Performance Review of Micro Surfacing and Slurry Seal Applications in Canada

Anton S. Kucharek, P.Eng., C.Chem.
Director Technical Services
McAsphalt Industries Limited
Toronto, Ontario

J. Keith Davidson, P.Eng.
Director Technology and Product Development
McAsphalt Industries Limited
Toronto, Ontario

Trevor Moore, P,Eng., G.S.C.
Technical Director
Miller Paving Limited
Gormley, Ontario

Peter Linton
Manager, Pavement Preservation Processes
Miller Paving Limited
Gormley, Ontario

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312 PERFORMANCE OF MICRO SURFACING AND SLURRY SEAL IN CANADA

ABSTRACT

Micro surfacing is a high performance surface treatment consisting of high-quality dense graded aggregate, bitumen emulsion, fillers, additives, polymers and water. It is one of the fastest growing processes world-wide because of its suitability for use both as a corrective and a preventive maintenance strategy, and because it's well suited for high traffic roadways. Slurry seal is a less expensive surface treatment that is constructed by the same basic principles as micro surfacing but lacks the aggregate structure capable of supporting high and very high traffic levels. It is usually applied on secondary roads and in lower traffic residential areas.

The current paper is presenting an overview of the use of micro surfacing and slurry seals in Canada for the last ten years or so. A number of key micro surfacing projects across Canada are reviewed according to their particular conditions and scope of use. Design and construction specifics are presented as well as the various provincial and municipal specifications in place at the time of construction. Special emphasis is laid on performance review after several years in the field, specific distresses, specific accomplishments and benefits of use.

RÉSUMÉ

Le microsurfaçage est un traitement de surface de haute performance constitué de granulats à granularité dense de haute qualité, d'émulsion de bitume, de filler, d'additif de polymères et d'eau. C'est un des procédés qui croissent le plus rapidement à travers le monde à cause de sa pertinence comme utilisation en stratégie d'entretien correctif et préventif et parce qu'il convient aux routes à fort trafic. Le coulis de scellement est un traitement de surface moins dispendieux qui est construit par les mêmes principes de base comme micro surfaçage mais n'a pas la structure de granulats capable de supporter des niveaux de trafic élevés et très élevés. Il est habituellement appliqué sur les routes secondaires et dans les quartiers résidentiels de trafic plus faible.

Le présent exposé donne une vue d'ensemble de l'utilisation du microsurfaçage et des coulis de scellement au Canada lors des dix dernières années. Un nombre de projets clés de microsurfaçage à travers le Canada sont évalués selon leurs conditions et possibilité d'utilisation particulières. On présente les détails de design et de construction ainsi que les diverses spécifications provinciales et municipales en place au moment de la construction. On place un emphase spécial sur l'évaluation de la performance après plusieurs années sur la route, les détériorations spécifiques, les accomplissements particuliers et les avantages d'utilisation.

1.0 INTRODUCTION

The development of the micro surfacing and slurry seal systems was a long, evolutionary process that started in Europe in the late 1920's. The development of the application techniques and the performance achieved by the surface treatments improved progressively over time [1].

It was only during the late 1970's that a definite transition took place from the slowly drying seal types to the reactive processes known today as quick set and quick traffic systems. This designation can be currently applied to both micro surfacing and slurry seal systems as long as they are engineered to perform this way.

This paper concentrates on the process and mix design aspect of the quick set and quick traffic version of the respective applications as well as the performance to date across Canada.

2.0 PROCESS DESCRIPTION

2.1 Slurry Seal Processes

Slurry seals are mixtures of mineral aggregates, cationic asphalt emulsion, water and additives mixed in specific proportions and placed over a properly prepared surface [2]. The asphalt emulsion can be neat or can be polymer modified. The additives that can be part of the recipe can be Portland cement, hydrated lime, fibres, break control additives, or other fillers.

The aggregate used as part of a slurry seal is a crushed aggregate with a gradation that can vary over a range of three or more gradation bands. The International Slurry Seal Association (ISSA) defines the accepted gradations as Type I, Type II and Type III, with Type I being the finest and Type III the coarsest gradation (Table 1). One characteristic of the aggregate used for slurry seal is that the fines content must be sufficiently high so that, when mixed with the emulsified bitumen, a mastic is formed that will constitute the continuous phase of the slurry application. This asphalt mastic will be the effective binder of the slurry seal application and will provide the sealing and waterproofing effect for the asphalt substrate. It will also ensure adequate bonding to the road and provide most of the structural capacity of the application. The larger chips are responsible mainly for abrasion resistance, wear, and surface macrotexture; they do not carry a significant structural role.

As a result, a slurry seal application will perform adequately on low volume roads, secondary roads and residential arteries. It is not designed to sustain heavy traffic and should not be applied in lifts thicker than about 1.5 times the maximum aggregate size. Contrary to an existing belief in our industry, the addition of polymer to a slurry seal will not improve the structural capacity of the application. Polymers will improve the wearing resistance, durability, and cohesion rate of the seal but will not add to the ability to support higher traffic levels.

2.2 Micro Surfacing Processes

Similar to the slurry seals presented in the previous section, micro surfacing consists of mineral aggregates, cationic asphalt emulsion, water and additives. The difference lies mainly in the aggregate and emulsion types. The aggregate used for micro surfacing applications is of very high quality, similar to the stone used in high end Superpave™ hot mix. The asphalt emulsion is always polymer modified in a micro

surfacing and contains a relatively high polymer dosage compared to other applications (usually 3 to 5 percent polymer).

Table 1. Aggregate Gradation Bands for Micro Surfacing

Sieve, mm	ISSA Type I, % passing	ISSA Type II, % passing	ISSA Type III, % passing	MTO Type III Modified, % passing
9.5	100	100	100	100
4.75	100	90-100	70-90	80-95
2.36	90-100	65-90	45-70	50-75
1.18	65-90	45-70	28-50	33-55
0.600	40-65	30-50	19-34	25-40
0.300	25-42	18-30	12-25	15-30
0.150	15-30	10-21	7-18	7-20
0.075	10-20	5-15	5-15	5-15

Note: ISSA stands for International Slurry Surfacing Association.
MTO stands for Ministry of Transportation Ontario.

The high quality stone will form a mineral skeleton that represents the primary structural element of the application. The asphalt mastic created from the bulk of the asphalt binder and the fine aggregate still exists but its main role is that of being a binder for the stone matrix, similar to a Stone Mastic Asphalt (SMA) mix. This structure confers the micro surfacing sufficient strength for supporting heavy traffic and allows its use on arterial roads and freeways. In fact, the stone matrix can be sufficiently strong to render a properly designed micro surfacing application capable of filling ruts in hot mix asphalt and on roads that carry very heavy traffic loads.

2.3 Project Selection

Depending on jurisdiction, availability of funding, state of the road network, and a number of other factors, the use of slurry seals and micro surfacing can be utilized to fulfill various functions. The main difference lies in the scope and placement timing. Applying the treatment at different times on a pavement condition index curve will translate into different functions fulfilled by the slurry surfacing.

Preventive maintenance is the first of these functions and it is this utilization where the effectiveness of these surface treatments is maximized. Selecting the right candidate roads for treatment is essential; the application must be done on roads that are structurally sound and the pavement is in relatively good condition. That means that the surfacing treatment is applied relatively high on the pavement condition curve. Most of the time, preventive maintenance is applied as part of some kind of asset management or pavement preservation program.

Slurry and micro surfacing can also be applied to restore surface characteristics. This is the situation where the application happens lower on the pavement condition curve, later in the pavement life. The road is still structurally sound but the substrate surface is starting to show distresses. Typical problems for this situation include a polished and/or low friction surface, aged and slightly pocked asphalt, slight profile deteriorations, slight rutting, flushing, minor cracking, etc.

It is not uncommon that slurry seal and micro surfacing are applied on roads that are normally too deteriorated for a surface treatment. Roads that start showing serious cracking, loss of profile, or structural problems are roads that should normally be treated with recycling or reconstruction, but are nevertheless surface treated with slurry systems. This approach is called a holding strategy and is applied in some jurisdictions as a low cost solution for extending the life of a pavement to properly allocate funds for rehabilitation. Some roads that are scheduled for reconstruction or for recycling often require a holding treatment for conferring an acceptable pavement condition for the last three to five years of service. Slurry seals and micro surfacing are capable of providing the holding performance necessary but this is not their intended primary use. Serious cracking and major profile loss can only be mitigated with success depending on the type, density, and severity of the existing distresses.

The principal effect of applying a slurry surfacing system on an existing pavement is the sealing of the pavement surface. This protects the asphalt from the effect of moisture ingress, oxidation, and aging by environmental factors thereby preventing further pavement degradation and pavement failure.

Pavement consolidation in the wheel paths is common on older pavements as a result of structurally inadequate base layers or increases in traffic. Micro surfacing is well suited for repairing minor ruts of such nature. The same is not valid for slurry seals. Depending on the rut depth, the repair can be done by applying a scratch coat and a top coat for small ruts or by filling deeper ruts using a rut box. The structural stone on stone matrix of micro surfacing provides sufficient strength for such use in the case where the ruts are dormant.

2.4 Performance Assessment and Typical Distresses of Micro Surfacing

A good performing slurry surfacing is one that delivers the objective of its use for a long time. The primary goal of any slurry application is to preserve and extend the life of the existing pavement. This purpose must be achieved while maintaining a high pavement condition index for the road and delivering a safe, comfortable and aesthetically pleasing road surface for the travelling public.

Generally, the estimated life for a micro surfacing application varies between 4 and 8 years of service, depending on traffic conditions. The life expectancy of a slurry seal is estimated between 3 and 7 years. It is not uncommon to see both types of applications exceed these periods of service. However, if a slurry surfacing is executed as part of a pavement preservation program, it is not desirable to allow the roadway to degrade beyond a given point. The next step of the road maintenance should be applied before the existing surface fails. This could be another re-surfacing or it could be a number of other different preservation treatments, depending on the project.

Some of the most commonly observed distresses on a micro surfacing are related to specific events during construction or to specific stresses during its service life. For example, applying a micro surfacing on a roadway where rutting is too advanced can lead to problems. Rut fill using micro surfacing must be done using a rut box if rut depths are over 12.5 mm. Application of a conventional scratch and surface application can lead to shoving and flushing of the mat. An example is shown in Figure 1.

Figure 1. Illustration of Micro Surfacing Shoving

A common temptation during micro surfacing construction is to apply more water to the mix than necessary. This may be done because a mat that is more fluid is easier to lay, or it can be done for control of the breaking time. Using more water than needed almost always leads to problems later in the life of the mat. Too much water leads to mix segregation, with the fines and part of the binder migrating to the surface and the lower portions remaining stony and under-asphalted. If this segregation is minor, it can lead to a shinier appearance of the surface, even though it is not true flushing, as there really is no excess binder in the mix. The micro might still perform adequate over time but the initial results are not optimum. An example of such a potential behaviour is shown in Figure 2. The picture shows a transverse joint where one mat was too wet and the other had a good consistency. The difference in surface aspect is obvious.

Figure 2. Illustration of the Effect of Excess Water on the Surface Characteristics

If the excess water is more extreme, the mastic will start to migrate to the surface and create a binder rich surface. A close-up of such a case is shown in Figure 3. This mat does not have an overall binder excess, but the too high water content used during construction lead to a flushed surface appearance and low skid resistance.

Figure 3. Micro Surfacing Macro Texture after Using Excess Water

Cracking can be observed relatively soon after construction reflecting through a micro surfacing mat, depending on the nature of the existing substrate cracks. This raises the importance of surface preparation. It is recommended that existing cracks in the roadway be sealed before micro surfacing is applied if the potential of crack reflection is high. This has to be done ideally the year before, or in any case at least two months before micro surfacing is laid.

Another common micro surfacing distress is wear. This can happen prematurely if there is a problem with the surfacing or can happen over its service life as a result of heavy traffic or snow ploughs. This type of distress relates to aggregate binder compatibility, to overall binder content and to the effectiveness of the polymer modification. The leaner mixes always abrade and wear more quickly than richer applications. As with hot mix, there is a strong correlation between mix durability and binder content.

3.0 SLURRY SYSTEMS ACROSS CANADA

Quick set and quick traffic slurry seals and micro surfacing have been applied across Canada from about the early nineties. The processes have evolved very differently depending on jurisdiction and the use of the slurry system processes is, to this day, very non-uniform. Some provinces or cities have embraced the

process and have made it part of their pavement preservation and pavement maintenance programs. It is usually in these jurisdictions where the processes perform the best, as both the agencies and the contractors have developed experience with the processes and have learned to avoid mistakes. Other places see no use or very minimal use of the slurry system processes. There might be various reasons why this happens, from not being familiar with the process to having witnessed failures sometime in the past. Over the next few sections we will try to summarize the key aspects of the utilization, the experience, the performance and the impressions about the slurry seals and micro surfacing applications across Canada.

3.1 Atlantic Canada

In the east, there is a lot of experience with micro surfacing. Its use, however, is uneven throughout the region, with some areas seeing strong use and with other areas seeing no use at all.

3.1.1 Nova Scotia

The Province of Nova Scotia was one of the early agencies to try out the micro surfacing process, with the first projects starting as early as 1993. The utilisation increased progressively and happened not only at provincial level but also at the municipal level. The specifications adopted were the ISSA specifications and remain so to this day.

Over the last number of years, the Province of Nova Scotia has completed a large number of micro surfacing projects every year. The vast majority of the application is used as preventive maintenance, usually on major highways. Significant portions of Highways 101 and 102 were surface treated with micro surfacing and performance remains excellent to this day.

Another example of good utilization of micro surfacing as a pavement preservation tool is Highway 104, the Cobequid Pass Toll Highway. This is a Public-Private Partnership (PPP) and is about 42 kilometres in length. The pavement preservation program of the Cobequid Pass Highway using micro surfacing was started around 2002. Since then, the entire highway was surface treated with excellent results. To our knowledge, the Cobequid Pass pavement preservation program is still continuing as the benefits are evident and the overall performance of the roadway is very good.

Halifax Regional Municipality (HRM) is another major agency that is utilizing micro surfacing as part of a comprehensive pavement management program. The first application of micro surfacing happened in 1995 and the program has grown steadily since. HRM resurfaces all types of roadways, including arterial roads, local streets and residential streets. HRM was facing a dilemma seen in other municipalities that utilize micro surfacing; how to deliver a surface that can support the very heavy city traffic and at the same time have a macrotexture that is not too rough, with noise levels sufficiently low for an urban area. Selecting a Type II micro surfacing gradation was not suitable because of the presence of some low level rutting on some arterial streets. The response was a fine Type III aggregate gradation, similar with what Ontario defines as a Type III Modified gradation. In addition, the contractor decided on utilizing a rubber tire roller on the mat, after the micro surfacing was sufficiently set to support early traffic (Figure 4). This improved the surface texture even more, to the point where it becomes almost un-distinguishable from a hot mix asphalt surface.

Besides Halifax, the City of Yarmouth has placed micro surfacing in the past in Nova Scotia, but their program is on a much smaller scale.

Figure 4. Rolling Micro Surfacing in Halifax for Smoother Finish

3.1.2 New Brunswick

New Brunswick Department of Transportation (NBDOT) started experimenting with micro surfacing also around 1995. The volumes grew over the years and the process is well established today, just as in Nova Scotia. Cities such as Moncton, Saint John and Edmundston have used micro surfacing as a pavement maintenance tool but on a scale smaller than HRM. During 2009 the City of Fredericton has initiated a pavement maintenance program and has tendered its first small micro surfacing program. To date, the feedback from the City of Fredericton is very positive and they decided to continue and grow the program for 2010.

However, the biggest micro surfacing volumes in New Brunswick for the last years were used by the PPP corporations MRDC and Brun-way. MRDC manages and maintains the Fredericton-Moncton Highway and started using micro surfacing in 2000 for some small repair projects. The potential of the process was quickly understood and it got adopted as a pavement preservation tool for the entire highway. The volumes of treatment grew steadily, with 2009 seeing the largest application volumes to date. To this date, about 90 percent of the micro surfacing applied during 2009 is considered to be performing excellent with about 10 percent or so showing some snow plough damage and early signs of distress. But the preservation program is considered a success overall and is scheduled to continue.

As an example of the type of micro surfacing mix that was placed on one of the MRDC sections, Table 2 shows the job mix formula and the principal design parameters.

Table 2. Job Mix Formula and Design Parameters for Moncton-Fredericton Highway Micro Surfacing

Ingredient	**Percent Mass, %**	**Specification**
ISSA Type III Screenings	100	100
CQS-1HP Emulsion	12.5 (±1.0)	
Portland Cement	1.0	0 – 2
Water	8	
Breaking Retardant	As required	
Parameters	**Result**	**Specification**
Residual Asphalt	8.125	5.5 – 9.5
Wet Cohesion, 30 minutes, cm.min	23	12 min.
Wet Cohesion, 60 minutes, cm.com	26	20 min
Wet Track Abrasion, 1 hour soak, g/m2	160	538 g/m^2 max
Wet Track Abrasion, 6 day soak, g/m2	275	807 g/m^2 max
Excess Asphalt Loaded Wheel, g/m2	265	538 g/m^2 max
Lateral Displacement Loaded Wheel, %	4.85	5.0 max
Wet Stripping, %	95	90 min.
Compatibility by SB&R	AAA (12 pts.)	11 Pts min.

Note: ISSA stands for International Slurry Surfacing Association
SB&R stands for Schultze, Breuer & Ruck

Brun-way is another PPP corporation managing the highway between Fredericton and the Quebec border. After starting micro surfacing in 2007, it is performing excellent and the preservation program is scheduled to continue.

New Brunswick has used occasionally small amounts of slurry seal, mainly at municipal level. These volumes are spotty and represent very isolated, local projects. Overall, micro surfacing is being used overwhelmingly over slurry seals, mainly because the vast majority of projects are placed on high traffic routes.

3.1.3 Other Atlantic Provinces

Newfoundland and Labrador tried a micro surfacing project in August 2002 on a highway west of Clarenville. The project was a rut fill and was completed successfully. However, the project failed during the first winter. The subsequent investigation of all the stakeholders involved concluded that the cause of the failure was likely a combination of factors including new and un-tested aggregate, less than ideal asphalt cement used for the emulsion manufacturing, and a high-demand project. Rut filling is usually a more demanding application and would be normally used after all the stakeholders are familiar and comfortable with the regular application of micro surfacing. Attempting a rut filling job on a high traffic roadway as the first ever micro surfacing project is like trying to run before learning to crawl. After this failure, no further micro surfacing projects were tried in Newfoundland.

Prince Edward Island tried a small micro surfacing project in 2005. To our knowledge no new ones were tendered, even though PEI had used slurry seals a number of years ago.

3.2 Quebec Experience

Quebec warmed to the idea of micro surfacing relatively recently, based on the positive experience in Ontario and in other jurisdictions. The first tenders were called during 2006, on Autoroute 30.

From 2007 to 2009, several micro surfacing projects were executed. Quebec has chosen the placement of micro surfacing on very high and heavy traffic highways. Examples of some of the highways that had surfaced sections are Autoroute 30 at Varennes, Autoroute 10 at Lac Brome, and Autoroute 70 at Chicoutimi.

Quebec developed their own provincial specifications, which are tailored after the ISSA A 143 [3] but are different in some aspects. The aggregate gradations specified by the Ministere des Transports du Quebec (MTQ) are different than the ISSA bands. The MTQ defines two gradations for micro surfacing, called Type A and Type B, with A being the finer band and B being more coarse. The MTQ construction specifications also differ slightly from the ISSA recommendations. For example:

- The minimum binder content is higher than in the ISSA document (7 percent compared to 5.5 percent),

- There are requirements for verification that the emulsion used for the design and the emulsions sampled from the job do not differ more than a specified tolerance, and

- The MTQ also uses an in-house developed compatibility test that measures residual coating (LC 25-009) [4] as acceptance criteria for emulsion-aggregate compatibility. This test is done in addition of the ISSA specified compatibility tests, namely the boiling test and the Schultze Breuer & Ruck test.

In reviewing the general performance of the projects executed so far, some are considered excellent and others did not meet the expectations. The worst performance to date was Autoroute 70 in Chicoutimi. The first section placed during 2008 was severely damaged by snow ploughs and the heavy truck traffic. Repairs were done in 2009 with better results but the outcome is still far from satisfactory. The main causes for the unsatisfactory performance of this project are a combination of factors: un-tested aggregate, borderline deep ruts and extremely severe climatic and traffic conditions (aggressive ploughing up to 6 months per year, heavy traffic using studded tires, etc). By contrast, Autoroute 30 at Mercier, done in 2006 has provided excellent performance to date. Another outstanding project is the section surfaced during 2009 on Autoroute 55.

3.3 Ontario Experience

Micro surfacing has been successfully utilized on numerous roadways and airports across Ontario with varying degrees of pavement distress since 1990 [5]. From 1990 until 1998 there were many trials conducted to determine its effectiveness on various roadway classifications and gain experience with the materials required to obtain the expected results. To date, micro surfacing has improved skid resistance and sealed pavements while correcting profile, rutting, and coarse aggregate loss thereby preserving the pavement and extending its life.

The treatment is now widely used by both provincial and municipal road owners in Ontario. Municipalities who have established micro surfacing programs include the City of Ottawa, County of Lanark, Town of Markham, County of Leeds and Grenville, County of Simcoe, Municipality of

Leamington, County of Essex, County of Elgin, County of Bruce, County of Perth, Township of Dawn-Euphemia, and Municipality of North Middlesex.

The specifications for micro surfacing have evolved since the first specification was published under Ontario Provincial Standard Specification (OPSS) 336 [6] in 1995. Modifications to this specification have evolved to now include provisions for multiple application types, tack coat application, modified gradation, and a two-year warranty in the revised specification published in 2009. As a method-based specification, it provides municipalities across Ontario with the information required to provide excellent micro surfacing material. The original specification and the revised specification in 2009 may be found at http://www.raqsb.mto.gov.on.ca/techpubs/ops.nsf/OPSHomepage.

The most unique aspect of the current micro surfacing specification is the allowance for a Type III Modified aggregate gradation. This is unique in comparison to specifications utilized across Canada. This gradation was developed by a partnership between industry representatives and the Ministry of Transportation Ontario (MTO) as a result of a need to have a gradation available that was coarser than a Type II but finer than a Type III. Our current practice in Ontario typically involves the use of the Type II gradation on urban and rural two lane roadways of moderate traffic levels and the Type III modified gradation for freeway and high traffic roadways.

The MTO specification has evolved significantly from the initial version of OPSS 336 as a result of their migration away from method-based to design-build contract delivery models. They currently utilize a Performance Requirement Special Provision which permits the Contractor to design the micro surfacing materials to meet performance requirements such as surface friction, ravelling, flushing, rippling, shoving, and de-lamination for a three year period. Although a full gradation specification is not mandated, the MTO will typically impose limitations on the 4.75 mm sieve. The Ministry has utilized performance contracts for micro surfacing since 2008. These contracts have typically changed the materials or application type utilized by contractors in Ontario.

Agency representatives across Ontario have recognized and realized the benefits of micro surfacing as a pavement preservation tool to extend the life of their pavements. The available aggregates in Ontario make this process very attractive to solve many issues that exist with Hot Mix Asphalt (HMA) pavements. We are blessed with high quality, non polished aggregates capable of forming the chemical bonds necessary to meet all of the performance requirements established by ISSA.

Despite the fact that micro surfacing has been utilized in Ontario to target various outcomes such as increased texture and waterproofing, its acceptance has been closely associated with its performance as a holding strategy on multiple MTO highways. Two such examples are the application of a double micro surfacing on Highway 15 and Highway 28.

3.3.1 Highway 15

A scratch and surface micro surfacing treatment was applied to MTO Highway 15 between Franktown and Smiths Falls over a total distance of 15.5 km as a holding strategy. The MTO and Contractor anticipated that the treatment would last for approximately three to five years due to the poor condition of the existing roadway. Figure 5 illustrates the condition of the existing roadway prior to micro surfacing.

Figure 5. Condition of Original Roadway prior to Micro Surfacing on Highway 15

As seen in Figure 5, the roadway was in need of a rehabilitation strategy but the owner did not have adequate funding to perform the necessary repairs. Instead they employed the micro surfacing treatment to extend the life of the pavement until proper funds were available to allocate to this highway section.

Prior to performing micro surfacing, crack repairs were completed in some of the most distressed areas to reduce the amount of reflective cracking during the life of the treatment. A Type III aggregate gradation was utilized for both the scratch and overlay treatments, which started on August 7, 2001 and ended on August 24, 2001. Figure 6 shows a picture of the treatment after construction.

Figure 6. Completed Micro Surfacing on Highway 15

Since this was one of the first projects that utilized micro surfacing as a holding strategy, the longevity of the treatment was unknown. The treatment lasted for seven years and was still in fair condition when it was rehabilitated in 2008, thereby providing more than 40 percent more life than the anticipated maximum.

Figure 7 shows pictures of the roadway taken after six years of service in 2007. As observed in the pictures, crack sealing was performed after the micro surfacing to prevent ingress of water further into the pavement structure to avoid further distress manifestation.

Figure 7. Condition of Pavement in 2007

3.3.2 Urban Application

The Town of Markham is one municipality that has been utilizing micro surfacing as a true preservation treatment for approximately nine years. The Town is located just north of the City of Toronto within the Regional Municipality of York occupying about 212 km^2 with a population of nearly 300,000 people. The population increased over 25 percent between 2001 and 2006 and as a result, Markham has experienced significant infrastructure growth.

As a means to manage their investment, Markham has adopted micro surfacing to extend the life of their pavements while the condition of the pavement is still very good. Micro surfacing has been successfully utilized within the Town on residential, collector, arterial, and industrial roadways with Annual Average Daily Traffic (AADT) volumes up to 20,000.

Due to the various traffic levels and roadway classifications within the Town, two aggregate gradations for micro surfacing have been utilized. The Type II aggregate gradation is utilized on residential and collector roadways whereas a Type III modified is utilized on the arterial and industrial roadways. Since the micro surfacing treatment is applied to roadways in very good condition with little distress, the Town employs a single treatment. Figure 8 illustrates typical candidates used for a single micro surfacing in the Town of Markham.

Figure 8. Illustration of Typical Micro surfacing Candidate in Markham

Most of the work performed in the Town has been accomplished with the use of a continuous mix machine. This machine will typically work with a nurse truck that supplies all of the required materials for the process. Where the geometry of the road being treated is not conducive for use of a nurse truck it is simply removed and the micro material is placed with the material held in storage on the continuous mix machine. This will typically occur at intersections or within cul-de-sacs. Due to the maintenance structures located within the urban cross section, special precautions need to be exercised during the course of the work. Maintenance structures need to be covered, typically with garbage bags, prior to micro placement and then removed afterwards. Figure 9 illustrates the continuous mix machine working in the Town of Markham.

Figure 9. Continuous Mix Machine Working in the Town of Markham in 2008

Care must also be taken when placing the mix along curbs to ensure that excessive material does not enter the concrete area. In addition extra traffic control precautions must be utilized to ensure pedestrian and vehicular traffic does not damage the freshly placed material. Figure 9 also illustrates the traffic control measures taken at business entrances.

The performance of micro surfacing in Markham has been generally excellent. Figure 10 shows a picture of a single treatment in service for four years.

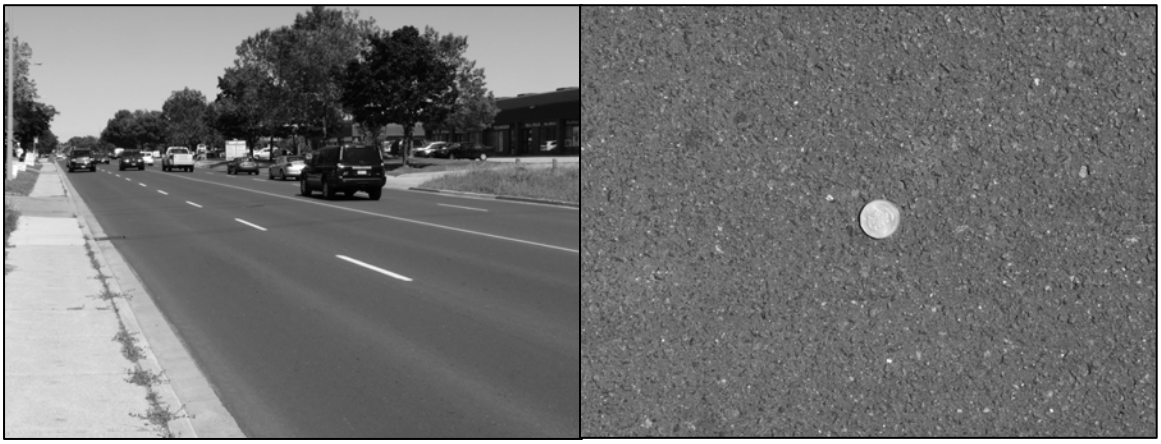

Figure 10. Performance of Micro Surfacing after Four Years

3.3.3 Centreline Application

The MTO has been utilizing micro surfacing effectively since 1990 to address numerous pavement distresses. A recent unique application involves a centreline treatment on freeways to a width ranging between 0.6 and 1.0 m. This strategy employs a single Type II aggregate gradation to increase the potential for the aggregate to fill the cracks typically caused by cold joint issues. Although it is common for cracks to reappear in micro surfacing early in their life, this application is successful as the entire crack is filled with material. In addition, these cracks are not considered working and are typically unaffected by pavement movement associated with freezing and thawing.

This application involves the removal of any existing loose crack sealant and cold patch material prior to the micro surfacing application. In highly distressed areas, the MTO prescribes hand HMA patching to avoid future distress propagation. Figure 11 illustrates the centreline joint before and after micro surfacing application.

Figure 11. Highway 401 Centreline Micro Surfacing Application

This application has been a successful, quick and economical alternative to grinding and replacing the joint area with HMA, which would result in two cold joints thereby creating a potential for more joint cracking in the future.

3.3.4 Airport Application

Ontario is a unique province with many communities being accessible only by air, rail, and ice roads. As access is limited to these areas, construction costs are high, which further encourages a pavement preservation methodology to keep good pavements in good condition. The Moosonee Airport is one such case located in Moosonee, Ontario at the Southern tip of James Bay. This airport is critical to the operations and transportation of the diamond mine industry for the area. The airport was initially constructed with a HMA surface which was pulverized in place and was paved with an open graded cold mix in the mid 1990's. It was the aging cold mix pavement that received a double Type II micro surface course in July 2007. All personnel, equipment and materials had to be railed to the site.

The micro surfacing was applied to both the runways and aprons and was constructed in stages in order to keep the air traffic moving. The surface had numerous large cracks which had to be repaired prior to micro surfacing. This task was performed by grinding an area to remove the crack and then filling these voids with micro material with a rut box spreader.

3.3.5 Slurry Seal

Slurry seals have been used in Ontario since the 1960's for both rural and urban low volume applications. Most of the work performed in an urban environment has been converted from slurry seal to micro surfacing due to traffic volumes and the ability of the micro to be traffic-ready within one hour. Slurry seals are effective in residential areas where the volume of traffic is low.

The slurry market in Ontario has been quite steady over the last decade due to its performance. Many municipalities have relied on slurry seals as their backbone treatment to preserve pavements – a trend that is now migrating into the provincial sector. Owners are rewarded with an impermeable maintenance seal that provides a life extension of their pavement that could not be possible utilizing many other asphalt technologies for the same financial commitment.

Slurry seals will typically utilize local aggregates conforming to OPSS specifications for Superpave hot mix, combined with the desired emulsion and additives to produce a mix conforming to the ISSA mix design parameters. These aggregates are generally extracted from a pit or quarry source of a metamorphic origin. Sedimentary aggregates within Ontario do not typically possess the consistent chemistry required to produce high quality slurry seals and are therefore rarely used.

3.4 Western Canada

3.4.1 Manitoba

In Manitoba, the adoption and introduction of micro surfacing was a relatively slow process. The Province decided to construct test sections during the early 2000's and several were built after approximately 2004. Following the good performance of the test sections, Manitoba Infrastructure and Transportation (MIT) decided to tender full contracts in 2007. Starting small in 2007, the volume of work increased rapidly, with 2009 being the highest. The biggest project in Manitoba to this date was resurfacing sections of Highway 1. An example of the micro surfacing placed on Highway 1 in Manitoba is shown in Table 3. So far, the performance of the existing jobs is excellent and MIT is committed to continuing the program for the years to come.

Table 3. Job Mix Formula and Design Parameters for Highway 1 in Manitoba

Ingredient	**Percent Mass, %**	**Specification**
ISSA Type III Screenings	100	100
CQS-1HP Emulsion	12.0 (±1.0)	
Portland Cement	1.0	0 – 2
Water	8	
Breaking Retardant	As required	
Parameters	**Result**	**Specification**
Residual Asphalt	7.8	5.5 – 9.5
Wet Cohesion, 30 minutes, cm.min	16	12 min.
Wet Cohesion, 60 minutes, cm.com	22	20 min
Wet Track Abrasion, 1 hour soak, g/m2	22.6	538 g/m^2 max
Wet Track Abrasion, 6 day soak, g/m2	75.3	807 g/m^2 max
Excess Asphalt Loaded Wheel, g/m2	382.4	538 g/m^2 max
Lateral Displacement Loaded Wheel, %	3.78	5.0 max
Wet Stripping, %	95	90 min.
Compatibility by SB&R	BAA (11 pts.)	11 Pts min.

Note: ISSA stands for International Slurry Surfacing Association
SB&R stands for Schultze, Breuer & Ruck

Manitoba is using micro surfacing primarily for pavement preservation and maintenance programs utilizing ISSA specifications for both the design and quality control aspects of the process. Adopting a new process is a challenge not only for the agency itself but also for material suppliers and local contractors. The introduction of the micro surfacing process was answered with a quick step-up from all stakeholders. Contractors that have never laid any type of slurry surfacing have responded to the demand by “picking up the trade” in record time. The inherent start-up pains of any new process were left behind very quickly and everyone became very professional and producing work of excellent quality.

3.4.2 Saskatchewan

Saskatchewan was an early player when it comes to micro surfacing with the first trial done as early as 1989. Ever since, with obvious ups and downs related to external factors, micro surfacing was consistently used in the province as part of pavement maintenance, preservation and rut filling (Figure 12).

One of the major challenges for the Prairie Provinces is the availability of high quality aggregate. Most of the aggregate comes from pits and their mineralogical characteristics and consistency is not always top quality. This is tough for the micro surfacing process where mineralogical consistency is of high importance. Nevertheless, with good crushing and processing practices this shortcoming was resolved and the industry was capable of producing excellent quality micro surfacing.

One specific application for micro surfacing developed by Saskatchewan Highways and Infrastructure is the sealing of transverse cracks. The department developed the Transverse Crack Machine (TCM) that essentially consists of a mixer box mounted on a skid steer. The crew produces small quantity batches engineered to have a long breaking time, usually between 10 and 20 minutes. With this, the skid steer moves down the road and slowly seals transverse cracks present in the pavement. The process works well and the performance noticed initially has permitted Saskatchewan Highways to increase the volume of the treatment. They currently operate two TCM units.

Figure 12. Texture of Micro Surfacing Rut Filling Before Top Coat

3.4.3 Alberta

Alberta Transportation has not done a lot of micro surfacing work to date. One project was done on Highway 3 and another project was executed on Highway 1 near Brooks. This was a transverse joint tender similar to the process utilized in Saskatchewan.

The municipal market in Alberta has been a lot more active. The City of Edmonton began using micro surfacing in 1992. At that time, it was mainly applied to industrial roads that were still in good condition, but were showing some signs of surface oxidation. This program was discontinued in the mid-90s due to budget issues, but returned in 1998. In 1999, the process started also in neighbourhoods that had been resurfaced ten years prior and with time that has become the standard practice. Edmonton is calling the product micro surfacing but the gradations used are a Type I and a Type II, with the Type I being used on residential roads. This is technically a polymer modified slurry seal. The Type I gradation is much more readily accepted on residential streets, as it delivers a very fine surface texture. In terms of volume, Edmonton's program varied widely for the last 10 years. The contribution of the micro surfacing program to the life cycle cost improvement of Edmonton's road network is outstanding, providing more service life per dollar than any other method of intervention. The program is currently at a point where re-treatment will begin on roads that were initially surfaced ten years ago.

3.4.4 British Columbia

The British Columbia Ministry of Highways had the first project done in the early nineties and it was a resounding failure. The placement of micro surfacing was done on Highway 3 – Manning Park and the snow ploughs essentially tore the surface to shreds over the first winter. After that it took a long time for

the bad memories to fade away and to re-ignite the process in BC. During the 2000's several small projects were executed by the Province in Kamloops, Nanaimo, Vernon, etc. Most of the performance to this date has been good.

The municipal market has also seen some small projects, also with mixed results. The Cities of Langley and Surrey have used micro surfacing on some small projects and the results were mixed. Kelowna had a decent size micro surfacing program for a number of years under their pavement preservation program. The City of Burnaby had a project failure when micro surfacing was applied over a geo-grid type membrane, aimed at reducing reflective cracking. The problem was that the membrane was designed for use with hot mix asphalt. Applying micro surfacing over it did not produce bonding to the substrate as it is a cold process. As a result, there was major de-lamination and de-bonding of the surface treatment, resulting in project failure. Recently, several municipalities in BC have expressed interest in starting or re-initiating pavement maintenance programs using micro surfacing as a pavement preservation tool.

4.0 SUMMARY

It is evident that micro surfacing and slurry seals are beneficial pavement preservation techniques for extending pavement life. They have formed the backbone of many municipal and provincial asset management programs due to their cost, performance, and environmental advantages compared to the alternatives. Experience indicates that this trend is consistent throughout Canada due to the versatility in process application including preservation, holding strategy, rut filling, and crack filling. Project selection, material selection, and method of placement are components that must be optimized to produce the desired results.

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