# Development and Evaluation of a Non-Tracking Asphalt Emulsion for Tack Coats and Fog Seals

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**ABSTRACT**

Tack coats are thin applications of asphalt emulsion between the layers of a pavement structure with the role of enhancing adhesion. Fog seals are thin emulsion applications to a pavement surface for protecting the surface from oxidation and water ingress, as well as reducing the risk of raveling and stone loss. One of the downsides of using asphalt emulsions for these applications is the required breaking and curing time. Even after curing, traditional emulsion grades will track onto nearby surfaces. Slow curing fog seals require longer road closures and/or a light sand application before trafficking.

This paper presents the development stages of a non-tracking emulsion developed for bond coats and fog seals. The emulsion was formulated and engineered to be fast curing and provide a hard, non-tracking surface, suitable to support traffic without the use of sand application. Its tracking properties were assessed using novel tracking and curing tests, and its performance as a bond coat was measured using the tack coat shear test developed by McAsphalt. Trial projects of tack coating and fog seals were conducted from 2013 to 2016 throughout several Canadian provinces. Performance to date in the field, as well as some observed challenges, are presented.

**RÉSUMÉ**

Les liants d’accrochage sont des applications minces d'émulsion de bitume entre les couches d'une structure de chaussée avec le rôle d'accroître l'adhésion. Les traitements de type "Fog seal" sont des applications minces d'émulsion sur une surface de chaussée pour protéger la surface contre l'oxydation et la pénétration d'eau, ainsi que pour réduire le risque d’arrachement et de perte de pierres. L'un des inconvénients de l'utilisation d'émulsions de bitume pour ces applications est le temps de rupture et de mûrissement requis. Même après le mûrissement, les grades traditionnels d'émulsion pénétreront dans les surfaces à proximité. Les traitements de type "Fog seal" à mûrissement lent nécessitent des fermetures de route plus longues et/ou une application légère de sable avant la remise en service.

Cet article présente les étapes de développement d'une émulsion sans suivi développée pour les couches de liaison et les traitements de type "Fog seal". L'émulsion a été formulée et conçue pour avoir un mûrissement rapide et fournir une surface dure sans suivi, adaptée pour supporter le trafic sans l'application de sable. Ses propriétés de suivi ont été évaluées en utilisant de nouveaux tests de suivi et de mûrissement, et sa performance en tant que couche de liaison a été mesurée à l'aide du test de cisaillement du liant d’accrochage développé par McAsphalt. Les projets d'essai de liant d’accrochage et de traitements de type "fog seal" ont été réalisés de 2013 à 2016 dans plusieurs provinces canadiennes. Les performances à ce jour sur le terrain, ainsi que certains défis observés, sont présentés.

## 1.0 INTRODUCTION

Tack coats and fog seals are two of the most important applications for asphalt emulsions. A tack coat has a structural role by providing adhesion between pavement lifts, while fog sealing is mostly used as a protective treatment for pavement surfaces of various types. Both tack coats and fog seals have traditionally used the same grade of emulsions, but these grades vary widely between jurisdictions.

Even though an application of tack coat is essential for the structural integrity and for durability of an asphalt pavement, it is not uncommon to see that some municipalities and, occasionally even larger agencies choose not to apply tack coat. The reasoning for this decision often lies in the inconvenience associated with allowing the time for the tack coat to cure and dry prior to applying the next lift of Hot Mix Asphalt (HMA). As harsh as it sounds, sometimes performance is compromised for the sake of convenience.

Numerous types of emulsions can be used for tack coating. Slow and rapid setting “traditional” emulsions, both cationic and anionic were, and still are, being specified across North America. Each and every one of them can be discussed in terms of its advantages or downsides as a tack coat, and various agencies swear by one material over the other. In reality, the tack coating process is not as demanding regarding specific parameters of the emulsions used, compared with other asphalt emulsion processes (e.g., chip sealing, prime coating, etc.). Any emulsion used for tack coat will provide a far superior interface bond strength than applying no tack coat at all [1].

## 2.0 TACK COATS (BOND COATS) AND FOG SEALS

### 2.1 Definitions and Scope

A tack coat is a thin layer of asphalt binder designed to provide adhesion between different pavement lifts. Tack coats, sometimes called bond coats, are usually applied as emulsions and are sprayed during pavement construction before the application of the next lift. Once the emulsion cures and the next layer is applied, compaction of the upper lift will bond both layers into one structure. In addition to its structural purpose, a tack coat also prevents slippage between pavement lifts under shear stresses applied by the moving traffic (e.g., sloped sections, breaking and accelerating, etc.).

Fog seals are light applications of an asphalt emulsion to the surface of a pavement structure. This structure can be a chip seal (single sized or graded), a cold mix (open or dense graded), an in-place recycled or a hot-mix asphalt surface. The scope of applying a fog seal can include: protection of the existing surface from raveling and aggregate loss; protection from oxidation and UV rays; protection from exposure to moisture; minor crack sealing, and replenishment of missing binder to the upper pavement areas. Fog seals can be considered as part of the surface treatment family and often require a light application of a clean sand (natural or manufactured) for blotting the surface immediately after spraying the emulsion. This is to prevent traffic from tracking or damaging the un-cured emulsion. The sand application is a downside of the process, as it requires additional equipment to be used and can often produce a temporary unpleasant look for the freshly treated section.

Both tack coats and fog seals use lower viscosity emulsions and often require dilutions from the stock emulsified asphalt before application for the same purpose. The dilution step is not always mandatory and is not required for certain jurisdictions. The main reason behind the low viscosity requirement is the need for the emulsion to penetrate small cracks, pores, and be able to intimately flow into the pavement macro and micro textures.

## 2.2 Existing Specifications

Table 1 summarizes the traditional emulsion specifications used today for tack and fog coating across Canadian provinces. Most of the time, municipalities follow the provincial specifications, provided they use tack coating during HMA construction. Table 2 outlines the main emulsion types used for tack coats by province.

**Table 1. Tack coating emulsion specifications in Canada.**

| Laboratory Test | SS-1 | RS-1 | CRS-1H |
|---|---|---|---|
| Viscosity, Saybolt Furol, 25ºC, SFs | 20 - 60 | 20 - 100 | 20 - 100 |
| Residue by Distillation, 260ºC, % | min. 57 | min. 55 | min. 57 |
| Settlement, 24h, % mass | … | … | max. 1 |
| Settlement, 5 days, % mass | max. 5 | max. 3 | … |
| Sieve Test, % | max. 0.1 | max. 0.1 | max. 0.1 |
| Demulsibility, 35 ml $CaCl_2$ 0.02N, % | … | min. 60 | … |
| Demulsibility, 35 ml DOSS 0.8%, % | … | … | min. 40 |
| Particle Charge | Negative/Neutral | Negative/Neutral | Positive |
| Penetration on Residue, 25ºC, dmm | 100 - 200 | 100 - 200 | … |
| $G^*/\sin(\delta)$ on Residue, 64°C, kPa | … | … | 1.0 – 3.5 |
| Solubility in TCE of Residue, % | min. 97.5 | min. 97.5 | … |
| Ash Content of Residue, % | … | … | max. 1 |

**Table 2. Types of emulsions used for tack coating in Canada.**

| Laboratory Test | SS-1 | RS-1 | CRS-1H |
|---|---|---|---|
| Used non-diluted for tack coats | Alberta<br>Manitoba | New Brunswick<br>Nova Scotia<br>Newfoundland<br>ON (early/late season) | Quebec |
| Used diluted for tack coats | BC<br>Ontario<br>PEI<br>Saskatchewan | … | … |

## 3.0 LABORATORY DEVELOPMENT

### 3.1 Overview

The scope behind the development of the current non-tracking emulsion is to achieve improvements in performance on several directions, when compared to "classic" emulsion grades:

- Develop an emulsion that has significantly shorter breaking and curing times;
- Ensure that the interface bond strength is at least equal to, or preferably better than, the current tack coats;

- Provide an emulsion that allows and supports construction traffic without being damaged or tracked by construction equipment tires and track spreaders; and

- The formulation should permit the usage of the emulsion as a fog seal without the need for sand blotting the treated surface.

Beside the main directions of the development work listed above, subsequent discussions with industry stakeholders yielded several other requirements. For a product to be successful across all jurisdictions in Canada and North America, it was essential to build in additional flexibility such as:

- Developing a product portfolio that contains both anionic and cationic emulsions;

- Allowing the product to be dilutable with water but at the same time perform well if it is sprayed in its concentrated form; and

- Depart as little as possible from established emulsion specifications.

Our experience with road agencies has shown that emulsion specifications have changed little over time and that new products are accepted more easily if their properties can be described within the frameworks and methodologies of specifications already in place.

### 3.2 Materials and Testing

The laboratory stage for development of the newly formulated non-tracking emulsions consisted of establishing starting recipes aimed at meeting the SS classification type, as well as a cationic equivalent. Five anionic emulsion formulations were prepared and tested; they are labeled by the letters B through F. A stock SS-1 emulsion was used as a benchmark for comparing the test results, labeled as A. For the cationic emulsion group, four different formulations were tested and they are labeled with letters from G through J.

The tests conducted on the emulsion groups include residue by evaporation or distillation; settlement over 5 days; particle size and particle size distribution; behaviour during dilution with water at a 50/50 rate; and drying and tracking performance. The particle size and particle size distribution were measured using a Horiba laser scatter particle size analyser.

The Drying and Tracking Test is adapted from ASTM D711 – "Standard Test Method for No-Pick-Up Time of Traffic Paint" [2]. Various versions and adaptations of this test were previously used to determine the tracking performance of emulsion residues [3, 4].

In our version of the test, the emulsion is applied as a thin film on top of a piece of roofing felt. This is the closest surface that replicates an asphalt pavement and at the same time is sufficiently smooth for controlling the thickness of the emulsion during the application. The film thickness we selected to be representative for a typical tack coat application was 0.5 mm and the tool used for applying the emulsion was a draw-down device developed in Quebec for applying tack coating emulsion on a granite plate [5]. The film thickness is verified using a gauge immediately after the emulsion is spread.

The tracking device consists of a steel cylinder that weights 5386 ± 28 grams and that has two synthetic rubber O-rings of 9.5 mm diameter and an outside diameter of 104 mm (Figure 1). The cylinder is rolled down a ramp of 1:6 slope and subsequently rolls over the film of emulsion and then over a clean sheet of paper (Figure 2).

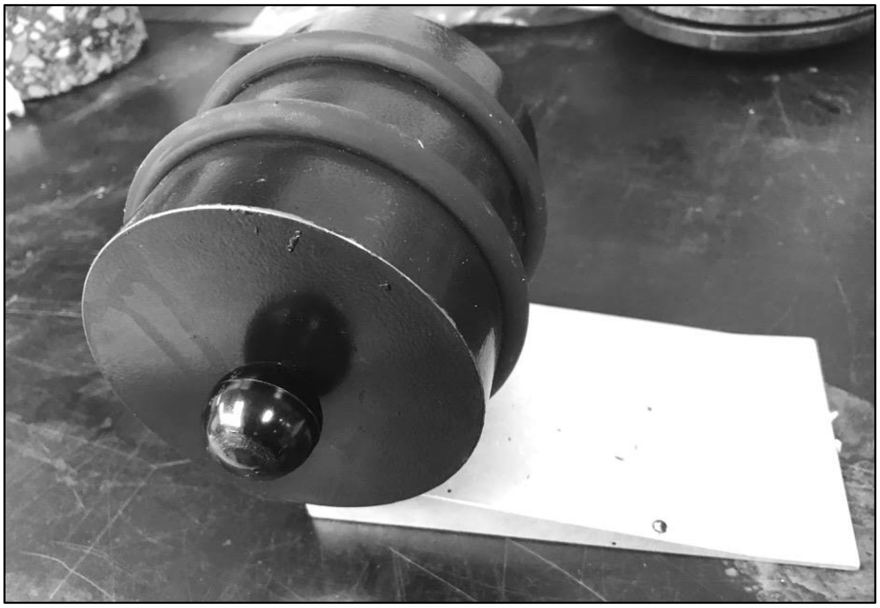

**Figure 1. Steel Cylinder with O-rings and Ramp**

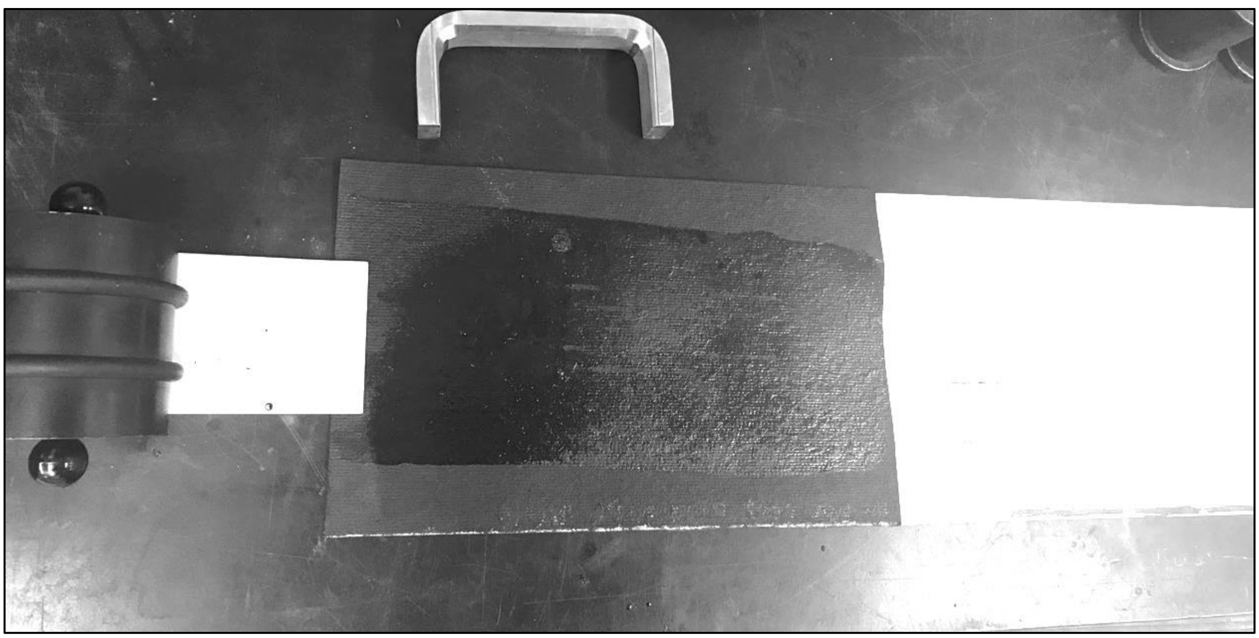

**Figure 2. Drying and Tracking Test Assembly**

The length of the roofing felt with the emulsion film is the same length as the rubber band circumference, namely 327 millimetres. This way, the whole length of the rubber rings will make contact with the emulsion.

The rubber bands around the steel cylinder will track the emulsion residue over the white paper, leaving a mark of a given length. This mark is measured and is expressed in percent of the length of the total sheet of paper.

The test in its current form measures two distinct parameters: the time it takes for the tack coating emulsion to break; and the tracking susceptibility of the emulsion residue once the breaking of the emulsion is completed. Both properties are important and both must be precisely designed and controlled for a non-tracking tack coat to perform adequately in the field.

After the application of the emulsion film onto the roofing felt, the steel cylinder is rolled over the emulsion and onto the tracking paper at intervals of every 10 minutes, to a maximum of 30 minutes. It was decided that if an emulsion has not broken to a significant degree within the first 30 minutes (when the test is conducted at the ambient temperature of 23 ± 2°C), it will not meet the expected field behaviour for the type of tack coat we are trying to develop. As a result, the sample would be deemed unsatisfactory to be used as a non-tracking tack coat.

### 3.3 Laboratory Results

Anionic emulsions A to F and cationic emulsions G to J were prepared in the laboratory using a Raschig small scale emulsion mill. The test results obtained are presented in Table 3 for the anionic samples and in Table 4 for the cationic ones.

**Table 3. Key Properties of Anionic Emulsion Samples**

| Emulsion | Residue, % | Settlement, 5 days, % | Median Particle Size, µ | Stability after Dilution | Tracking 10 min, % | Tracking 20 min, % | Tracking 30 min, % |
|---|---|---|---|---|---|---|---|
| A | 61.2 | 0.3 | 1.96 | Good | 98 | 60 | 49.5 |
| B | 65.2 | 0.33 | 4.22 | Good | 89 | 7.5 | 1 |
| C | 64.8 | 2.13 | 2.76 | Good | 90 | 12.5 | 0 |
| D | 62.6 | 6.11 | 2.47 | Good | 93 | 26 | 0 |
| E | 61.5 | 2.25 | 2.87 | Good | 85 | 5 | 0 |
| F | 61.7 | 2.6 | 2.42 | Poor | 28 | 1 | 0 |

**Table 4. Key Properties of Cationic Emulsion Samples**

| Emulsion | Residue, % | Settlement, 5 days, % | Median Particle Size, µ | Stability after Dilution | Tracking 10 min, % | Tracking 20 min, % | Tracking 30 min, % |
|---|---|---|---|---|---|---|---|
| G | 62.8 | 4.85 | 5.40 | Good | 85 | 12 | 1 |
| H | 64.6 | 10+ | 3.40 | Poor | 94.5 | 45.5 | 1 |
| I | 65.3 | 10+ | 11.81 | Poor | 20 | 0.5 | 0 |
| J | 65.2 | 3.51 | 5.84 | Good | 95 | 91 | 12 |

The most important parameter in selecting a non-tracking tack coating emulsion is the result of the Drying and Tracking test. One internal objective set for the non-tracking emulsion was to be entirely non-tracking at 30 minutes of curing time, under ambient conditions. Utilizing a tack coat that requires an excessive time to break is a major inconvenience for the paving process, regardless if the emulsion develops non-tracking behaviour afterwards. Figures 3 and 4 show examples of the tracking results for the samples “J” and “C,” respectively.

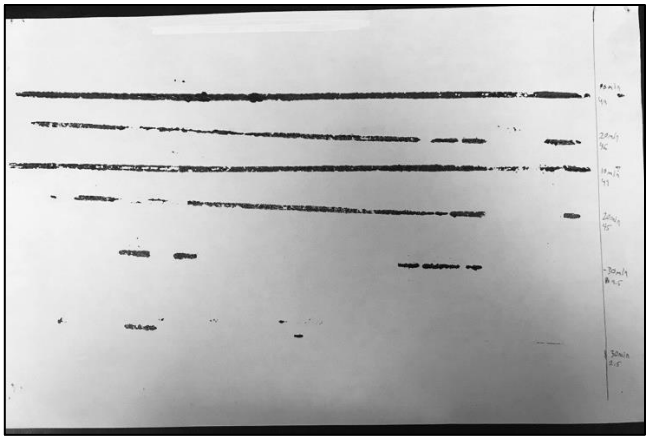

Figure 3. Tracking Result for Sample "J"

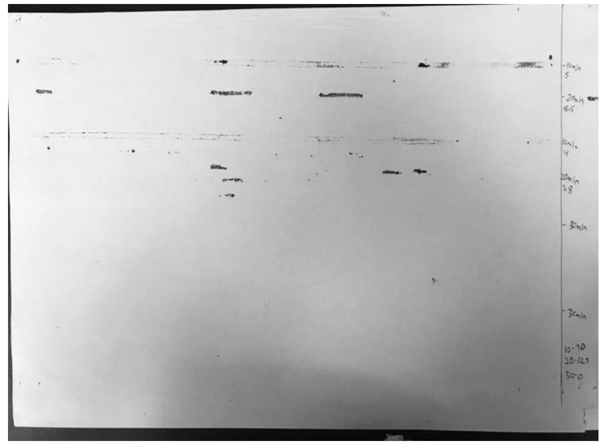

Figure 4. Tracking Result for Sample "C"

The risk also exists of designing an emulsion that breaks too fast for real life conditions. Experiments with emulsions that displayed extremely fast breaking behaviour have produced serious difficulties when applied in the field. Such an emulsion will plug the spray nozzles of the tack coating distributor as soon as the equipment has stopped spraying for a few minutes. An emulsion with the tracking results similar with sample "I" presents a real risk of such problems, although the laboratory results for this particular sample were likely a combination of a very fast breaking formula combined with a coarse and borderline unstable product.

Plotting the tracking results of the emulsions (Figures 5 and 6) helps the analysis of the breaking and tracking and the selection process for the best suitable formulation.

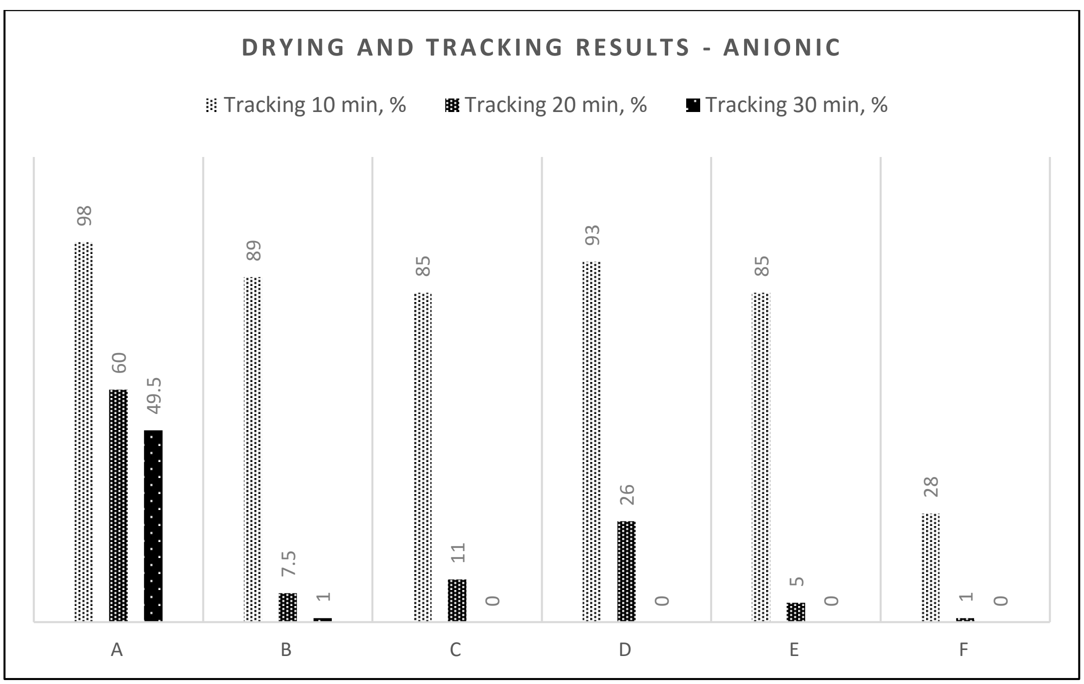


Figure 5. Tracking results for the anionic emulsion group.

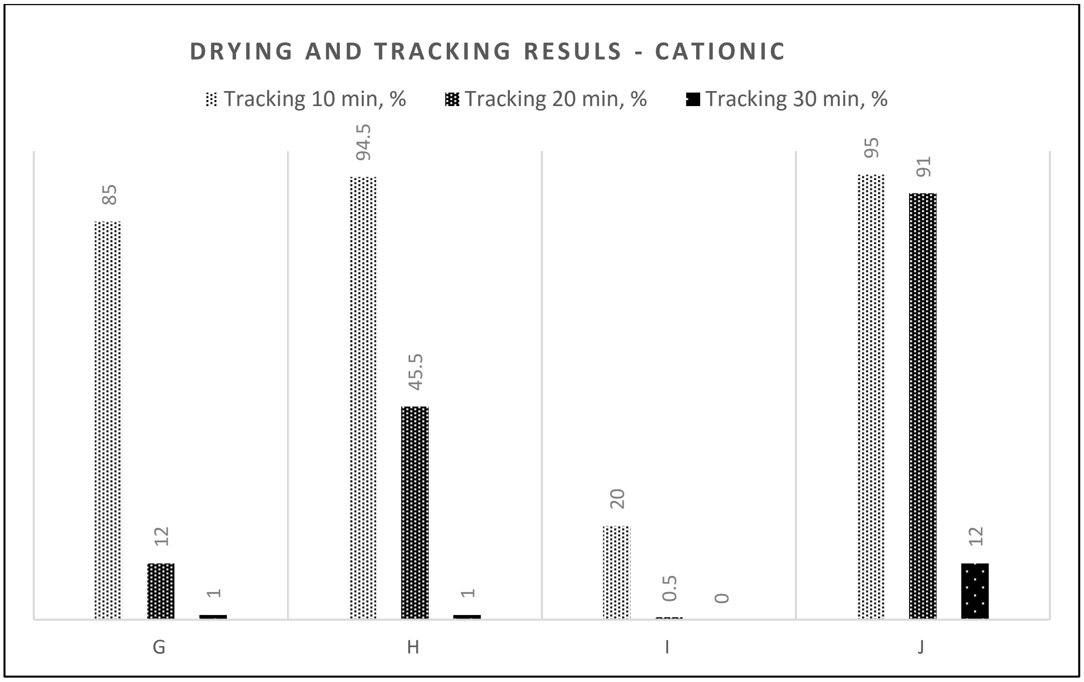


**Figure 6. Tracking results for the cationic emulsion group.**

It is evident that all anionic formulas show significantly quicker breaking time and much less tracking compared to Sample A, which is a traditional SS-1 emulsion widely used as a tack coat. Subsequently, further criteria were used in selecting the best suited emulsion formulation. Emulsions that showed questionable stability or settlement results were eliminated; so were emulsion formulas that did not show good stability or adequate behaviour when diluted 50/50 with water. Economic considerations were also reviewed when ranking emulsions; tack coating need not become an expensive process or municipalities will be tempted to skip it. Emulsion "C" on the anionic side and emulsion "G" on the cationic side were selected as having the best-balanced set of properties.

### 3.4 Bond Strength Testing

Bond strength testing was conducted on the anionic emulsion sample C and compared to the bond strength obtained from a standard SS-1 emulsion. The testing was conducted on laboratory-prepared specimens in duplicate, using the McAsphalt shear strength apparatus and the Tack Coating Shear Testing method [1]. A photo of the mold used for measuring the tack coat bond strength is shown in Figure 7. Figure 8 shows a 100 mm (4-inch) specimen mounted in the mold, ready for testing using the Pine Stability Tester.

The hot-mix asphalt used for the preparation of the specimens was HL-3 mix sampled from the Miller Whitby hot mix plant. The specimens were prepared by using 100 gyrations for the lower half of the briquette, followed by cooling the mold assembly. After cooling, the tack coat was applied to the mix at an application rate corresponding to 0.1 kg/m$^2$ of residue. This rate was selected because it is the standard application rate for tack coat in several provinces (Ontario, New Brunswick, etc.). After the tack coat has dried, the second half of the briquette was gyrated on top, using 50 gyrations. The specimens were de-molded and cured for 24 hours before they were sheared along the interface as described, at room temperature. The bond strength was calculated for each emulsion and the results are presented in Table 5.

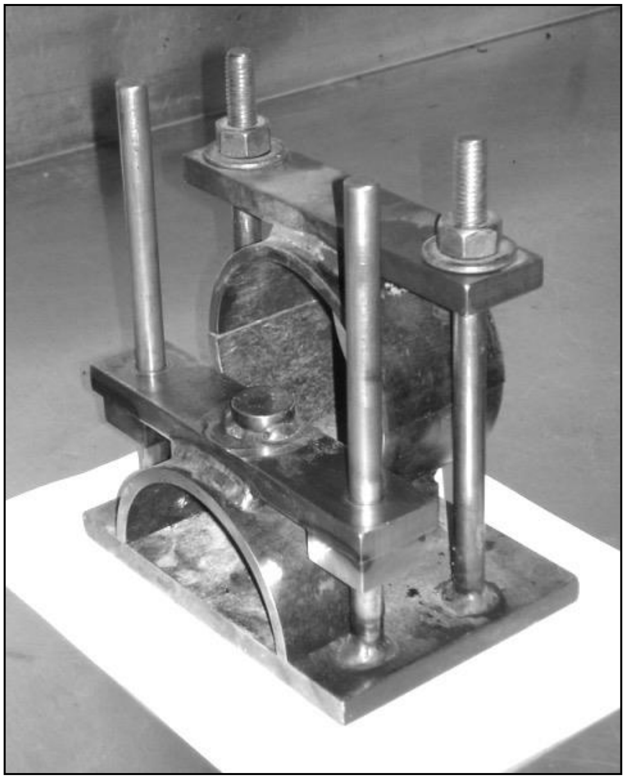

**Figure 7. Mold for bond strength testing.**

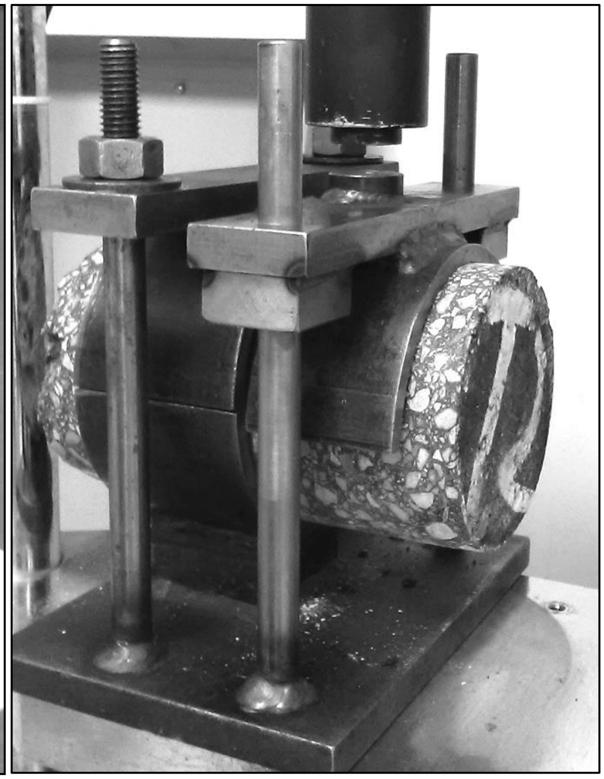

**Figure 8. Specimen ready for bond testing.**

**Table 5. Shear strength comparison of SS-1 vs "C" non-tracking emulsion.**

| Sample | SS-1 Tack Coat, Shear Strength, kPa | "C" Non-tracking Tack Coat, Shear Strength, kPa |
|---|---|---|
| Specimen 1 | 1982.2 | 2378.7 |
| Specimen 2 | 2038.9 | 2350.4 |
| **Average** | **2010.6** | **2364.6** |

The testing procedure shows and good testing reproducibility between similar specimens. The non-tracking anionic emulsion "C" show a 17.6 percent improvement in strength over its SS-1 benchmark emulsion. This comparison was done without additional research on optimizing the application rate for the emulsion "C," which might be different from the 0.1 kg/m$^2$ used for this test. According to NCHRP Report 712 [6], depending on the type of substrate, optimum residual application rates for tack coats varies between 0.15 kg/m$^2$ for fresh asphalt lifts to 0.25 kg/m$^2$ for milled surfaces or old asphalt. A further study is presently conducted by McAsphalt Industries for determining the optimum field application rate for non-tracking emulsions.

## 4.0 FIELD TRIALS

In parallel with the work conducted during the laboratory development, several field trials were scheduled. This process aided the laboratory development work by validating or invalidating several emulsion formulations. The Drying and Tracking test is a useful tool for ranking drying and tracking behaviour of emulsions in the laboratory, but it will not provide any information about field-specific constraints and will not capture every parameter required for producing a high-performance tack coat or fog seal.

Over the last four years McAsphalt arranged and conducted over 10 field trials where non-tracking emulsions in various development stages were used for tack coating, and approximately the same number of field trials for fog sealing. A selection of the most important trials, as well as the trials that provided the most meaningful and useful information for the product development and optimization, are presented in the following sections.

### 4.1 Tack Coat, Hillcrest Avenue, Airdrie, Alberta, May 2015

The trial was conducted when the top lift was constructed on a couple of streets in a recently built subdivision. The non-tracking emulsion used was an anionic formulation of the SS type and the application used emulsion diluted to approximately 50 percent residue. The application temperature was 65°C and the spray rate was 0.4 L/m$^2$, meaning approximately 0.2 L/m$^2$ residual. The paving contractor was Volker Stevin and the weather was clear with the air temperature during the application between 7 and 12°C. The emulsion dried to a non-tracking state and was traffic ready in 15 minutes.

To test the interfacial bond strength, 4 x 100 mm diameter cores were taken from the newly surfaced Hillcrest Avenue where the non-tracking tack coat was used; at the same time 4 other 100 mm cores were taken from a nearby street that was resurfaced at the same time but for which SS-1 dilute was used for tack coat:

- T1 -T4 represent 4 cores taken from a pavement using SS-1 emulsion used for tack coating
- H1- H4 represent 4 cores taken from a pavement trials using non-tracking tack coat emulsion

The field cores were tested using the Tack Coat Shear Testing procedure developed at the McAsphalt Research Centre, as presented in the lab testing section. The experimental results measured on the specimens using SS-1 emulsion for tack coat (T1 – T4) are shown in Table 6.

**Table 6. Shear test results for the T1 – T4 field specimens.**

| Specimen | Peak Load, lbf | Peak Load, N | Bond Strength, kPa |
|---|---|---|---|
| T1 | 1650 | 7339.5 | 1071.5 |
| T2 | 1630 | 7250.6 | 1058.5 |
| T3 | 1700 | 7562.0 | 1103.9 |
| T4 | 1625 | 7228.3 | 1055.2 |
| **Average** | **1651.3** | **7345.1** | **1072.3** |

From analyzing the results presented in Table 6, we have seen that all the SS-1 specimens have shown a clean failure mode at the tack coat interface and the consistency obtained for all the four specimens is very good. A photo of a specimen before and after shearing is shown in Figure 9. The interface is shown using the arrow.

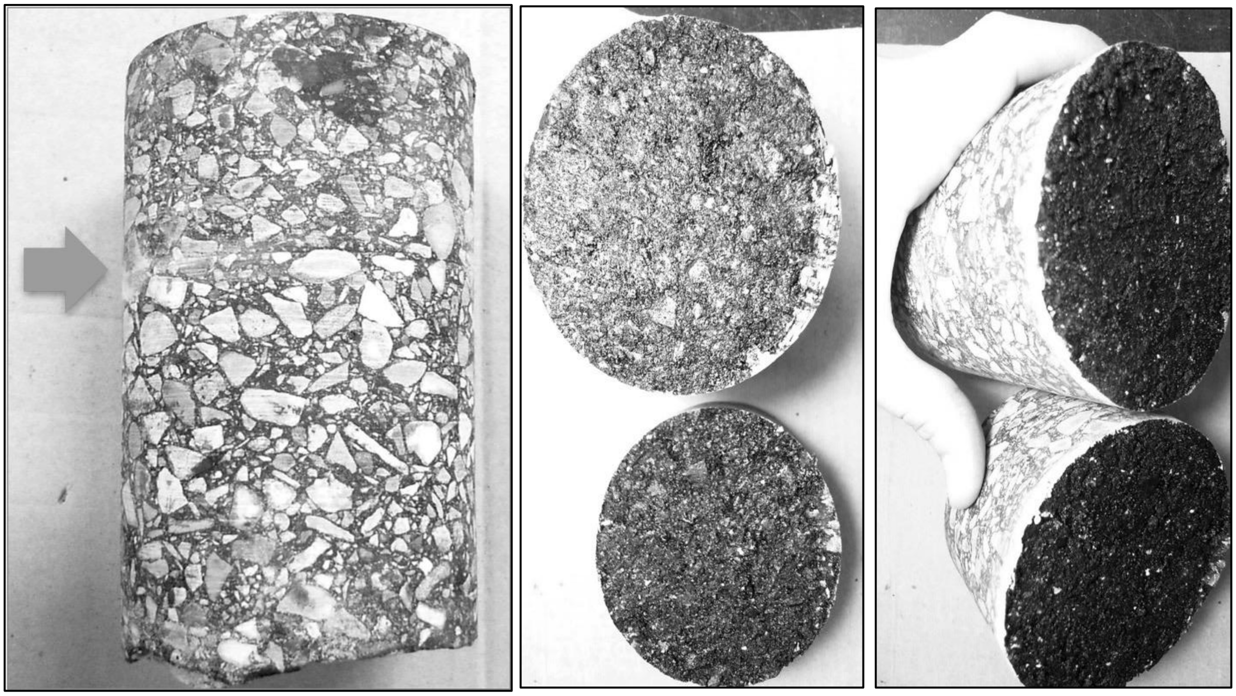

**Figure 9. a.) Specimen T1 before shear testing; b.) and c.) after shear testing**

The experimental results measured on the specimens using the non-tracking SS type emulsion for tack coating (H1 – H4) are shown in Table 7.

**Table 7. Shear test results for the H1 – H4 field specimens.**

| Specimen | Peak Load, lbf | Peak Load, N | Bond Strength, kPa |
|---|---|---|---|
| H1 | 1500 | 6672.3 | 974.1 |
| H2 | 1120 | 4982.0 | 727.3 |
| H3 | 1825 | 8118.0 | 1185.1 |
| H4 | 1450 | 6449.9 | 941.6 |

From analyzing the results presented in Table 7, it is obvious that the non-tracking tack results show much higher variability between the specimens. At the same time, three out of the four samples show lower bond strengths than the briquettes using SS-1 emulsion as tack coat. The reason for the lower results observed in the H samples lies in the failure mode: 3 out of the 4 specimens did not fail at the tack coat interface but failed within the top lift of the HMA. Defects and weak spots were visible in the top HMA for the H specimens before conducting the testing.

Figure 10a shows the H2 specimen before shearing (arrow points to the weak section); Figure 10b shows H2 after shearing where the failure mode through the weak HMA section is visible.

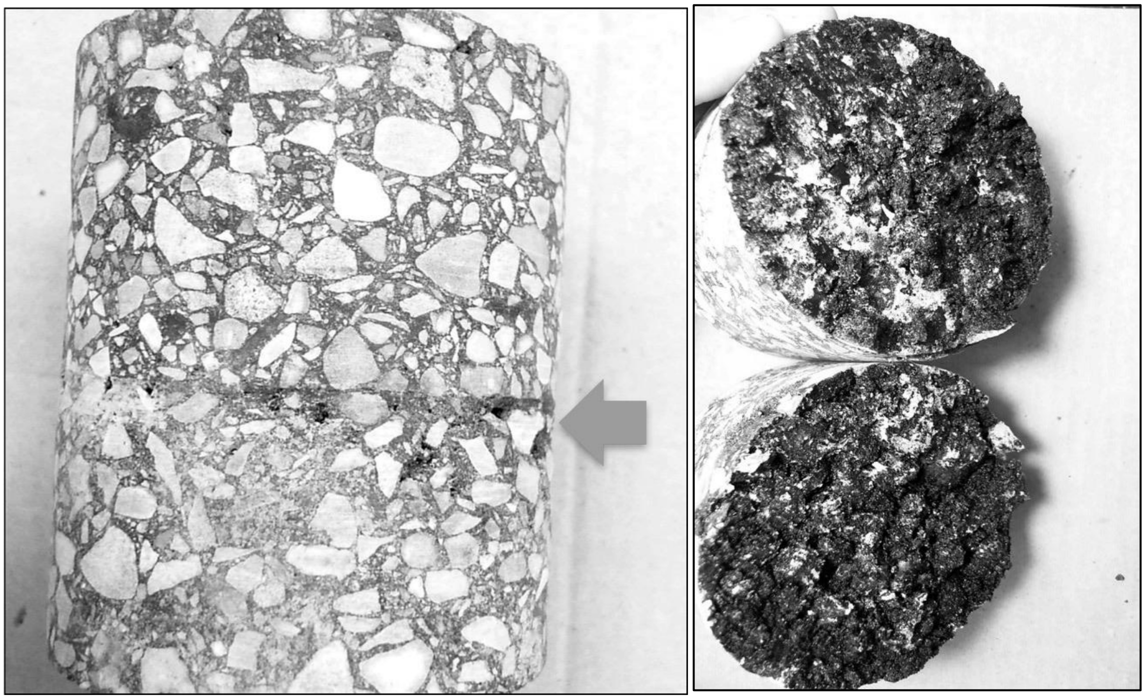

**Figure 10. a.) Specimen H2 before shearing (HMA defects visible); b.) after shearing.**

Only specimen H3 out of the four H briquettes failed predominantly at the tack coat interface. About two thirds of the cross section sheared through the tack coat and the rest through a weak section of the HMA. Specimen H3 had the highest measured bond strength at 1185.1 kPa, higher than any of the four T specimens using SS-1 emulsion. A photo of the sheared H3 specimen is shown in Figure 11.

**Figure 11. Specimen H3 after shearing; a majority failure mode area is at the interface.**

This field trial allowed us to conclude that the interfacial bond strength for the non-tracking tack coat is higher than for the SS-1 when the failure mode is correct; unfortunately, other field parameters such as a weak mix hampered a clear field data collection and accurate measurement of the true interfacial bond strength.

### 4.2 Tack Coat, Rte 106, Memramcook, New Brunswick, September 2015

The paving on this project was placed over Cold In-place Recycled with Expanded Asphalt Mixture (CIREAM). The non-tracking tack coat was anionic of the SS type and the application rate was 0.2 L/$m^2$ of emulsion diluted to a 35 percent residue (0.07 L/$m^2$ residual). The contractor was MacDonald Paving and Construction Limited and the tack coat spraying was done by Industrial Cold Milling Limited. The weather was sunny, air temperature was 23°C with 60 percent relative humidity and light winds. The emulsion was dry, non-tacky and traffic ready after 9 minutes from its application.

Overall, the tack coat displayed excellent performance and the dried emulsion was robust enough to resist damage and picking by the construction traffic. Except in localized spots where some picking was observed but only on the tires of the Material Transfer Vehicle (MTV). Figure 12 shows mix trucks driving over the tack coat with no damage; Figure 13 shows the type of pick-up seen on the MTV tires.

**Figure 12. Trucks over non-tracking tack coat.**

**Figure 13. MTV picking of the tack coat.**

In analyzing the details of the MTV damage to the tack coat, it became obvious that the pick-up was because of the lower cohesion of the substrate (i.e., the CIREAM). The MTV was heavy enough to force limited adhesion between its tires and the freshly cured emulsion but, with rolling, the failure occurred cohesively within the CIREAM and not at any of the interfaces of the tack coat (tack/mix or tack/tire). In other words, the adhesion of the tack coat to the CIREAM was stronger than the strength of the CIREAM itself.

This was the first instance were the effect of applying a strong tack coat over a weak substrate was directly observed. A weak substrate could be anything from a bituminous layer with low cohesion, as seen above, to a surface that wasn’t properly cleaned prior to applying the emulsion. Subsequently, we have recorded another instance where the same non-tracking SS type tack was applied to a milled asphalt pavement that was not properly swept. The MTV tires collected the tack coat almost like a rolled belt. The tack coat layer is strong and cohesive, but if the adhesion to the substrate or the cohesion of the substrate are weak, failure will always happen at the weakest point. Such behaviour can be easily avoided by just properly sweeping the milled surface prior to tack coating, which is a best practice in the tack coating process. A more performant material can penalize bad behaviour more severely.

### 4.3 Tack Coat, Rte 2, Moncton, New Brunswick, June 2017

This project was more a regular paving project than a trial, but it was used to sample field cores for bond strength testing. The paving was placing a lift of a type D ½" HMA over a milled asphalt surface. The surface was clean and the tack coating used non-tracking emulsion of the SS type, diluted to approximately 35 percent residue. The application rate was 0.3 L/m$^2$ (approx. 0.1 L/m$^2$ residual) and the tack coat was traffic ready in 15 minutes. The air temperature was 17°C. There was absolutely no pick-up or tracking of the tack coat by either the trucks, the MTV, or by the paver.

Three cores of 100 mm diameter were sampled from the field and tested for bond strength and the results are shown in Table 8. Unfortunately, there were no field samples available for comparison with the RS-1 tack coat, the standard emulsion used for tack coating in New Brunswick.

**Table 8. Non-tracking SS type Emulsion Bond Strength on Rte 2**

| Specimen | Peak Load, lbf | Peak Load, N | Bond Strength, kPa |
|---|---|---|---|
| 1 | 1850 | 8229.2 | 1048.3 |
| 2 | 1870 | 8318.2 | 1059.6 |
| 3 | 2480 | 11031.6 | 1405.2 |
| **Average** | **2066.7** | **9193.0** | **1171.0** |

In analyzing the results, the sheared field cores didn't fail cleanly at the tack coating interface. The underlying mix shows some signs of stripping and weakness and the failure happened partially through the tack and partially through the base mix (Figure 14). The only conclusion we can draw at this point is that the interfacial bond strength of the non-tracking tack coat itself is higher than the currently measured values.

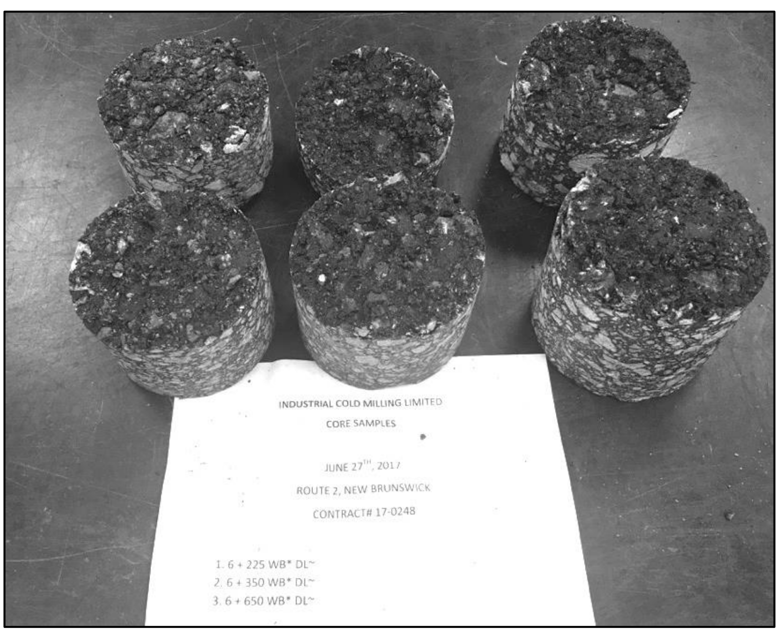


**Figure 14. Rte 2 Field Specimens after Bond Strength Testing**

From the laboratory and field samples tested so far for interfacial bond strength, laboratory samples show substantially higher bond strengths than the field samples. This disagrees with the observed behaviour reported in NCHRP Report 712 [6] and is likely a result of our laboratory specimen preparation method, which are not glued but compacted in the mold over the tack coat. If we compare our bond strength values obtained in the field with the typical values for Interfacial Shear Strength (ISS) reported in NCHRP 712 for somewhat similar application rates for non-tracking tack coat tested at 20°C (Table 9), our measured values are significantly higher. The results could be influenced by a difference in the loading rate between the two test methods. However, this observation warrants further research and we are currently conducting a larger study of measuring the bond strength for various emulsions and various application rates in the field, especially in lights of the strong dependency of the ISS to the residual application rate reported in NCHRP Report 712 [6].

**Table 9. Comparison of Bond Strengths on field specimens with the ISS reported in NCHRP 712**

| Sample | Residual, L/m$^2$ | Bond Strength, kPa | Bond Strength, psi | NCHRP 712 Mean ISS, psi |
|---|---|---|---|---|
| Airdrie H3 | 0.2 | 1185.1 | 171.8 | 101 @ 0.28 L/m$^2$ residual |
| Rte 2 Average | 0.1 | 1171.0 | 169.8 | 39.7 @ 0.14 L/m$^2$ residual |

### 4.4 Fog Seal, Hanwell Road (Rte 640), Fredericton, New Brunswick, September 2015

Hanwell Road was chip sealed in June of 2015 and New Brunswick Department of Transportation and Infrastructure (NBDTI) decided to fog seal the road section to provide better stone retention and resistance to snow plough damage. A non-tracking emulsion of the SS type was selected for the fog sealing process, which was conducted in September 2015, approximately 3 months after the seal was constructed. The emulsion was diluted to 36 percent residue and the application rate was 0.7 L/m$^2$ on flat sections and 0.6 L/m$^2$ on sloped sections. The weather was clear and the air temperature varied between 18°C in the morning hours to 25°C during early afternoon. No blotting sand was used. The surface was traffic ready in approximately 30 minutes but in some shady sections traffic was kept off the surface for up to 3 hours, just to ensure the complete curing of the fog seal. Figures 15 and 16 show the surface and the general aspect of Rte 640, 9 days after the application of the fog seal.

**Figure 15. Chip seal texture after fog seal.**

**Figure 16. Rte 640 with fog seal application.**

## 5.0 CONCLUSIONS AND SUMMARY

Tack coating is a treatment that is predominantly constructed by using emulsified asphalts and this thin bituminous layer plays an essential role in the structural make-up of an asphalt pavement. While tack coating is likely the most tolerant process when it comes to the type of the suitable asphalt emulsion, precise formulation of the emulsion is required if its behaviour during construction and its performance in service is to be maximized.

The development of a class of emulsions designed to work as non-tracking tack coats and fog seals was started in the laboratory by first laying out as set of performance parameters. Extensive formulation and testing was conducted and various types of asphalt cements, emulsifying chemistries, and additives were evaluated. Newly developed and adapted tests, such as the Drying and Tracking test, were used to measure and rank the time required for a tack coat to dry and cure, as well as its tracking behaviour. Interfacial bond strength measurements were conducted both on laboratory and field samples to ensure the newly developed emulsions do provide an adequate and sufficiently strong bond between the pavement layers.

The non-tracking emulsions gradually gained acceptance and trust with road agencies. Several provinces have adopted specifications to allow for these materials to be used as tack coats and/or fog seals. Most recently, the Ontario Ministry of Transportation has developed a specification for an SS-1HH emulsion specifically for allowing the usage of non-tracking tack coats. The specification is identical with the old SS-1 emulsion, used for traditional tack coats for long time, except for the Penetration of Residue, which requires a 20 – 55 dmm range. This type of generic listing is much easier for agencies to implement and is, at the same time, easy for the construction industry to adopt. Even though there is a lot more to formulating a non-tracking emulsion than switching to a lower penetration asphalt cement, specifications that keep it simple and are aligned with the existing industry expertise and acceptance procedures can be adopted quickly and relatively "pain free." The logical next stage in optimization of these new tack coating materials is a field study on determining the application rate that will maximize the interfacial bond strength for non-tracking tack coats.

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