

## **Review of Micro Surfacing: Environmental, Economical, and Performance Analysis**

### Introduction

Micro surfacing is a pavement preservation treatment application which extends the life of existing roads by improving surface distresses. The micro surfacing mixture consists of 100% manufactured aggregate, polymer-modified asphalt emulsion, water, and additives. Micro surfacing can correct surface problems such as wheel ruts, transverse and longitudinal cracking, and raveling. By providing a surface cover, micro surfacing protects the underlying asphalt from oxidation, water influx, and aging [1].

Micro surfacing was developed in Germany in the early 1970s and was first used in Canada and the United States in the 1980s [1, 2]. Micro surfacing has been used all throughout Canada on various types of roads and generally lasts for four to eight years when used as a corrective treatment [1]. The service life of micro surfacing is typically seven to ten years when used as a preventative maintenance treatment, however there have been roads reported as performing well after ten years [2].

### Pavement Preservation

Pavement preservation treatments can significantly extend the life of a road by improving the surface condition. The most important step for a successful pavement preservation program is to apply the proper treatment before a road deteriorates to the point of rehabilitation. Figure 1 shows that when a preventative treatment is applied at the optimal time, the pavement condition can be maintained near to its original condition [3].

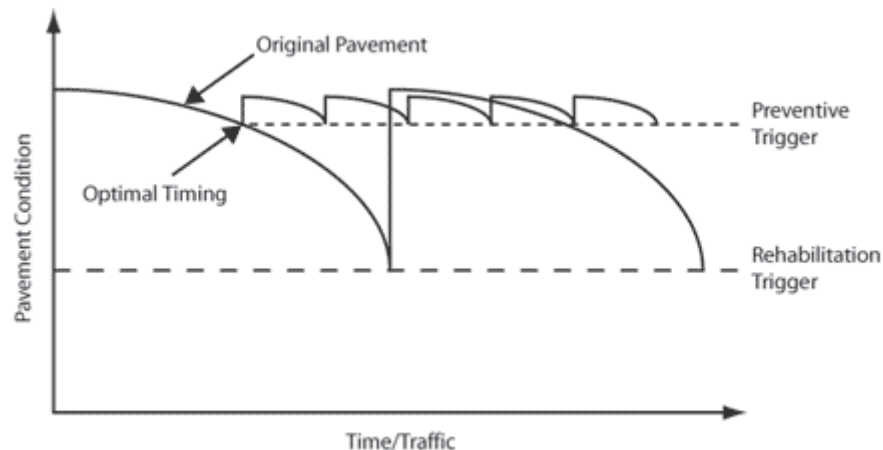


Figure 1. Pavement condition vs time or traffic [3].

Providing that the road base is structurally sound, pavement preservation programs will extend the life of roads at a lower cost than rehabilitation. For example, an analysis of the average cost of roads over 25 years was done comparing rehabilitation to pavement preservation [3]. In one scenario, a road was built and then required one major construction over its 25 year life. In the other scenario, a road was built and then required five preservation treatments over its 25 year life. The cost of a proper preservation program involving preservation treatments was 35% less than no preventative maintenance and reconstruction [3]. Figure 2 further demonstrates the potential cost savings of a pavement preservation program.

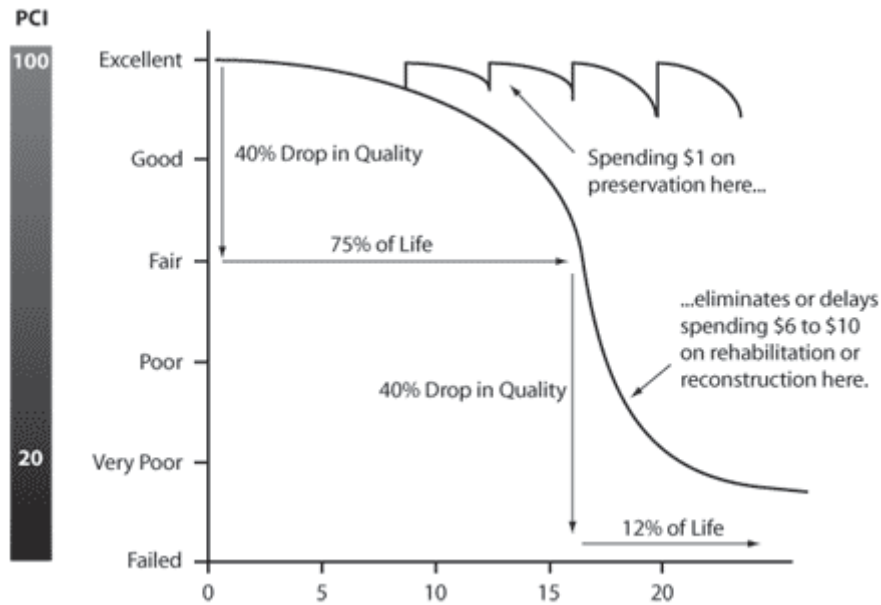


Figure 2. Pavement condition index (PCI) vs. time [3].

Preventative pavement treatments are non-structural [3] and therefore their objective differs from a rehabilitation application such as a 50mm mill and overlay. However, micro surfacing prevents or delays the use of rehabilitation applications such as 50mm mill and overlay. Therefore, this paper will compare the environmental and economic differences between micro surfacing and mill and overlays in order to assess the life-cycle outcomes of both options.

### Construction Process

The micro surfacing treatment is applied using a continuous flow mixer, a multi-blade, a double-shafted mixer, and a spreader box [2] (see Figure 3). The materials are continually mixed in the proportions determined by a laboratory mix design and then evenly spread on the road by the spreader box. Loose material on the existing road surface must be cleared and any wide cracks (approximately 1cm or larger) should be filled before the micro surfacing mixture is applied [4]. The outside temperature must be a minimum of 10°C and rising when the micro surfacing mixture is applied [2]. The micro surfacing process is quick and therefore has minimal disruption to traffic flow. The return to traffic time is usually one hour [2].



Figure 3. Micro surfacing construction process.

Micro surfacing should only be applied to roads which exhibit surface problems but are structurally sound. Roads that have one or more of the following conditions may be good candidates for micro surfacing treatment:

- Longitudinal cracks
- Transverse cracks
- Raveling
- Wheel path ruts
- Oxidation
- Bleeding
- Polished surfaces

Micro surfacing applications are generally applied at a thickness of 10 to 12mm [5]. The treatment may be applied to the entire width of a road or limited to targeted areas when used for crack filling. Wheel ruts up to 50mm deep can be filled by micro surfacing, then a top coat of micro surfacing is generally applied over the entire road surface. Ruts over 12.5mm must be filled using a rut box [1]. A tack coat is not usually required, but a tack coat may be used if the existing asphalt road is extremely dry and raveled or if the road is concrete or brick [4].

The International Slurry Surfacing Association (ISSA) specifies that the aggregate used in micro surfacing must be high-quality, densely graded, and 100% crushed [4]. The aggregate is classified as a Type II (less coarse) or a Type III (coarser). Type II aggregates are generally used in urban and residential streets to fill surface voids, seal, and act as a durable wearing surface. Type II aggregates can also be used on airport

runways. Type III aggregates are generally used on highways and other high volume roads to provide skid resistance and fill ruts and voids [4].

The micro surfacing construction process can be completed quickly and allows normal traffic flow to resume in minimal time. Micro surfacing construction is performed using ambient temperature materials and less aggregate than other applications, which reduces safety risks for construction crews [6]. In order to get the best performance, micro surfacing must be applied properly by knowledgeable construction crews.

### Environmental Analysis

A 10mm micro surfacing process has been found to emit approximately 83% less carbon dioxide (CO<sub>2</sub>), 86% fewer nitrogen oxides (NO<sub>x</sub>), and 84% fewer sulfur oxides (SO<sub>x</sub>) compared to the 50mm mill and overlay on a square meter basis [5]. It was determined that using micro surfacing instead of mill and overlay for approximately 1,000 two-lane km of road saved approximately 28,500 tonnes of CO<sub>2</sub> emissions over 10 years in Ontario [5]. That amount of CO<sub>2</sub> emissions saved is equivalent to the greenhouse gas emissions of 6,000 cars for one year [7].

The 10mm micro surfacing process has been determined to use 40 to 86% less energy than the 50mm mill and overlay [5, 6]. Even when a tack coat is required for micro surfacing or when 40% reclaimed asphalt pavement (RAP) is used in hot mix asphalt, the micro surfacing process uses significantly less energy and resources than a 50mm mill and overlay over their life-cycles [6].

Micro surfacing reduces the use of aggregate; a non-renewable resource. In Ontario it was found that when the life-cycle time is accounted for, micro surfacing uses 76% less aggregate than 50mm mill and overlay [5]. In a wide study throughout the United States, it was determined that micro surfacing uses 150% less aggregate than 50mm mill and overlay throughout the life-cycle [6]. This preserves non-renewable resources, lowers the production of waste, and lowers construction costs.

Applying micro surfacing to roads before the need for rehabilitation treatments such as 50mm mill and overlay greatly reduces energy usage and greenhouse gas emissions. Hot mix asphalt applications require more energy to heat and apply the asphalt mixture than the micro surfacing process. Additionally, more greenhouse gases and smog are emitted from the hot mix processes due to more transportation of materials required [6]. Micro surfacing provides numerous environmental benefits over hot mix asphalt applications and is the more sustainable option.

### Economical Analysis

Micro surfacing is an economical treatment option. The initial construction costs of micro surfacing has been reported as 53% lower than 50mm mill and overlay in Ontario [5]. When the service life is accounted for, the annualized unit cost of micro surfacing is 34% lower than 50mm mill and overlay [5]. Similarly, in a study across the United States the life-cycle cost of micro surfacing was 28% lower than 50mm mill and overlay [6]. It was determined that using micro surfacing instead of mill and overlay in Ontario for approximately 1,000 two-lane km of road saved the province approximately \$37,000,000 over 10 years [5].

Micro surfacing can be used as a holding strategy for pavements when funding for rehabilitation is not immediately available. For example, Highway 15 in Ontario was in need of rehabilitation in 2001 due to damage including extensive longitudinal cracking, but funding for rehabilitation was not available at that time [1]. A Type III micro surfacing treatment was applied as a holding strategy and the road lasted until

2008 when rehabilitation was performed. Although some crack sealing was required during that time frame, the life time of the road was extended for seven years using micro surfacing as a holding strategy [1]. Micro surfacing is effective at reducing initial costs and life-cycle costs at any stage of a roads' life.

### Performance Analysis

Numerous studies have shown that micro surfacing is a suitable choice for surface crack repair [2]. Micro surfacing acts as a sealant to prevent water from entering existing cracks in hot mix pavement which reduces the effect of freeze-thaw cycles [5]. In Ontario, micro surfacing as a treatment for cracks has been shown to extend the pavement life by an average of three years [5]. Micro surfacing has also been successfully used to fill centerline cracks caused by cold joint issues [1]. However, micro surfacing may not be the best solution for reflective cracking that is a result of structural damage, as the reflective cracks may quickly reappear in the micro surfacing treatment [2].

Micro surfacing can improve the skid resistance and general surface condition of roads which can make them safer to drive on. Micro surfacing has been determined to potentially reduce vehicle crashes by 26 to 34% depending on traffic volume but regardless of weather conditions [8]. In Whitby, Ontario, an intersection with an ADT of approximately 30,000 had a skid number (SN) of approximately 28 increased to a SN of approximately 52 after micro surfacing was applied [9]. An SN of 40 or above is generally considered adequate, and therefore micro surfacing can improve a poor surface to an acceptable condition [9]. Even with creating excellent friction, micro surfacing applications have been found to create minimal noise [10]. Other surface treatment like chip seals can increase the noise level of roads [9].

The smoothness of a road can be measured by the international roughness index (IRI). In Manitoba, a section of the Trans Canada highway was treated with micro surfacing and the average IRI value improved by approximately 0.2mm/m [11]. In the United States, micro surfacing was found to improve the smoothness by an average of 0.4mm/m [12]. Roads which have been micro surfaced result in a smooth drive with smooth transitions between joints [13].

The micro surfacing mixture creates an asphalt mastic because the fine aggregate combines with the asphalt emulsion. This mastic acts as a binder for the stone matrix and the resulting structure is strong enough to be used to fill ruts on roads with heavy traffic [1] (see Figure 4). Other surface treatments such as chip seals are not effective treatments for rutting [9]. In the United States, a study evaluating the effectiveness of rutting over the micro surfacing life-cycle found that rutting was decreased by 92 to 96% when micro surfacing was used [12].



Figure 4. Micro surfacing used to fill wheel ruts: before (left photo) and after (right photo).

Micro surfacing has been used successfully on roads with low, medium, and high volume traffic [2]. Micro surfacing has been recommended for use on roads with average daily traffic (ADT) values varying between less than 5000 ADT to over 30,000 ADT [14]. In Markham, Ontario, micro surfacing has been used on residential, arterial, and industrial roads with annual average daily traffic (AADT) counts of under 20,000 since 2001 [1]. In the 1990s, Ontario was applying micro surfacing on high volume freeways and freeways with ADT values of approximately 15,000 [15]. In addition to good performance on various types of roads, micro surfacing has an aesthetically pleasing appearance as it restores the black surface colour of the pavement [10] (see Figure 5).



Figure 5. Micro surfacing used in a residential area to preserve pavement condition.

## Conclusion

Micro surfacing is an effective surface treatment to prolong the life span of paved roads by preserving or improving the condition of paved roads. Whether used as a preventative treatment, corrective treatment, or holding strategy, micro surfacing lowers pavement life-cycle costs. Micro surfacing can deliver excellent performance on wheel ruts, small surface cracks, and reintroduce skid resistance to pavement surfaces while lowering energy requirements and lowering greenhouse gas emissions.

Prepared By:

Clare Workman

*Clare Workman*

Technical Director, M.Sc.  
Western Asphalt Products  
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