one best fit solution.

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1.0 INTRODUCTION

The Trans-Canada Highway (TCH) is considered one of the most challenging environments for the Department of Transportation and Infrastructure (TI), due to the combination of high traffic volume, heavy truck loads and high speeds. In response to this challenging environment TI has paid close attention to the pavement performance.

In 2017, five trial wear areas, approximately 4.75 km, were paved on the TCH within the Avalon Region. The trial wear areas were constructed in response to a Construction industry request to evaluate different Performance Grade (PG) binders with varying Marshall air void contents.

Asphalt binder is the cement that holds the components of an asphalt mixture together and are categorized based on a Performance Grade (PG) system that was developed by the Strategic Highway Research Program. PG binder physical properties are influenced by high and low environmental temperatures. Binders are selected to ensure that they resist plastic/permanent deformation at high temperatures, while also resisting cracking at low temperatures. They are graded to ensure the physical requirements are met in accordance with their average 7-day maximum pavement design temperature and minimum pavement design temperature. Asphalt binders can also be modified with a polymer to enhance a PG binders performance characteristics such as resistance to fatigue, rutting, stripping, thermal cracking and temperature susceptibility.

Air voids are pockets of air that exist within a compacted asphalt mix and are a function of the durability of a mix. Asphalt mixtures are designed in Newfoundland and Labrador (NL) using the Marshall mix design procedure according to the Asphalt Institute Manual. The Marshall mix design method was developed in the late 1940's and is an accepted asphalt mix design method. Specimens are compacted in the laboratory using a Marshall hammer, which determines the mixtures bulk density and Marshall air voids at varying asphalt binder contents. In theory, the degree of compaction would replicate the in-place compaction of a roadway after multiple years in service.

Mixtures with in-place air void contents that are too high can produce pavements with decreased stiffness, accelerated aging, raveling, and increased moisture damage. Mixtures with in-place air void contents that are too low can produce pavements with flushing/bleeding and plastic deformation. Various sources indicate that the in-place air voids in a compacted Hot Mix Asphalt (HMA) should not be less than 3.0% and no more than 8.0%.

Asphalt mixture design details, field data and ongoing test data from the trial project have been summarized and are presented in the following sections. Trial sections have been continually tested for smoothness and rut depth profiles since construction. Based on the information gathered preliminary performance conclusions are discussed in addition to lessons learned from this trial project.

2.0 Trial Wear Project

In response to a Construction industry request to further evaluate pavement performance, with respect to lower Marshall air voids, the Department conducted this trial project.

The trial wear area project was an addendum to project 127-16 THP: Cold planing and repaving various sections of Route 1 Trans-Canada Highway in the Avalon Region including the Outer Ring Road, Route 75 Veterans Memorial Drive, Route 2 Pitt's Memorial Drive and Route 3 Robert E. Howlett Memorial Drive as well as repairs to the Topsail Road overpass in the west bound lanes of the Outer Ring Road. The construction of the trial wear areas consisted of cold planing the existing roadway, the application of tack coat and repaving using asphalt mixtures with varying PG binders and Marshall air void contents.

2.1 Location Information

The highway trial areas were selected from the TCH area that was already planned for resurfacing in 2017. The areas are located in the right West Bound lane, between the TCH intersection of Route 61 (Foxtrap Access Road) and Butter Pot Provincial Park as indicated in Figure 2.1.1 below.

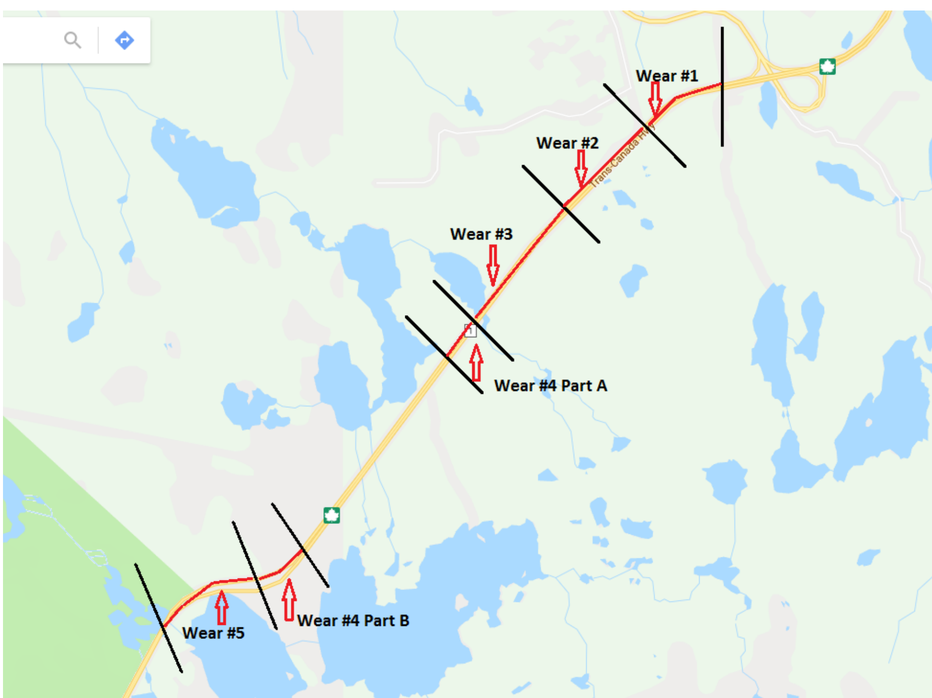


Figure 2.1.1: Trial Wear Areas

The stations for the beginning and end of each of the trial wear areas, as well as the approximate length are presented in Table 1.

Table 1: Trial Wear Area Stations

Trial Wear Area	Beginning Station	End Station	Approximate Length (m)
1	31 + 250	32 + 140	890
2	32 + 140	33 + 080	940
3	33 + 080	34 + 060	980
4 Part A	34 + 060	34 + 527	467
4 Part B	36 + 200	36 + 737	537
5	36 + 737	37 + 678	941

This section of the TCH is classified as a RAD 100, high class highway with a maximum speed of 100 km/hr and an average daily traffic volume of approximately 17,474 vehicles.

3.0 DESIGN AND CONSTRUCTION

The tender for the project was awarded to Concord Paving Ltd. in May of 2017 and Municipal Construction was subcontracted to support the project. The asphalt mixture designs, materials testing and Quality Control (QC) testing was completed by DMG Consulting Limited.

3.1 PRELIMINARY PHYSICAL PROPERTY TESTING

The source of the asphalt aggregate for the trial wear areas originated from a quarry located off the TCH operated by Municipal Construction. The material consists of quarried rock that was blast from natural rock formations, crushed and graded to meet the requirements of the high class surface course asphalt envelope. The material was crushed into two different sizes, material with diameter greater than 4.75 mm, commonly referred to as +1/4 inch and material with diameter less than 4.75 mm, commonly referred to as -1/4 inch. The blend sand required for the asphalt mix was imported from Terra Nova pit, a natural sand deposit, located in the Central Region of the island.

Aggregate accounts for the majority of an asphalt mixture and a durable material is required to support traffic loading. All materials utilized in asphalt mixtures must meet the physical properties requirements outlined in TI's Highway Specification Book. Required testing included particle shape and gradation, texture, toughness, resistance to weathering and the presence of deleterious substances. High traffic environments and surface asphalt pavement courses have the most stringent requirements as they are required to withstand greater traffic imposed stress and wear. Course aggregate, fine aggregate and blend sand samples were tested as per the respective ATSM, CSA or AAHSTO standards and the results are provided in Appendix A.

The results indicate that the materials utilized in the asphalt mixes met the specified physical property requirements.

3.2 ASPHALT MIXTURE DESIGNS

Asphalt mixture designs were submitted to TI's Materials Engineering Division (MED) for review. The mix designs were required to meet the minimum/maximum physical property requirements for asphalt mix as outlined in Table 2 below, with the exception of those mixes targeting 1.0% Marshall air voids.

Table 2- Physical Requirements for Asphaltic Concrete Mixtures

	Minimum	Maximum
MARSHALL STABILITY AT 60^{O}C (N) (I) FOR HIGHWAY CLASSIFICATIONS RLU-60, RLU-70, RLU-80 (II) FOR HIGHWAY CLASSIFICATIONS RAU & RAD-100, RAU & RAD-90, RCU-80	5 400 8 000	NA NA
MARSHALL FLOW INDEX (MM)	2.5	4.25
AIR VOIDS (%) (I) FOR All HIGHWAY CLASSIFICATIONS RLU-60, RLU-70, RLU-80, RAU & RAD-100, RAU & RAD-90, RCU-80	2.5	4.5
VOIDS IN COMPACTED MINERAL AGGREGATES (%) (I) LEVELING & BASE COURSE (II) SURFACE COURSE	14.0 15.0	NA NA
MODIFIED LOTMAN AASHTO T283 - TENSILE STRENGTH RATIO (PLUS VISUAL) 330.02.01.05	0.8	NA
PERCENTAGE RETAINED COATING OF AGGREGATE - BOILING WATER TEST ASTM D3625 (%)	95	NA
MOISTURE CONTENT OF HOT MIX ASPHALT BY OVEN METHOD, AASHTO T329 AS PERCENT OF HMA (%)	NA	0.3

The Contactor provided surface course mix designs for three of the specified asphalt binders. A summary of the mix designs for each trial wear area is provided in Table 3 below. Asphalt mix designs for trial wear areas 2 and 4 were not provided.

Table 3- Asphalt Mixture Designs for Trial Wear Areas

Mixture Properties	Trial Wear Area				
	1	2	3	4 Part A/B	5
PG Binder	64-34 PMA	64-34 PMA	64-28 PMA	64-28 PMA	58-28
Bitumen Content, %	6.5	-	6.65	-	6.65
Bulk Specific Gravity	2.346	-	2.383	-	2.416
Marshall Stability, kN	12.8	-	8.7	-	11.5
Marshall Flow, mm	4.0	-	3.6	-	3.1
Mix Design Marshall Air Voids, %	3.5	-	2.6	-	1.5
Voids in Mineral Aggregate, %	17.5	-	16.3	-	15.2
% Passing 19.0 mm	100	-	100	-	100
% Passing 12.5 mm	98.2	-	98.2	-	98.2
% Passing 9.5 mm	88.9	-	88.9	-	88.9
% Passing 4.75 mm	60.1	-	60.1	-	60.1
% Passing 2.00 mm	40.4	-	40.4	-	40.4
% Passing 0.425 mm	20.6	-	20.6	-	20.6
% Passing 0.150 mm	9.0	-	9.0	-	9.0
% Passing 0.075 mm	4.2	-	4.2	-	4.5

3.3 CONSTRUCTION

In preparation for paving, the trial wear areas were milled to an approximate depth of 50 mm using a cold-milling machine. Removal was completed on the right side of the west bound lane of the TCH for the full lane width. The milling operation and tack coat application took place on October 21, 2017 and the areas were cleaned prior to the application of tack coat.

Tack coat consisted of a Catatonic Rapid Setting (CRS-1) emulsified asphalt. A sample of tack coat was collected by the Contractor on August 15, 2017 and submitted to TI for compliance testing. Quality assurance (QA) testing of the tack coat was completed and tested against the requirements of ASTM D2397 "Standard Specifications for Cationic Emulsified Asphalt." The results of this testing met the minimum requirements with the exception of demulsibility as presented in Appendix B. Demulsibility is a measure of the rate in which the asphalt and water separate from the emulsion and set on the roadway. However, the chemical used in the test may not be as effective with very rapid setting tack coat due to the products emulsifier. This appears to be a testing issue as no performance issues were noted in the field and the tack coat was breaking at an appropriate rate.

Asphalt placement for the five (5) trial sections took place on October 24 and October 25, 2017. Approximately 2468 tonnes of asphalt was supplied and placed from Municipal Construction's TCH Plant during the two day operation.

4.0 POST CONSTRUCTION EVALUATION

4.1 FIELD TESTING DATA

QC field testing was completed by the Contractors' materials consultant and QA field testing was completed by TI's materials inspectors. The QA testing was completed in a field laboratory provided by the Contractor located in TI's Avondale depot. Testing was completed in accordance with TI's specifications as outlined in the Highway Specification Manual.

As identified in the tender, 3 loose samples and 3 cores were taken from each trial section for testing. The loose samples were used to test the asphalt material properties and the extracted cores were used to test for compaction and thickness. The average of the QA test results for each trial area is presented in Table 4 below. A full summary of the QA testing results for each trial wear area is provided in Appendix C.

Table 4- Average QA Test Results for Trial Wear Areas

	Trial Wear Area				
	1	**2**	**3**	**4 Part A/B**	**5**
PG Binder	64-34 PMA	64-34 PMA	64-28 PMA	64-28 PMA	58-28
Target Marshall Air Voids, %	2.5	1.0	2.5	1.0	1.0
Bitumen Content, %	6.31	6.56	6.41	6.58	6.48
Bulk Specific Gravity	2.387	2.406	2.394	2.402	2.402
Marshall Stability, kN	10.1	11.8	12.4	14.3	13.3
Marshall Flow, mm	3.43	4.29	3.65	4.17	3.88
Actual Marshall Air Voids, %	2.25	1.35	2.55	1.29	1.78
Voids in Mineral Aggregate, %	15.9	15.4	15.8	15.6	15.6
% Passing 19.0 mm	100	100	100	100	100
% Passing 12.5 mm	98.9	98.6	98.5	98.5	97.2
% Passing 9.5 mm	87.7	87.9	87.7	87.1	85.3
% Passing 4.75 mm	58.9	59.4	59.6	59.4	57.7
% Passing 2.00 mm	36.7	37.9	37.5	37.8	37.1
% Passing 0.425 mm	20.1	20.6	20.6	21.0	20.7
% Passing 0.150 mm	8.7	8.6	8.9	8.6	8.7
% Passing 0.075 mm	4.3	4.2	4.4	4.3	4.3
Thickness, mm	49	47	52	49	48
Compaction, %	96.0	97.9	96.8	98.2	97.9

For trial wear areas 2 and 4, the Contractor increased the asphalt bitumen content in order to lower the Marshall air void content.

4.2 BINDER TESTING

The Department of Transportation and Infrastructure routinely use three different PG binder grades based on location and highway classification. PG 58-28 is mainly used across the island however, PG 64-34 PMA is utilized on high volume/high speed roadways for increased performance. Labrador uses a PG 58-34 PMA due to the temperature variations based on its location.

Three different PG binders were utilized in the trial areas, PG 64-34 PMA, PG 64-28 PMA and PG 58-28. The PG 64-34 and PG 64-28 are both polymer modified asphalt binders that contain a Styrene-Butadiene-Styrene (SBS) elastomer. As per the TI's Specification, a sample of each asphalt binder was collected by the Contractor and witnessed by a TI Department Representative. Those samples were then forwarded to a specialized laboratory, in Ontario, capable of performing PG binder classification testing. A summary of the temperature grading results are presented in Table 5 below and as indicated the binders met and exceeded the required grading. Complete test results for the binder testing are provided in Appendix D.

Polymer Modified binders have the ability to increase a binders elasticity at low temperatures, which is the ability for the asphalt binder to recover after a stress/load is removed. In order to determine the presence of the polymer an elastic recovery test is performed as per ASTM D6084 "Standard Test Method for Elastic Recovery of Asphalt Materials by Ductilometer". Both binders that contained SBS polymer met the minimum elastic recovery criteria specified in the contract documents.

Table 5- PG Binder Classification

Target PG Binder Grade	Actual PG Binder Grade
64-34	70-34
64-28	67.5-31.8
58-28	60.5-29.9

Testing for the addition of antistrip additive by Modified Lottman and Boiling Water Test was not completed for the trial wear areas. However, this testing was completed for other areas of the project on the PG 64-34 polymer modified asphalt (PMA) binder and the testing results met the minimum requirements.

4.3 SMOOTHNESS

The Department purchased an automatic road analyzer (ARAN) vehicle in the fall of 2007. The ARAN has a modular platform that was customized with the addition of longitudinal and transverse profile subsystems that are capable of collecting smoothness and rutting values. This data is supported by a locational referencing system through the utilization of a distance measuring instrument (wheel encoder) and a correction aided GPS system.

Pavement smoothness is a measure of overall pavement ride quality. The International Roughness Index (IRI) is the standard statistical measurement used to determine the amount of roughness (smoothness) in a longitudinal profile (driving direction). IRI measures the deviation from perfect flatness in millimeters per meter (mm/m) and is a good simulation of a vehicles response to the roadway. An IRI of 0 mm/m indicates absolute smoothness. Testing was conducted on the newly placed asphalt pavement in accordance with ASTM E950 "Standard Test Method for Measuring the Longitudinal Profile of Travelled Surfaces with an Accelerometer Established Inertial Profiling Reference". IRI values were recorded for the left and right wheel paths at 10 m intervals in the direction of traffic. The IRI for left and right wheel paths were averaged to obtain a value for each trial wear area. The average IRI values for each trial wear area prior to rehabilitation and for each year after construction are presented in Table 6 and the full left and right wheel path results are presented in Appendix E. It is important to note that the accuracy of the ARAN IRI data is ±0.1 mm/m.

Table 6- Average Bi-yearly IRI Values for Trial Wear Areas

Average IRI (mm/m)	Trial Wear Area				
	1	2	3	4 Part A/B	5
Spring 2017*	1.73	1.13	1.72	1.44	1.66
Fall 2017	0.60	0.55	0.66	0.54	0.64
Spring 2018	0.60	0.54	0.67	0.55	0.66
Fall 2018	0.59	0.51	0.64	0.56	0.64
Spring 2019	0.61	0.53	0.67	0.57	0.65
Fall 2019	0.62	0.54	0.66	0.58	0.65
Spring 2020	0.64	0.54	0.68	0.59	0.67
Fall 2020	0.68	0.56	0.70	0.65	0.73
Spring 2021	0.65	0.55	0.68	0.61	0.68
Fall 2021**	0.64	0.52	0.68	0.62	0.66

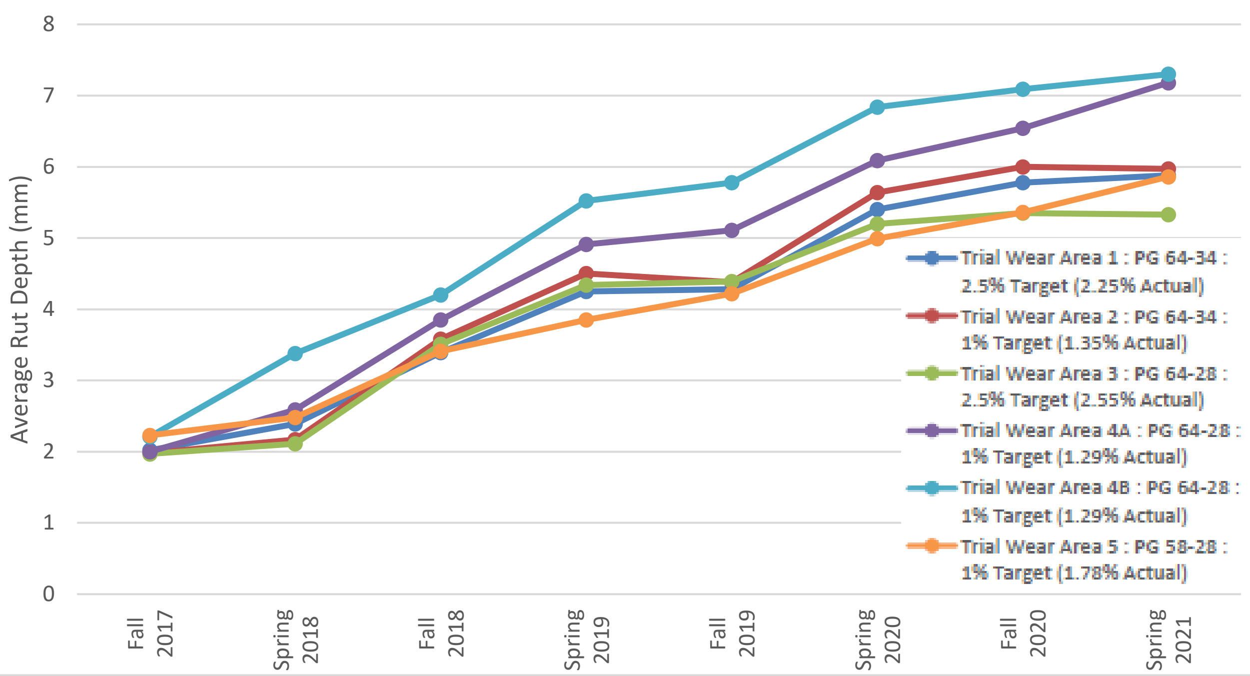
*prior to rehabilitation

** Data collected with the high speed profiler

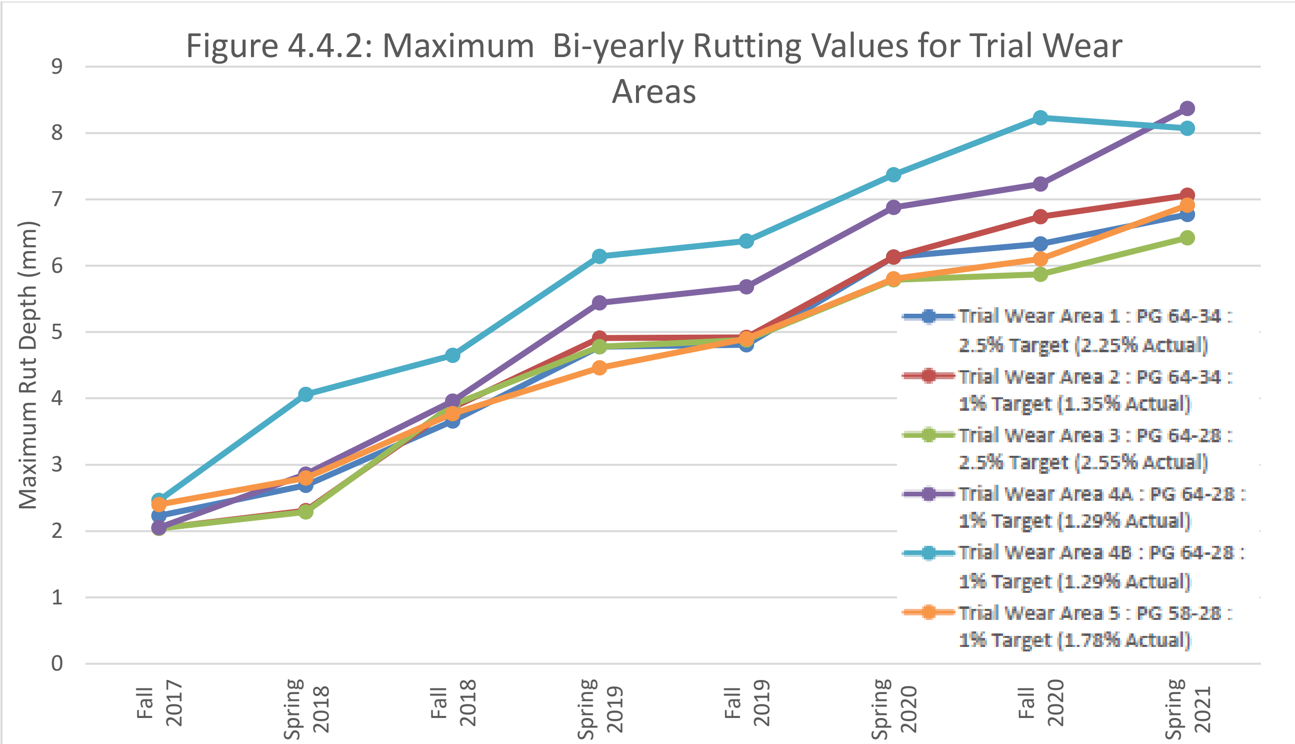
4.4 RUT DEPTH PROFILE

Rutting is a major safety concern in asphalt pavements as it can lead to loss of skid resistance and hydroplaning in wet weather. The average rut depth is determined by obtaining rutting measurements within the left and right wheel paths using the Department's ARAN 4900. The straight edge method is used when calculating wheel path rut depths as per ASTM E 1703/E 1703M "Standard Test Method for Measuring Rut-Depth of Pavement Surface using a Straightedge". Rut depth measurements are based on the averaged readings over the preceding 10 meters, while data values are reported over 50 meters. Figure 4.4.1 below, shows the average bi-yearly rutting values for each of the trial wear areas. It is important to note that the accuracy of the ARAN rut data is ± 1 mm.

Figure 4.4.1: Average Bi-yearly Rutting Values for Trial Wear Areas



The maximum rut depth is the highest individual measurement of rut depth in either the left or right wheel path. Figure 4.4.2 below shows the maximum bi-yearly rut depth for each of the trial wear areas.



Rut depth data in the fall of 2021 was unable to be collected due to unavailability of the ARAN equipment. The full rutting data for the left and right wheel paths as well as the rutting data prior to rehabilitation is presented in Appendix E.

5.0 PRELIMINARY PERFORMANCE CONCLUSIONS

In reviewing the performance of the trial wear areas, focus was placed on the in-place air voids, smoothness and rut depth profiles.

One of the most critical asphalt pavement performance characteristics are the in-place air voids. The in-place air voids are more indicative of field performance then the Marshall design air voids as they represent what is actually in-place and are influenced by construction practices and compaction. Constructing a pavement that has high durability and long service life is about achieving balance. Research indicates that pavements with optimum in-place density (low in-place air voids) are most resilient to water and air infiltration. Low in-place air voids help reduce permeability of the asphalt mat, which increases resistance to moisture susceptibility and premature oxidation. However, all asphalt mixtures still require the presence of some air voids to allow for additional compaction from traffic loading and the expansion of asphalt binder during high temperatures. In addition, previously mentioned surface distresses such as plastic deformation and flushing/bleeding can arise when the in-place air voids are too low. The average in-place air voids for each of the trial wear areas was determined from the density of the in-place cores and are summarized in Table 7.

Table 7- In-place Air Voids for Trial Wear Areas

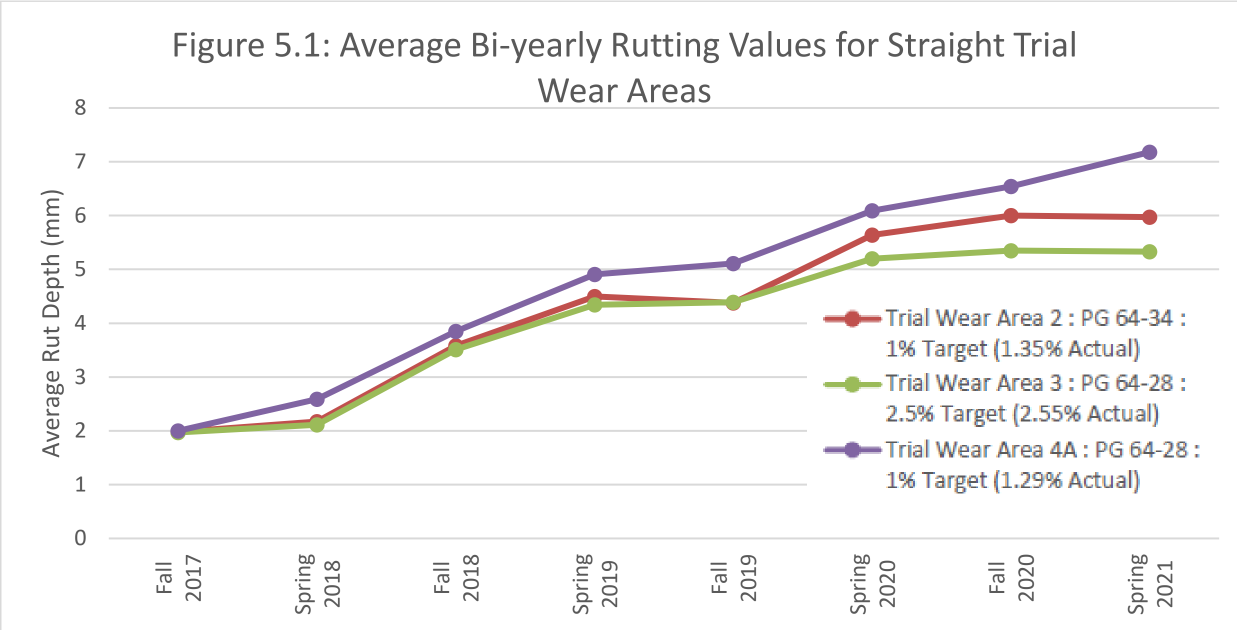
Trial Wear Area	In-place Air Voids (%)
1	4.0
2	2.1
3	3.2
4	1.8
5	2.1

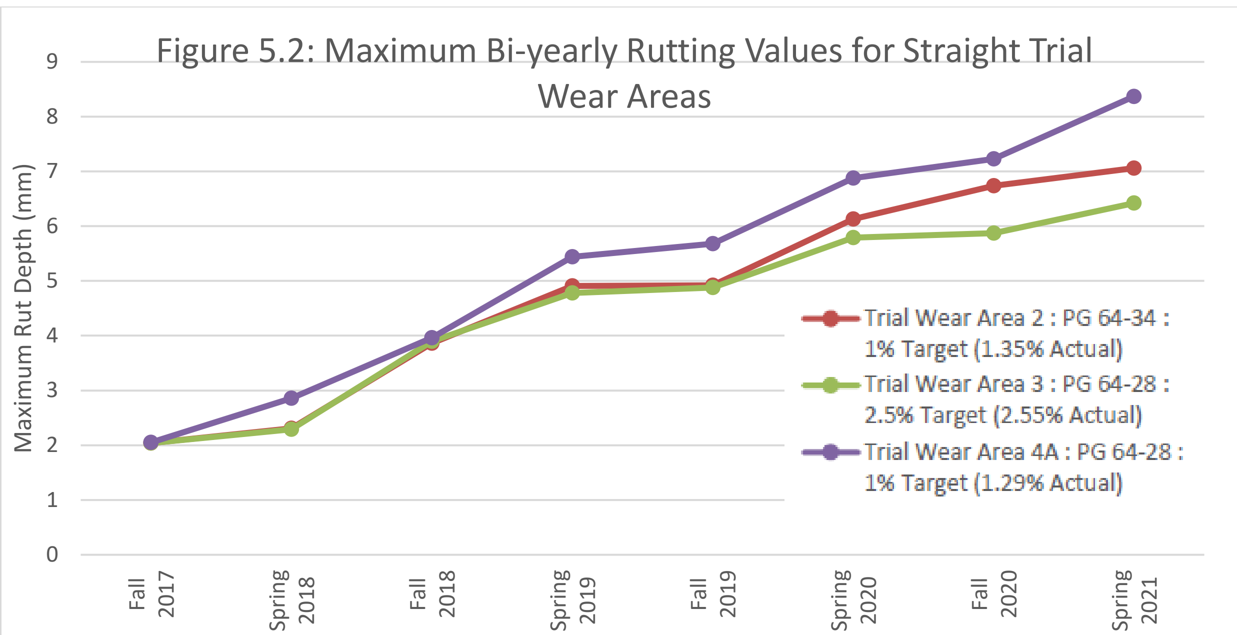
In-place air voids between 3% and 8% are the desired target for asphalt pavements due to their increased service life and durability. Lower in-place air voids are more susceptible to rutting and deformation. Trial wear areas 1 and 3 have in-place air voids within the desired target and are also the areas associated with the least amount of rutting to date.

A user's perception of roadway quality is primarily based on smoothness. The IRI values prior to construction in the spring of 2017 to the resurfacing in the fall of 2017 show an improvement in the smoothness of the trial wear areas of the TCH. However, the IRI values from the resurfacing in the fall of 2017 to the present indicate there has been little change over time and little variation in smoothness of the areas.

The three PG binder grades utilized in this project were PG 64-34 PMA, PG 64-28 PMA and PG 58-28. Binders modified with polymer are expected to perform better than the PG 58-28 due to their ability to withstand greater temperature extremes creating more resistance to rutting and fatigue. The average and maximum rut depths indicate that the increase in bitumen content and associated decrease to the air void content caused a slight increase in the average and maximum rut depths for the PG 64-34 PMA and PG 64-28 PMA sections. The PG 58-28 binder with targeted 1% Marshall air voids (1.78% actual) appeared to be on par in terms of average and maximum rutting values with the PG 64-34 PMA and PG 64-28 PMA that targeted 2.5% Marshall air voids (2.25% and 2.55% actual) however, it has shown a sharper increase in values over the past year in comparison to the other trial sections.

A direct comparison of the trial wear areas by PG binder and Marshall air void content alone is difficult to complete as the roadway sections vary between straight or curved portions of the TCH. Vehicular traffic behaves differently over straight and curved roadway sections. On straight sections drivers tend to stay in the same wheel paths. However, on curved sections drivers tend to have a preference for driving to the inside or outside of the lane and the wheel path is therefore wider leading to more variable results. Trial wear areas 2 and 3 are on straight sections of the roadway, while trial wear areas 1 and 5 are on curved sections of the roadway. Trial wear area 4 has two parts, part A is a straight section and part B is a curved section of the roadway. A comparison of the average and maximum rutting data for each type of roadway section is shown in Figures 5.1 to 5.4 below.





When comparing the rutting data for the straight sections of roadway, the PG 64-28 PMA with targeted 2.5% Marshall air voids (2.55% actual) outperformed the PG 64-34 PMA and PG 64-28 PMA both with targeted 1.0% Marshall air voids. The graphs indicate that as time passes the average and maximum rutting values are increasing and the trial wear areas are displaying greater separation from each other.

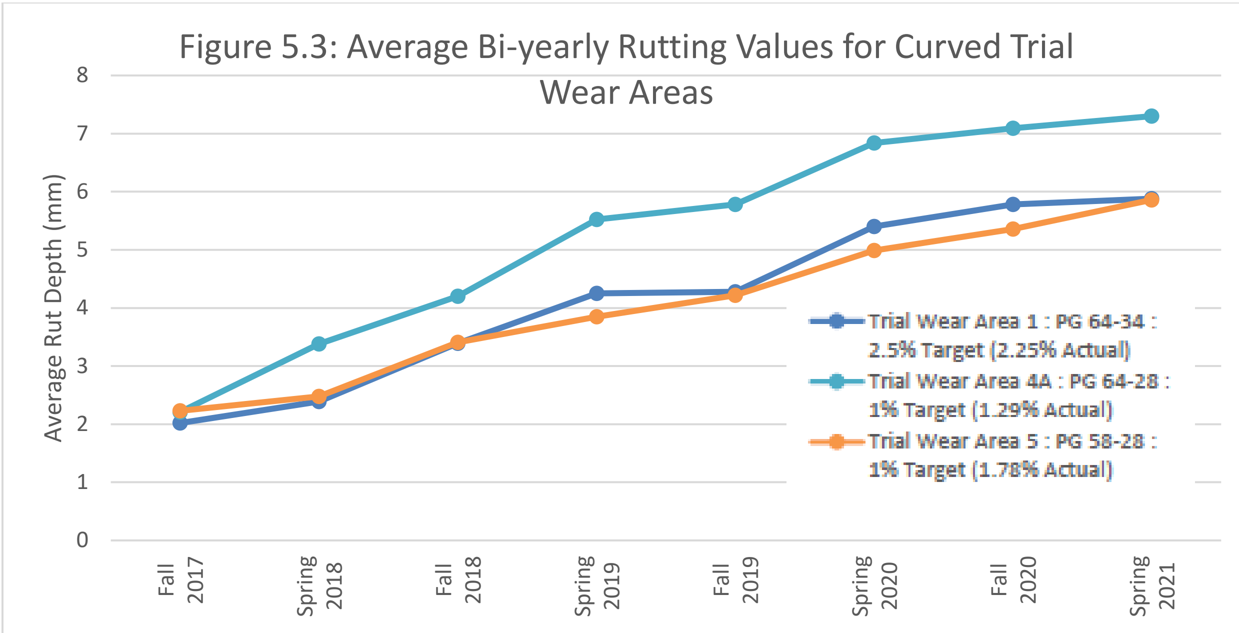


Figure 5.3: Average Bi-yearly Rutting Values for Curved Trial Wear Areas

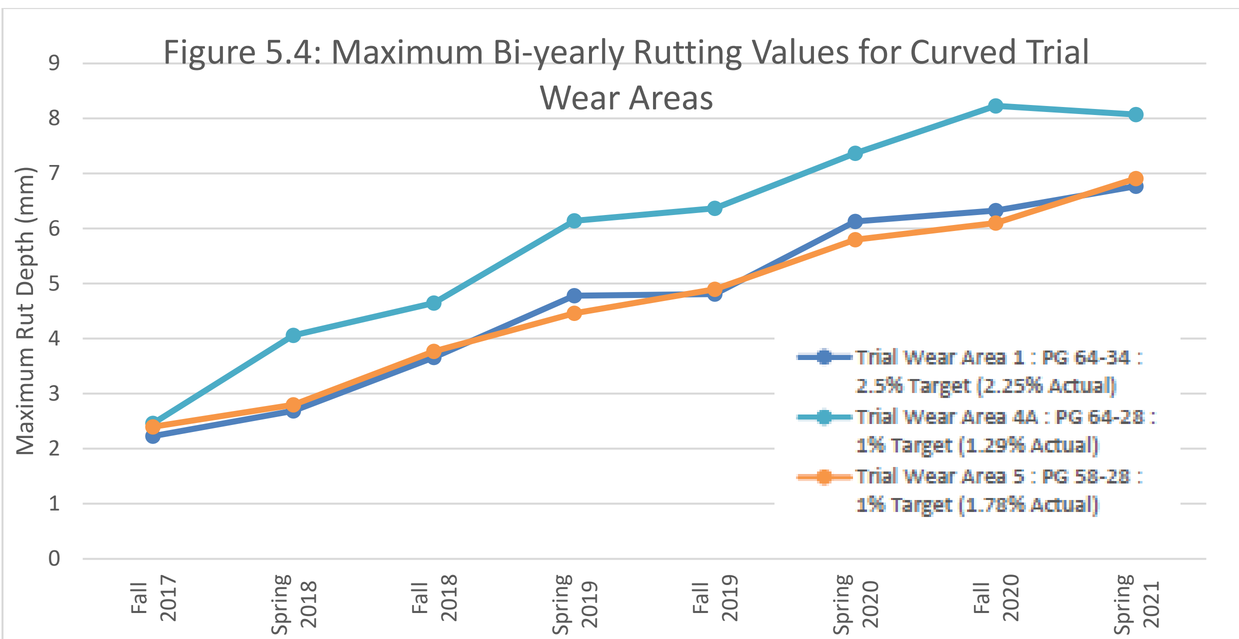


Figure 5.4: Maximum Bi-yearly Rutting Values for Curved Trial Wear Areas

When comparing the rutting data for the curved sections of roadway, the PG 64-34 PMA with targeted 2.5% Marshall air voids (2.25% actual) outperformed the PG 64-28 PMA with targeted 1.0% Marshall air voids (1.29% actual). The average and maximum rut depths for the PG 58-28 with targeted 1.0% Marshall air voids (1.78% actual) are on par with the PG 64-34 PMA at targeted 2.5% Marshall air voids (2.25% actual). However, it is important to note that the Marshall air voids for the PG 58-28 were actually 1.78% in the field and the results have displayed a sharper increase in rutting values within the last year. It is likely the wheel path for PG 64-34 PMA at the targeted 2.5% Marshall air voids (2.25% actual) is more consistent with a narrower wheel path due to the gradual curve. In comparison, the PG 58-28 at the targeted 1% Marshall air voids (1.78% actual) has a sharper curve with a theoretically wider wheel path, as shown in Figure 2.1.1 in Section 2.1.

6.0 CONTINUED PERFORMANCE MONITORING

The true performance of the trial wear areas will not be known until more time from resurfacing has elapsed. As the roadway surface undergoes additional freeze-thaw cycles and repeated traffic loading the asphalt will begin to show increased signs of distress. Pavement distresses should present with increases in the measured smoothness and rutting values collected bi-yearly by TI. Continuing to collect this data will aid in understanding the performance of the trial wear areas and provide a more distinctive trend.

7.0 LESSONS LEARNED

When completing trials for comparison purposes it is important to choose roadway sections with similar geometry where vehicular traffic will behave consistently in all areas. Straight sections of road will have less variation in the wheel paths while curved sections of roadway will have wider, more varied wheel paths. In addition, uphill roadway sections may have additional forces applied from vehicular traffic then downhill sections and thus increased wear. The varied geometry of the trial wear areas makes the evaluation and comparison more challenging.

Laboratory asphalt mix designs were completed using the Marshall mix design method which is based on volumetric principals. As per the Asphalt Institute Manual for mix design methods, the intent of a mix design includes compacting specimens in an attempt to stimulate the in-place density after a pavement has endured several years of traffic. Laboratory compaction methods do not always statistically produce field measured qualities, as it is difficult to stimulate field compaction. Nonetheless, laboratory generated air voids are a valuable parameter used to predict the eventual in-place pavement air void content.

In addition, after the development of the Marshall mix design method, roadways have seen an increase in tire pressure and the associated degree of compaction for this laboratory test may not necessarily be indicative of the in-place field density after a period of time. While Marshall air voids are a good indication for developing a design mix formula, the in-place density and in-place air void values must be closely monitored in the field as they are better indicators of long term performance.

8.0 CONCLUSION

Five trial wear areas were constructed in response to a Construction industry request to evaluate different PG binders; PG 64-34 PMA, PG 64-28 PMA and PG 58-28 with varying Marshall air void content targets of 2.5% and 1.0%. In order to decrease the targeted Marshall air void contents to 1.0% the asphalt bitumen content was increased. No issues were encountered with the material physical property testing or the physical requirements for asphalt mix designs in TI's specification. During construction, the field testing data indicated that the HMA produced met the required mix properties, with the exception of mixes produced targeting 1.0% Marshall air voids. Evaluation of the trial wear areas following construction consisted of reviewing the in-place air void contents, measurement of IRI values for smoothness verification and rutting depths in the left and right wheel paths.

A user's perception of ride quality in the trial wear areas should still remain high as the IRI values have stayed consistent since construction. Rutting values for the areas are increasing over time, however variability exists across the test sections due to grade changes and geometry. When comparing the trial wear areas, taking into consideration the geometry, the data is currently displaying that the asphalt mixtures produced targeting 2.5% Marshall air voids outperformed the mixtures that targeted 1.0% Marshall air voids. This is consistent with industry recommendations and experience. The higher PG Binder grades, PG 64-34 PMA and PG 64-28 PMA are generally on par with each other with the PG 64-28 PMA slightly outperforming the PG 64-34 PMA. It is expected for these binders to preform similarly as they both have the same amount of polymerization and the minimum pavement design temperature for both binders is suitable for the climatic conditions of the trial wear areas.

Trial wear area 5, paved with PG 58-28 and targeting 1.0% Marshall air voids (1.78% actual) is displaying results that appear to be on par with the other areas. However, the sharper curved geometry and downhill grade of the area is frequently correlated with a reduction in rutting. Furthermore, the most recent rutting data is showing a steeper increase in rut depths. Additional time will have to pass to gain a better understanding of the true performance of trial wear area 5.

The mixes produced targeting Marshall air voids of 1.0% resulted in high degrees of compaction and low in-place air voids that exceeded asphalt industry recommendations. This can create the potential for premature rutting from plastic deformation and flushing/bleeding which is a safety concern for users due to reduced roadway friction. Continued production of mixes with very low Marshall values and high in-place compaction is not advisable based on these preliminary results, industry research and best practice guidelines. As such, it is recommended to continue the use of polymer modified asphalt binders, at industry recommended air voids (2.5-4.5%) in high traffic environments.

Four years have passed since resurfacing of the five trial wear areas on the TCH and additional data will need to be collected to establish if the expected pavement life can be achieved for each trial wear area.

REFERENCES

Asphalt Institute. Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types*,* Manual Series No. 2, Lexington (2014).

Asphalt Institute. The Asphalt Handbook*,* Manual Series No. 4, Lexington (2007).

Brown ER, Cross SA. "Comparison of Laboratory and Field Density of Asphalt Mixtures", Transportation Research Record (1991).

Davidson JK. "Introduction to Asphalt Emulsions*".* Public Works Canada Seminar: Charlottetown, PEI (1995).

APPENDIX A – PHYSICAL PROPERTY TESTING ASPHALT AGGREGATE

DMG Consulting Limited

185 Roe Avenue, P.O. Box 194, Gander
Newfoundland, A1V-2C6
Ph. 256-7501

ACCEPTANCE TEST RESULTS SUMMARY

Project : 127-16
Client : Concord Paving
Contractor : Concord Paving
Material : Asphalt Aggregate surface
Location : Municipal TCH Quarry Blend Sand Terra Nova

DESCRIPTION OF TESTS	TEST METHOD	RESULT	UNIT	SPECIFIED MIN	SPECIFIED MAX
L.A. Abrasion					
Granulars	ASTM C - 131		%		
Surface asphalt		14.50	%		35
100/500 ratio		0.230			0.265
Base Asphalt					
100/500 ratio			%		
Bulk Specific Gravity					
Coarse Aggregate	ASTM C - 127	2.702		2.200	
Fine Aggregate	ASTM C - 128	2.649			
Crushed Fine Aggregate					
Naturally Occuring Fines					
Blend Sand		2.591			
Absorption					
Coarse Agg	ASTM C - 127	0.577	%		1.75
Fine Aggregate	ASTM C - 128	0.695	%		2.0
Blend Sand	ASTM C - 128	0.583			
Combined Average		0.634	%		
Flat & Elongated	SEE SPEC		%		
Class A			%		35
Class B			%		35
Asphalt Aggs		1.2	%		20
Freezing & Thawing	CSA A23.2 - 24A	3.0	%		8
Loss by Washing	ASTM C - 117	1.20	%		1.75
Soundness	ASTM C 88				
Surface			%		12
Base			%		12
Fine Micro Deval	ASTM D-7428-08	8.3	%		18 Agg, 30 Gran.
Coarse Micro Deval	ASTM D 6928	5.2	%		18 Agg, 25 Gran.
Blend Sand Micro Deval	ASTM D-7428-08	6.2			19
Sand Equivalent	ASTM D 2419	70.2	%	50	
Petrographic No. (Fine Agg)	CSA A23.2 - 15A	111.0			135 Fine Agg, 150 Gran
Petrographic No. (Coarse Agg)	CSA A23.2 - 15A	111.0			135 Coarse Agg
Low Density Particles	CSA A23.2 - 4A	0.0	%		1.0 Surface
			%		1.0 Base
Crushed Fragments	ASTM D 5821				
RLU - 60, 70, 80			%	50	
RLU - 100 RAD 100			%	70	
RCU - 80		100.0	%	90	
Fine Aggregate	ASTM C 1252				
Angularity		47.3	%	45	
Friable or slatey siltstone	CSA A23.2 - 15A	0.0			1.0
Clay Size Particles	CSA A23.2 - 3A	0.0			1.0
Modified Lottman Test (anti-strip)	AASHTO T 283				
Ratio		0.92		0.80	
Rating		0.01		0	10
Modified Lottman Test					
Ratio		0.84		0.80	
Rating		0.2		0	10
Boiling Water Test	ASTM D 3625	98.5	%	95	
PLASTICITY INDEX - FINE AGG.	ASTM D 4318	0			0

APPENDIX B – CRS-1 TACK COAT TEST RESULTS

Englobe
1821 Albion Road, Unit 7 Toronto (Ontario) M9W 5W8
T 416.213.1060 | **F** 416.213.1070
toronto@englobecorp.com | www.englobecorp.com

TO: Graig G. Hancock CLIENT: Government of Newfoundland and Labrador **FAX:** 709-729-2203

FROM: Dawit Amar, Laboratory Supervisor **DATE:** 22/11/2017-rev **PROJECT No.:** P008145

ASPHALT EMULSION TEST RESULTS

PRODUCT	CRS-1	
PROJECT/LOCATION	P.O # 217009716-10 /	
SAMPLE DESCRIPTION	Project No: 127-16,CRS-1	
SAMPLE DATE	August-15-17	
TESTING DATE	September-22-17	
ROS No.	71023	
TEST RESULTS	Specification ASTM D2397	RESULTS
Viscosity, Saybolt Furol , at 50°C, SFS	20 - 100	61.69
Storage Stability test, 24 hrs., %	1 max	-0.1
Demulsibility,35ml.0.8% dioctyl sodium sulfosuccinate,%	40min	**28.2** *
Sieve Test, % by mass	0.1 max	0.04
Residue by distillation, %	60 min	60.4
Particle Charge Test, ASTM D7402	Positive	Positive
Oil distillate, by volume of emulsion, %	3 max	0
TESTS ON RESIDUE FROM DISTILLATION TEST		
Penetration at 25°C, 100g, 5s	100 - 250	116
Ductility at 25°C, 5cm/min, cm	40 min	40+
Solubility in Trichloroethylene, %	97.5 min	99.97

Star (*) adjacent to test result indicates non-compliance with project specification.
Results in Brackets ( ) indicate a retested result.

COMMENTS: ______________________________

SIGNATURE: [signature], Englobe Corp. Date: 22/11/2017-rev
Dawit Amar, Laboratory Supervisor

APPENDIX C – TRIAL AREA FIELD RESULTS

GOVERNMENT OF NEWFOUNDLAND AND LABRADOR
DEPARTMENT OF TRANSPORTATION & WORKS - MATERIALS ENGINEERING DIVISION
278 LEMARCHANT ROAD ST. JOHN'S, NL A1E 1P7

Area: 1

Project Number:	127-16 THP	Spec. Gravity of Agg:	2.660
Project Name:	Pavement Wear Trial Areas	Solvent Used for Extraction:	N-Propyl Bromide
Contractor:	Concord Paving	Absorbed AC%:	0.40
Source Name:	Municipial Quarry TCH	Pavement Course:	Surface: PG 64-34 PMA, 2.5% Voids

Sample #	**– 1**	**– 2**	**– 3**	**– 4**	**– 5**	**– 6**	**Avg**	**JMF**	***Avg Dev**
Date	24-Oct-17	24-Oct-17	24-Oct-17						
Time	8:15 AM	8:50 AM	9.25 AM						
Station	31+419	31+780	32 +005						
Offset, m									
Latitude***	N° 47.4467	N° 47.4450	N° 47.4436	N°	N°	N°			
Longitude***	W° 52.9624	W° 52.9664	W° 52.9685	W°	W°	W°			
Mix Moisture	--	--	--						
Corr. AC%	6.33	6.25	6.34				**6.31**	**6.50**	0.19
% Pass **19.0**	100	100	100				**100.0**	**100**	0.00
12.5	99.2	99.1	98.5				**98.9**	**98.2**	0.73
9.5	87.5	88.0	87.7				**87.7**	**88.9**	1.17
4.75	59.8	57.7	59.3				**58.9**	**60.1**	1.17
2.00	35.9	37.2	37.1				**36.7**	**40.4**	3.67
0.425	19.6	20.4	20.3				**20.1**	**20.6**	0.50
0.150	8.0	9.2	8.9				**8.7**	**9.0**	0.43
0.075	4.1	4.4	4.4				**4.3**	**4.2**	0.17
Dust Ratio	0.69	0.75	0.74				**0.73**	**0.7**	0.03
Sub Lot #	**– 1**	**– 2**	**– 3**	**– 4**	**– 5**	**– 6**	**Avg**	**JMF**	****Avg Dev**
Bulk,kg/m^3	2.372	2.397	2.392				**2.387**	**2.346**	0.041
MTD,kg/m^3	2.436	2.454	2.436				**2.442**	**2.430**	0.012
Air Voids,%	2.63	2.32	1.81				**2.25**	**2.5**	0.25
VMA,%	16.49	15.54	15.78				**15.9**	**17.5**	1.56
Stability,Kn	7.7	13.3	9.3				**10.1**	**12.8**	2.70
Flow,mm	2.96	3.50	3.84				**3.43**	**4.0**	0.57
Core #	**– 1**	**– 2**	**– 3**	**– 4**	**– 5**	**– 6**	**Avg**	**Spec**	
Date	24-Oct-17	24-Oct-17	24-Oct-17						
Station	31+436	31+696	32+000						
Offset, m	3.2	1.9	1.4 R						
Latitude***	N° 47.4467	N° 47.4455	N° 47.4436	N°	N°	N°			
Longitude***	W° 52.9626	W° 52.9656	W° 52.9685	W°	W°	W°			
BD,kg/m^3	2.318	2.373	2.341				**2.344**		
Thickness	49	52	46				**49**	**50**	
Comp,% MTD	95.2	96.7	96.1				**96.0**	**94.0**	

Comments:

Tested By: **Reviewed By:**

***Avg Dev refers to the sum of the absolute value of the deviations divided by the number of tests in the lot**

****Avg Dev**

*****Please record coordinates in Decimal Degrees**

GOVERNMENT OF NEWFOUNDLAND AND LABRADOR
DEPARTMENT OF TRANSPORTATION & WORKS - MATERIALS ENGINEERING DIVISION
278 LEMARCHANT ROAD ST. JOHN'S, NL A1E 1P7

Area: 2

Project Number:	127-16 THP	Spec. Gravity of Agg:	2.660
Project Name:	Pavement Wear Trial Areas	Solvent Used for Extraction:	N-Propyl Bromide
Contractor:	Concord Paving	Absorbed AC%:	0.40
Source Name:	Municipal Quarry TCH	Pavement Course:	Surface: PG 64-34 PMA, 1% Voids

Sample #	**- 1**	**- 2**	**- 3**	**- 4**	**- 5**	**- 6**	**Avg**	**JMF**	***Avg Dev**
Date	24-Oct-17	24-Oct-17	24-Oct-17						
Time	9:47 AM	10:07 AM	10:40 AM						
Station	32+300	32+460	32+700						
Offset, m									
Latitude***	N° 47.4417	N° 47.4406	N° 47.4391	N°	N°	N°			
Longitude***	W° 52.9712	W° 52.9729	W° 52.9748	W°	W°	W°			
Mix Moisture	--	--	--						
Corr. AC%	6.55	6.61	6.51				**6.56**	**6.50**	0.06
% Pass **19.0**	100	100	100				**100.0**	**100**	0.00
12.5	98.4	98.9	98.4				**98.6**	**98.2**	0.37
9.5	87.1	89.9	86.6				**87.9**	**88.9**	1.70
4.75	59.0	60.5	58.7				**59.4**	**60.1**	0.97
2.00	38.2	38.1	37.3				**37.9**	**40.4**	2.53
0.425	20.9	20.8	20.1				**20.6**	**20.6**	0.33
0.150	8.9	9.4	7.6				**8.6**	**9**	0.63
0.075	4.2	4.6	3.9				**4.2**	**4.2**	0.23
Dust Ratio	0.68	0.74	0.64				**0.69**	**0.7**	0.04

Sub Lot #	**- 1**	**- 2**	**- 3**	**- 4**	**- 5**	**- 6**	**Avg**	**JMF**	****Avg Dev**
Bulk,kg/m^3	2.395	2.411	2.413				**2.406**	**2.346**	0.060
MTD,kg/m^3	2.438	2.439	2.441				**2.439**	**2.430**	0.009
Air Voids,%	1.76	1.15	1.15				**1.35**	**1.0**	0.35
VMA,%	15.88	15.37	15.04				**15.4**	**17.5**	2.07
Stability,Kn	9.8	14.1	11.6				**11.8**	**12.8**	0.97
Flow,mm	4.61	3.88	4.39				**4.29**	**4.0**	0.29

Core #	**- 1**	**- 2**	**- 3**	**- 4**	**- 5**	**- 6**	**Avg**	**Spec**
Date	24-Oct-17	24-Oct-17	24-Oct-17					
Station	32+290	32+470	32+710					
Offset, m	2.6	1.0	1.6					
Latitude***	N° 47.4418	N° 47.4406	N° 47.4391	N°	N°	N°		
Longitude***	W° 52.9711	W° 52.9727	W° 52.9749	W°	W°	W°		
BD,kg/m^3	2.392	2.392	2.381				**2.388**	
Thickness	46	49	46				**47**	**50**
Comp,% MTD	98.1	98.1	97.5				**97.9**	**94.0**

Comments: Contractor/Consultant advised they would increase asphalt content and fines in order to lower the air voids.

Tested By: **Reviewed By:**

***Avg Dev refers to the sum of the absolute value of the deviations divided by the number of tests in the lot**
****Avg Dev**
*****Please record coordinates in Decimal Degrees**

GOVERNMENT OF NEWFOUNDLAND AND LABRADOR
DEPARTMENT OF TRANSPORTATION & WORKS - MATERIALS ENGINEERING DIVISION
278 LEMARCHANT ROAD ST. JOHN'S, NL A1E 1P7

Area: 3

Project Number:	127-16 THP	Spec. Gravity of Agg:	2.660
Project Name:	Pavement Wear Trial Areas	Solvent Used for Extraction:	N-Propyl Bromide
Contractor:	Concord Paving	Absorbed AC%:	0.71
Source Name:	Municipial Quarry TCH	Pavement Course:	Surface: PG 64-28 PMA, 2.5% Voids

Sample #	**- 1**	**- 2**	**- 3**	**- 4**	**- 5**	**- 6**	**Avg**	**JMF**	***Avg Dev**
Date	24-Oct-17	24-Oct-17	24-Oct-17						
Time	12:11 PM	12:37 PM	1:00 PM						
Station	33+390	33+660	33+860						
Offset, m									
Latitude***	N° 47.4345	N°	N°	N°	N°	N°			
Longitude***	W° 52.9811	W°	W°	W°	W°	W°			
Mix Moisture	--	--	--						
Corr. AC%	6.30	6.35	6.57				**6.41**	**6.65**	0.24
% Pass **19.0**	100	100	100				**100.0**	**100**	0.00
12.5	98.6	98.7	98.3				**98.5**	**98.2**	0.33
9.5	87.1	86.6	89.3				**87.7**	**88.9**	1.50
4.75	59.1	59.1	60.5				**59.6**	**60.1**	0.80
2.00	37.3	37.6	37.7				**37.5**	**40.4**	2.87
0.425	20.7	20.7	20.4				**20.6**	**20.6**	0.13
0.150	8.9	9.0	8.7				**8.9**	**9.0**	0.13
0.075	4.4	4.5	4.2				**4.4**	**4.2**	0.17
Dust Ratio	0.78	0.79	0.71				**0.76**	**0.7**	0.06
Sub Lot #	**- 1**	**- 2**	**- 3**	**- 4**	**- 5**	**- 6**	**Avg**	**JMF**	****Avg Dev**
Bulk,kg/m^3	2.400	2.402	2.379				**2.394**	**2.383**	0.011
MTD,kg/m^3	2.459	2.462	2.448				**2.456**	**2.445**	0.011
Air Voids,%	2.40	2.44	2.82				**2.55**	**2.6**	0.05
VMA,%	15.46	15.45	16.44				**15.8**	**16.3**	0.52
Stability,Kn	11.4	13.0	12.83				**12.4**	**8.7**	3.71
Flow,mm	3.95	3.25	3.75				**3.65**	**3.6**	0.05
Core #	**- 1**	**- 2**	**- 3**	**- 4**	**- 5**	**- 6**	**Avg**	**Spec**	
Date	24-Oct-17	24-Oct-17	24-Oct-17						
Station	33+410	33+677	33+870						
Offset, m	2.3	0.9	3.1						
Latitude***	N° 47.4345	N° 47.4329	N° 47.4312	N°	N°	N°			
Longitude***	W° 52.9812	W° 52.9833	W° 52.9848	W°	W°	W°			
BD,kg/m^3	2.385	2.373	2.373				**2.377**		
Thickness	53	51	53				**52**	**50**	
Comp,% MTD	97.0	96.4	96.9				**96.8**	**94.0**	

Comments:

Tested By: **Reviewed By:**

***Avg Dev refers to the sum of the absolute value of the deviations divided by the number of tests in the lot**
****Avg Dev**
*****Please record coordinates in Decimal Degrees**

GOVERNMENT OF NEWFOUNDLAND AND LABRADOR
DEPARTMENT OF TRANSPORTATION & WORKS - MATERIALS ENGINEERING DIVISION
278 LEMARCHANT ROAD ST. JOHN'S, NL A1E 1P7

Area: 4

Project Number:	127-16 THP	Spec. Gravity of Agg:	2.660
Project Name:	Pavement Wear Trial Areas	Solvent Used for Extraction:	N-Propyl Bromide
Contractor:	Concord Paving	Absorbed AC%:	0.71
Source Name:	Municipial Quarry TCH	Pavement Course:	Surface: PG 64-28 PMA, 1 % Voids

Sample #	**- 1**	**- 2**	**- 3**	**- 4**	**- 5**	**- 6**	**Avg**	**JMF**	***Avg Dev**
Date	24-Oct-17	24-Oct-17	24-Oct-17						
Time	1:56 PM	2:10 PM	2:30 PM						
Station	34+300	34+380	34+480						
Offset, m									
Latitude***	N° 47.4281	N° 47.4275	N° 47.4268	N°	N°	N°			
Longitude***	W° 52.9882	W° 52.9889	W° 52.9896	W°	W°	W°			
Mix Moisture	--	--	--						
Corr. AC%	6.40	6.60	6.74				**6.58**	**6.65**	0.13
% Pass **19.0**	100	100	100				**100.0**	**100**	0.00
12.5	98.7	98.7	98.2				**98.5**	**98.2**	0.33
9.5	86.0	87.0	88.2				**87.1**	**88.9**	1.83
4.75	57.5	59.8	60.8				**59.4**	**60.1**	1.20
2.00	36.7	38.5	38.2				**37.8**	**40.4**	2.60
0.425	20.6	21.4	20.9				**21.0**	**20.6**	0.37
0.150	8.1	9.1	8.5				**8.6**	**9.0**	0.50
0.075	4.1	4.6	4.2				**4.3**	**4.2**	0.17
Dust Ratio	0.71	0.77	0.69				**0.72**	**0.7**	0.03
Sub Lot #	**- 1**	**- 2**	**- 3**	**- 4**	**- 5**	**- 6**	**Avg**	**JMF**	****Avg Dev**
Bulk,kg/m^3	2.398	2.406	2.403				**2.402**	**2.383**	0.019
MTD,kg/m^3	2.432	2.433	2.436				**2.434**	**2.445**	0.011
Air Voids,%	1.4	1.11	1.35				**1.29**	**1.0**	0.29
VMA,%	15.62	15.52	15.75				**15.6**	**16.3**	0.67
Stability,Kn	13.91	13.80	15.14				**14.3**	**8.7**	5.58
Flow,mm	4.00	3.88	4.63				**4.17**	**3.6**	0.57
Core #	**- 1**	**- 2**	**- 3**	**- 4**	**- 5**	**- 6**	**Avg**	**Spec**	
Date	24-Oct-17	24-Oct-17	24-Oct-17						
Station	34+311	34+390	34+490						
Offset, m	2.1	2.5	0.8						
Latitude***	N° 47.4280	N° 47.4275	N° 47.4268	N°	N°	N°			
Longitude***	W° 52.9883	W° 52.9889	W° 52.9897	W°	W°	W°			
BD,kg/m^3	2.392	2.391	2.382				**2.388**		
Thickness	47	49	51				**49**	**50**	
Comp,% MTD	98.4	98.3	97.8				**98.2**	**94.0**	

Comments: Contractor/Consultant advised they would increase asphalt content and fines in order to lower the air voids.

Tested By: **Reviewed By:**

***Avg Dev refers to the sum of the absolute value of the deviations divided by the number of tests in the lot**
****Avg Dev**
*****Please record coordinates in Decimal Degrees**

GOVERNMENT OF NEWFOUNDLAND AND LABRADOR
DEPARTMENT OF TRANSPORTATION & WORKS - MATERIALS ENGINEERING DIVISION
278 LEMARCHANT ROAD ST. JOHN'S, NL A1E 1P7

Area: 5

Project Number:	127-16 THP	Spec. Gravity of Agg:	2.660
Project Name:	Pavement Wear Trial Areas	Solvent Used for Extraction:	N-Propyl Bromide
Contractor:	Concord Paving	Absorbed AC%:	0.84
Source Name:	Municipial Quarry TCH	Pavement Course:	Surface: PG 58-28, 1 % Voids

Sample #	**– 1**	**– 2**	**– 3**	**– 4**	**– 5**	**– 6**	**Avg**	**JMF**	***Avg Dev**
Date	25-Oct-17	25-Oct-17	25-Oct-17						
Time	8:45 AM	9:10 AM	9:45 AM						
Station	36+900	37+260	37+480						
Offset, m									
Latitude***	N°47.4112	N°47.4099	N° 47.40844	N°	N°	N°			
Longitude***	W°53.0130	W°53.0173	W° 53.0191	W°	W°	W°			
Mix Moisture	--	--	--						
Corr. AC%	6.47	6.51	6.45				**6.48**	**6.65**	0.17
% Pass **19.0**	100	100	100				**100.0**	**100**	0.00
12.5	97.0	96.8	97.8				**97.2**	**98.2**	1.00
9.5	87.2	83.6	85.1				**85.3**	**88.9**	3.60
4.75	59.0	57.3	56.9				**57.7**	**60.1**	2.37
2.00	38.0	37.1	36.2				**37.1**	**40.4**	3.30
0.425	21.3	20.7	20.1				**20.7**	**20.6**	0.43
0.150	8.7	8.5	8.8				**8.7**	**9.0**	0.33
0.075	4.5	4.0	4.5				**4.3**	**4.2**	0.26
Dust Ratio	0.79	0.7	0.8				**0.76**	**0.7**	0.06
Sub Lot #	**– 1**	**– 2**	**– 3**	**– 4**	**– 5**	**– 6**	**Avg**	**JMF**	****Avg Dev**
Bulk,kg/m^3	2.392	2.403	2.41				**2.402**	**2.416**	0.014
MTD,kg/m^3	2.448	2.442	2.445				**2.445**	**2.454**	0.009
Air Voids,%	2.3	1.60	1.43				**1.78**	**1.5**	0.28
VMA,%	15.9	15.5	15.25				**15.6**	**15.2**	0.35
Stability,Kn	13.74	12.39	13.70				**13.3**	**11.5**	1.78
Flow,mm	4.00	4.00	3.63				**3.88**	**3.1**	0.78

Core #	**– 1**	**– 2**	**– 3**	**– 4**	**– 5**	**– 6**	**Avg**	**Spec**
Date	25-Oct-17	25-Oct-17	25-Oct-17					
Station	36+912	37+370	37+500					
Offset, m	1.5	2.6	0.8					
Latitude***	N° 47.4112	N° 47.40924	N° 47.4083	N°	N°	N°		
Longitude***	W° 53.0132	W°53.0183	W° 53.0192	W°	W°	W°		
BD,kg/m^3	2.396	2.371	2.412				**2.393**	
Thickness	50	47	48				**48**	**50**
Comp,% MTD	98.0	97.1	98.7				**97.9**	**94.0**

Comments:

Tested By: **Reviewed By:**

***Avg Dev refers to the sum of the absolute value of the deviations divided by the number of tests in the lot**
****Avg Dev**
*****Please record coordinates in Decimal Degrees**

APPENDIX D – PG BINDER CLASSIFICATION AND PHYSICAL PROPERTY TESTING

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PERFORMANCE GRADING OF ASPHALT BINDER TEST RESULTS
AASHTO M320, R29, T313 AND T315, TP-70 AND MTO LS-227
GOVERNMENT OF NEWFOUNDLAND AND LABRADOR

PROJECT NO.: P008145 CONTRACT: 127-16THP DATE:

PROJECT/LOCATION: Trial Wear Areas TCH,

SAMPLE ID: 72224 SEAL NO.: P.O.#217009716-23

CONTRACTOR: Concord Paving SUPPLIER: API SAMPLE DATE: 24/10/2017

LOT NO.: - SUBLOT NO.: - SAMPLE RECEIVED DATE: 31/10/2017

PGAC GRADE: PG64-34 MSCR TEST TEMP.: 58 MSCR TRAFFIC GRADE:

PERFORMANCE GRADE SPECIFIED	**PG 64-34**
Max. and Min. Pavement Design Temp, °C	Max 64, Min -34
Original Binder	
Flash Point Temp. (Min. 230°C), °C	262
Ash Content, (max. 1.0%), %	-
Rotational Visc. (Max. 3 Pa.s (3000 cP)) Test Temp. @ 135°C, Pa.s	0.580
Dynamic Shear, AASHTO T315: G*/sinδ, (Min 1.00 kPa) Test Temp. @ 10 rad/s, kPa	1.745 @ 64°C 1.194 @ 70°C 0.992 @ 71°C *
Rolling Thin Film Oven Residue	
Mass loss, Percent change, (1.00 Max. Loss)	-0.943
Dynamic Shear, AASHTO T315: G*/sinδ, (Min 2.2 kPa) Test Temp. @ 10 rad/s, kPa	4.372 @ 64°C 2.276 @ 70°C 2.159 @ 70.5°C *
Pressure Aging Vessel Residue aging 20 hrs. @ 2.07 Mpa	
Dynamic Shear, AASHTO T315: G*sinδ, (Max. 5,000 kPa) Test Temp. @ 10 rad/s, kPa	2665 @ 19°C 3987 @ 12°C 5210 @ 14°C *
Creep Stiffness, AASHTO T313: S, (Max. 300 MPa) Test Temp. @ 60 s., MPa	299 @ -24°C 663 @ -30°C *
Slope of log Creep Stiffness v. Log Time, AASHTO T313: m-value, (Min. 0.300)	0.316 @ -24°C 0.242 @ -30°C *
Additional Tests (Upon Request)	
Multiple Stress Creep and Recovery (MSCR), AASHTO T350-14	
MSCR, Non-recoverable Creep Compliance at 3.2 kPa, Jnr3.2 (kPa^{-1}) (≥4.5 kPa-1)	0.53
MSCR, Average Percent Recovery at 3.2 kPa, R3.2 (%) (≤ 24.71 %)	36.6
MSCR, Difference Non-recoverable Creep Compliance, Jnrdiff (%)	30
Elastic Recovery (ASTM D6084, B), 10°C, %	75
Forced Ductility, Force Ratio (AASHTO T300), 4°C	0.364
Toughness (ASTM D5801), 25°C, N-mm	10210
Tenacity (ASTM D5801), 25°C, N-mm	6938

(*) indicates result does not meet Specification for this parameter.

CONFORMS TO SPECIFICATION: **YES** [X] **NO** [ ]

ACTUAL PG GRADE: **PG70-34**

COMMENTS:

SIGNATURE: [signature] DATE: 12/12/2017 (revised)

Dawit Amar/Laboratory Supervisor

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PERFORMANCE GRADING OF ASPHALT BINDER TEST RESULTS
AASHTO M320, R29, T313 AND T315, TP-70 AND MTO LS-227
GOVERNMENT OF NEWFOUNDLAND AND LABRADOR

PROJECT NO.: P008145 CONTRACT: 127-16THP DATE: 12/2017 (revis

PROJECT/LOCATION: Trial Wear Areas TCH,

SAMPLE ID: 72224 SEAL NO.: P.O.#217009716-23

CONTRACTOR: Concord Paving SUPPLIER: API SAMPLE DATE: 24/10/2017

LOT NO.: - SUBLOT NO.: - SAMPLE RECEIVED DATE: 31/10/2017

PGAC GRADE: PG64-28 MSCR TEST TEMP.: 58 MSCR TRAFFIC GRADE:

PERFORMANCE GRADE SPECIFIED	**PG 64-28**
Max. and Min. Pavement Design Temp, °C	Max 64, Min -28
Original Binder	
Flash Point Temp. (Min. 230°C), °C	269
Ash Content, (max. 1.0%), %	-
Rotational Visc. (Max. 3 Pa.s (3000 cP)) Test Temp. @ 135°C, Pa.s	0.480
Dynamic Shear, AASHTO T315: G*/sinδ, (Min 1.00 kPa) Test Temp. @ 10 rad/s, kPa	1.441 @ 64°C 1.133 @ 67.5°C 1.073 @ 68°C
Rolling Thin Film Oven Residue	
Mass loss, Percent change, (1.00 Max. Loss)	-0.592
Dynamic Shear, AASHTO T315: G*/sinδ, (Min 2.2 kPa) Test Temp. @ 10 rad/s, kPa	3.245 @ 64°C 2.219 @ 67.5°C 2.155 @ 68°C *
Pressure Aging Vessel Residue aging 20 hrs. @ 2.07 Mpa	
Dynamic Shear, AASHTO T315: G*sinδ, (Max. 5,000 kPa) Test Temp. @ 10 rad/s, kPa	2359 @ 22°C 5223 @ 16°C * 4984 @ 16.5°C
Creep Stiffness, AASHTO T313: S, (Max. 300 MPa) Test Temp. @ 60 s., MPa	194 @ -18°C 387 @ -24°C *
Slope of log Creep Stiffness v. Log Time, AASHTO T313: m-value, (Min. 0.300)	0.356 @ -18°C 0.289 @ -24°C *
Additional Tests (Upon Request)	
Multiple Stress Creep and Recovery (MSCR), AASHTO T350-14	
MSCR, Non-recoverable Creep Compliance at 3.2 kPa, Jnr3.2 (kPa^{-1}) (≥4.5 kPa-1)	0.84
MSCR, Average Percent Recovery at 3.2 kPa, R3.2 (%) (≤ 20.75 %)	29.4
MSCR, Difference Non-recoverable Creep Compliance, Jnrdiff (%)	36.3
Elastic Recovery (ASTM D6084, B), 10°C, %	68.5
Forced Ductility, Force Ratio (AASHTO T300), 4°C	0.274
Toughness (ASTM D5801), 25°C, N-mm	7706
Tenacity (ASTM D5801), 25°C, N-mm	4102

(*) indicates result does not meet Specification for this parameter.

CONFORMS TO SPECIFICATION: **YES** [X] **NO** [ ]

ACTUAL PG GRADE: **PG 67.5-31.8**

COMMENTS:

SIGNATURE: [signature] DATE: 12/12/2017 (revised)

Dawit Amar/Laboratory Supervisor

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PERFORMANCE GRADING OF ASPHALT BINDER TEST RESULTS
AASHTO M320, R29, T313 AND T315, TP-70 AND MTO LS-227
GOVERNMENT OF NEWFOUNDLAND AND LABRADOR

PROJECT NO.: P008145 CONTRACT: 127-16THP DATE: 12/2017 (revis

PROJECT/LOCATION: Trial Wear Areas TCH,

SAMPLE ID: 72224 SEAL NO.: P.O.#217009716-23

CONTRACTOR: Concord Paving SUPPLIER: API SAMPLE DATE: 25/10/2017

LOT NO.: - SUBLOT NO.: - SAMPLE RECEIVED DATE: 31/10/2017

PGAC GRADE: PG58-28 MSCR TEST TEMP.: 58 MSCR TRAFFIC GRADE:

PERFORMANCE GRADE SPECIFIED	**PG 58-28**
Max. and Min. Pavement Design Temp, °C	Max 58, Min -28
Original Binder	
Flash Point Temp. (Min. 230°C), °C	288
Ash Content, (max. 1.0%), %	-
Rotational Visc. (Max. 3 Pa.s (3000 cP)) Test Temp. @ 135°C, Pa.s	0.303
Dynamic Shear, AASHTO T315: G*/sinδ, (Min 1.00 kPa) Test Temp. @ 10 rad/s, kPa	1.572 @ 58°C 1.211 @ 60.5°C 1.111 @ 61°C
Rolling Thin Film Oven Residue	
Mass loss, Percent change, (1.00 Max. Loss)	-0.406
Dynamic Shear, AASHTO T315: G*/sinδ, (Min 2.2 kPa) Test Temp. @ 10 rad/s, kPa	3.408 @ 58°C 2.349 @ 60.5°C 2.178 @ 61°C *
Pressure Aging Vessel Residue aging 20 hrs. @ 2.07 Mpa	
Dynamic Shear, AASHTO T315: G*sinδ, (Max. 5,000 kPa) Test Temp. @ 10 rad/s, kPa	4481 @ 19°C 4887 @ 18.5°C 5240 @ 18°C *
Creep Stiffness, AASHTO T313: S, (Max. 300 MPa) Test Temp. @ 60 s., MPa	243 @ -18°C 474 @ -24°C *
Slope of log Creep Stiffness v. Log Time, AASHTO T313: m-value, (Min. 0.300)	0.327 @ -18°C 0.253 @ -24°C *
Additional Tests (Upon Request)	
Multiple Stress Creep and Recovery (MSCR), AASHTO T350-14	
MSCR, Non-recoverable Creep Compliance at 3.2 kPa, Jnr3.2 (kPa^{-1}) (NA)	2.83
MSCR, Average Percent Recovery at 3.2 kPa, R3.2 (%) (NA)	1.6
MSCR, Difference Non-recoverable Creep Compliance, Jnrdiff (%)	14.8
Elastic Recovery (ASTM D6084, B), 10°C, %	10
Forced Ductility, Force Ratio (AASHTO T300), 4°C	0.002
Toughness (ASTM D5801), 25°C, N-mm	3754
Tenacity (ASTM D5801), 25°C, N-mm	840

(*) indicates result does not meet Specification for this parameter.

CONFORMS TO SPECIFICATION: **YES** [X] **NO** [ ]

ACTUAL PG GRADE: **PG 60.5-29.9**

COMMENTS:

SIGNATURE: [signature] DATE: 12/12/2017 (revised)

Dawit Amar/Laboratory Supervisor

APPENDIX E – IRI AND RUT DEPTH DATA

2017 Pavement Wear ARAN Data Summary

Wear #1 64-34 2.5% Air Voids Start - 47.4470/52.9602									
	Fall 2017	**Spring 2018**	**Fall 2018**	**Spring 2019**	**Fall 2019**	**Summer 2020**	**Fall 2020**	**Spring 2021**	**Fall 2021 HS Profiler**
Left Rut	2.20	2.37	2.99	3.69	3.77	4.74	5.22	4.96	N/A
Right Rut	1.88	2.35	3.59	4.66	4.62	6.08	6.19	6.69	N/A
Max Rut	**2.23**	**2.69**	**3.66**	**4.78**	**4.81**	**6.13**	**6.33**	**6.77**	**N/A**
Avg Rut	2.02	2.39	3.39	4.25	4.28	5.40	5.78	5.88	
Left IRI	0.63	0.64	0.63	0.65	0.66	0.68	0.69	0.69	0.71
Right IRI	0.56	0.57	0.55	0.58	0.57	0.60	0.66	0.61	0.57
Avg IRI	0.60	0.60	0.59	0.61	0.62	0.64	0.68	0.65	0.64

Max Rut Winter 2018 Damage	0.45
Max Rut Summer 2018 Damage	0.97
Max Rut Winter 2019 Damage	1.12
Max Rut Summer 2019 Damage	0.03
Max Rut Winter 2020 Damage	1.32
Max Rut Summer 2020 Damage	0.20
Max Rut Winter 2021 Damage	0.43

Wear #2 64-34 1.0% Air Voids Start - 47.4427/52.9697									
	Fall 2017	**Spring 2018**	**Fall 2018**	**Spring 2019**	**Fall 2019**	**Summer 2020**	**Fall 2020**	**Spring 2021**	**Fall 2021 HS Profiler**
Left Rut	1.93	2.09	2.97	3.84	3.83	4.92	5.26	4.71	N/A
Right Rut	1.93	2.20	3.86	4.84	4.84	6.13	6.71	7.04	N/A
Max Rut	**2.04**	**2.31**	**3.86**	**4.91**	**4.92**	**6.13**	**6.74**	**7.06**	**N/A**
Avg Rut	1.98	2.17	3.58	4.50	4.38	5.64	6.00	5.97	
Left IRI	0.55	0.54	0.50	0.53	0.53	0.52	0.53	0.53	0.51
Right IRI	0.55	0.54	0.52	0.54	0.54	0.56	0.60	0.57	0.52
Avg IRI	0.55	0.54	0.51	0.53	0.54	0.54	0.56	0.55	0.52

Max Rut Winter 2018 Damage	0.27
Max Rut Summer 2018 Damage	1.55
Max Rut Winter 2019 Damage	1.05
Max Rut Summer 2019 Damage	0.01
Max Rut Winter 2020 Damage	1.21
Max Rut Summer 2020 Damage	0.61
Max Rut Winter 2021 Damage	0.31

Wear #3 64-28 2.5% Air Voids Start - 47.4367/52.9783									
	Fall 2017	**Spring 2018**	**Fall 2018**	**Spring 2019**	**Fall 2019**	**Summer 2020**	**Fall 2020**	**Spring 2021**	**Fall 2021 HS Profiler**
Left Rut	1.96	2.00	2.99	3.61	3.89	4.47	4.80	4.35	N/A
Right Rut	1.95	2.29	3.90	4.76	4.86	5.78	5.83	6.38	N/A
Max Rut	**2.04**	**2.29**	**3.90**	**4.78**	**4.88**	**5.79**	**5.87**	**6.42**	**N/A**
Avg Rut	1.97	2.11	3.51	4.34	4.39	5.20	5.35	5.33	
Left IRI	0.67	0.68	0.65	0.67	0.68	0.69	0.68	0.69	0.70
Right IRI	0.65	0.65	0.62	0.68	0.65	0.67	0.72	0.67	0.66
Avg IRI	0.66	0.67	0.64	0.67	0.66	0.68	0.70	0.68	0.68

Max Rut Winter 2018 Damage	0.25
Max Rut Summer 2018 Damage	1.61
Max Rut Winter 2019 Damage	0.88
Max Rut Summer 2019 Damage	0.10
Max Rut Winter 2020 Damage	0.92
Max Rut Summer 2020 Damage	0.07
Max Rut Winter 2021 Damage	0.55

Wear #4 64-28 Part A and B 1.0% Air Voids Start - 47.4298/52.9863									
	Fall 2017	**Spring 2018**	**Fall 2018**	**Spring 2019**	**Fall 2019**	**Summer 2020**	**Fall 2020**	**Spring 2021**	**Fall 2021 HS Profiler**
Left Rut	2.00	2.71	3.82	4.84	5.03	6.11	6.02	6.59	N/A
Right Rut	2.26	3.43	4.04	5.58	5.80	6.90	7.66	7.89	N/A
Max Rut	**2.29**	**3.58**	**4.39**	**5.84**	**6.07**	**7.16**	**7.82**	**8.19**	**N/A**
Avg Rut	2.13	3.06	4.07	5.26	5.48	6.53	6.88	7.25	
Left IRI	0.56	0.58	0.56	0.58	0.60	0.61	0.62	0.61	0.62
Right IRI	0.53	0.52	0.55	0.56	0.5661	0.58	0.68	0.62	0.62
Avg IRI	0.54	0.55	0.56	0.57	0.58	0.59	0.65	0.61	0.62

Max Rut Winter 2018 Damage	1.29
Max Rut Summer 2018 Damage	0.81
Max Rut Winter 2019 Damage	1.45
Max Rut Summer 2019 Damage	0.23
Max Rut Winter 2020 Damage	1.09
Max Rut Summer 2020 Damage	0.66
Max Rut Winter 2021 Damage	0.37

Wear #5 58-28 1.0% Air Voids Start - 47.4114/52.0109									
	Fall 2017	Spring 2018	Fall 2018	Spring 2019	Fall 2019	Summer 2020	Fall 2020	Spring 2021	Fall 2021 HS Profiler
Left Rut	2.11	2.20	2.86	3.19	3.47	4.09	4.63	4.78	N/A
Right Rut	2.25	2.67	3.75	4.40	4.87	5.78	5.85	6.85	N/A
Max Rut	**2.40**	**2.80**	**3.77**	**4.46**	**4.90**	**5.80**	**6.10**	**6.91**	**N/A**
Avg Rut	2.23	2.48	3.41	3.85	4.22	4.99	5.36	5.86	
Left IRI	0.71	0.73	0.71	0.71	0.72	0.73	0.77	0.74	0.72
Right IRI	0.57	0.60	0.58	0.58	0.58	0.61	0.69	0.63	0.59
Avg IRI	0.64	0.66	0.64	0.65	0.65	0.67	0.73	0.68	0.66

Max Rut Winter 2018 Damage	0.39
Max Rut Summer 2018 Damage	0.97
Max Rut Winter 2019 Damage	0.69
Max Rut Summer 2019 Damage	0.44
Max Rut Winter 2020 Damage	0.91
Max Rut Summer 2020 Damage	0.30
Max Rut Winter 2021 Damage	0.81