Thin Surfacing - Effective Way of Improving Road Safety within Scarce Road Maintenance Budget

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ABSTRACT:

It is generally known that timely application of preventive maintenance treatments, including thin surfacings, extends the service life of asphalt pavements. Numerous books and technical papers provide descriptions of various types of thin surfacings and other preventive maintenance treatments and show their ability to extend pavement performance curves. However, there is generally a lack of practical examples of thin surfacing applications, including costs involved, the benefits and in what circumstances they should be used for best return on investment. This paper describes the treatments including costs and user benefits, indicates limitations of particular treatments, and provides practical examples of the use of thin surfacings. The benefits include road safety improvements, mainly surface texture and frictional characteristics and correcting surface irregularities.

1. INTRODUCTION

The preventive maintenance treatments for asphalt pavements generally include crack sealing, fog sealing, surface rejuvenating, micro-milling and thin surfacings. Thin surfacings are applied to existing pavements to preserve the pavement, retard the rate of future deterioration, and maintain and improve the functional condition of the pavement without increasing structural capacity [1]. These thin surface treatments also reduce the need for routine maintenance and can significantly extend the life of pavements. However, as they only preserve, not improve the structural capacity, they have to be applied while the pavements are still in good structural condition. In fact, the better the pavement condition when thin surfacings are applied, the longer the treatments will last and the more cost effective it is [2]. There is generally little information on their use for road safety improvements. When applied properly, thin surfacings can correct some surface irregularities including rutting and significantly improve frictional characteristics of pavement surface and thus improve the road safety.

There are currently six types of thin surfacings available in Ontario: surface treatments/chip seals; slurry seals; microsurfacing; Metro-Mat$^{(TM)}$; Nova Chip; and thin asphalt concrete overlays. Surface treatments, slurry seals, microsurfacings and thin asphalt overlays have been used successfully by Ontario municipalities for many years. Nova Chip was introduced in the late 90's and Metro-Mat$^{(TM)}$ is a new process but gaining more attention in Ontario.

Pavement safety depends mainly on the following factors [3]:

- skid resistance and surface texture
- roughness
- surface condition (rutting, potholes, etc.)
- evironmental and weather conditions
- pavement geometrics
- color and light reflectivity
- paving materials used
- lane marking, safety signs and roadside obstacles.

Proper application of some of the thin surfacings can correct surface irregularities, including minor transverse profile corrections and low severity rutting, and significantly improve pavement skid resistance and surface texture.

2. THIN SURFACINGS – DESCRIPTION, FEASIBILITY AND APPLICATION EXAMPLES

2.1. Surface Treatment – Chip Seal

Chip seals consist of a single application of conventional or polymer modified asphalt emulsion followed immediately by an aggregate cover. The goal is to have the aggregate particles embed themselves into the asphalt layer with about 30 percent of each particle exposed to provide texture. Applications with two layers are referred to as a double chip seal. Chip seals can be applied at any time in a pavement's life as an economical, durable and widely available treatment [4] and [5]. The construction of chip seal is covered by the Ontario Provincial Standard OPSS 304.

Chip seals can waterproof the pavement surface, provide sealing of low severity cracks, and restore surface friction. The chip seal membrane also slows down the asphalt cement oxidation process within the original asphalt surface layer. Chip seals are not effective on pavements exhibiting medium to major fatigue, linear or block cracking, rutting, roughness and shoving [6]. The serviceable life of a chip seal treatment is considered to be 3 to 6 years with a typical average of 4 years under low to moderate traffic. The typical cost of a chip seal treatment in Ontario ranges from \$1.40 to \$1.75/m^2 (if polymer modified emulsion is used). Numerous qualified and experienced contractors are available throughout Ontario.

Chip seals should only be applied in favourable weather conditions and their performance can be adversely affected if installed in wet weather. Also, the asphalt binder needs time to cure. Due to the risk

of loose chips and excessive noise, chip seals are now used mainly on low volume rural roads in Ontario. Another characteristic feature of chip seals is that their appearance is largely controlled by the color of the aggregate used. Thus, they represent excellent context sensitive road surfacing solutions in rural environments.

Figure 1 shows a chip seal application on Coates Road between Highway 12 and Regional Road 2 (Simcoe Street) in Oshawa, Ontario. The close up shows the surface texture after the treatment application.

Figure 1 – Chip seal applied on Coats Road in Oshawa, Ontario in 2004.
The close-up shows the surface treatment.

Pavement frictional characteristics are controlled by microtexture and marotexture. Microtexture is the presence of microscopic angles and points on the face of exposed aggregate. Microtexture is considered to be the critical element of surface friction at low to medium speed and dry pavement. Macrotexture is the presence of surface canals on the surface that allows water to escape from between the tire and pavement surface and avoid hydroplanning. Macrotexture controls the friction at high speed and wet weather.

In Canada the pavement skid resistance is measured using a locked wheel method in wet conditions and reported in terms of Skid Number (SN). Typically, SN values equal or greater than 40 are considered adequate. SN values for a new chip seal can range from 45 to more than 60 (if high quality aggregates are used) with the average about 50 [7].

2.2. Slurry Seal

A conventional slurry seal is a mixture of well graded fine aggregate, slow setting asphalt emulsion, water and mineral filler (most often Portland cement). It is considered to be a thermal process. The conventional process takes from two to eight hours to cure depending on the heat and humidity. The construction of slurry seals is covered by OPSS 337.

Aggregate, water, filler and emulsion are proportioned and blended together in a mixer and applied immediately to the pavement surface with a spreader box. The slurry is applied basically one aggregate

layer thick [8]. As slurry seals have to set, they should not be placed during rainy or high humidity weather. The ambient temperature should be above about 10ºC.

Slurry seals will not perform well if the underlying pavement exhibits medium to major fatigue, linear or block cracking, rutting, roughness or shoving [6]. It should be applied only where the existing surface is stable with only low-severity cracking.

Slurry seals, as the name implies, seal the existing pavement surface, slow surface raveling, seal small cracks and improve surface friction. They are effective where the primary problem is excessive oxidation and hardening of the asphalt concrete or where there are aggregate 'pop-outs' in asphalt wearing courses incorporating soft limestone. Slurry seals do not have a strong skeleton and are typically applied as one aggregate layer thick. They are not suitable to correct surface irregularities and rutting.

The life of a slurry seal is from 3 to 5 years. The typical cost of slurry seals range from \$1.35 to \$1.50/m^2 for a single lift and \$1.75 to \$2.00/m^2 for a double lift. Experienced slurry seal contractors are available throughout Ontario and the product is highly reliable.

Over the last several years another type of slurry seal, a cape seal treatment has become popular in Ontario. In this process, a slurry seal is applied to a newly constructed chip seal to improve the retention of the stone chips and seal the open voids. The cost of a cape seal is about \$3.5/m^2. This treatment has a life expectancy from 9 to 15 years with the typical life about 9 years before re-application. Figure 2 shows a cape seal application on Halls Road in Whitby, Ontario in 2003.

Figure 2 – Cape seal applied on Hall's Road in Whitby, Ontario in 2003.
The close-up shows the surface texture.

2.3. Microsurfacing

Microsurfacing is a mixture of polymer modified emulsion, well graded crushed mineral premium aggregate (typically 9.5 mm minus), mineral filler (normally Portland cement), water and chemical additives that control the break time, i.e. the time for the emulsion to achieve a set [9]. The aggregates are tough in terms of hardness and resistance to polishing. Microsurfacing is a chemically controlled

process. The materials are mixed in a truck mounted traveling plant and then deposited into a spreader box. No compaction is needed and traffic may be allowed on the mat within an hour after placement. The construction of microsurfacing is covered by OPSS 336. This pavement treatment typically involves two coats including a scratch or leveling coat followed by a surface coat. A typical rate of application is 10 lane kilometers per day.

Microsurfaing is applied on streets or highways carrying medium to high volume traffic, on high speed roads and airfield pavements. The pavements should be in good structural condition and not exhibiting any significant structural surface distresses (not to be used on pavements with moderate to heavy alligator cracking). Microsurfacing has a strong skeleton and can be applied in relatively thick layers; it is very effective in correcting surface irregularities including minor transverse profile corrections, and low to medium severity surface wheel track rutting problems [8].

Microsurfacing provides a high quality skid resistant surface for an existing asphalt concrete pavement, seals the pavement surface, restores surface profile, eliminates hydroplaning, and provides a surface that is more resistant to rutting and shoving. Microsurfaing is applied at ambient temperatures and has low energy requirements. Due to its quick application rate, it causes minimum disruption to traffic. The life expectancy of microsurfaing is 7 or more years. The typical cost ranges from \$3.75 to \$4.00/m^2. A number of qualified microsurfaing contractors are available in Ontario.

Figures 3 and 4 show microsurfacing application on Thickson Road in Whitby, Ontario in 1993. Figure 5 shows the condition in 2004. This section of Thickson Road through a busy intersection, carries about 30,000 vehicles per day. The original surface course asphalt incorporated relatively soft limestone prone to polishing. During the rehabilitation, low to medium severity rutting was filled with the first lift of microsurfacing and then the surface lift was applied. The close-up view in Figure 4 compares the surface of the original HL 1 surface containing polished limestone aggregate and the texture of the microsurfacing surface applied on this section. The Skid Number as measured with tha ASTM brake force trailer almost doubled from about 28 before to about 52 after the microsurfacing application. After 11 years of service, while in a number of areas the microsurfacing has worn off, it has remained intact and functional on the majority of the section (see Figure 5).

Figure 3 – Rut filling with microsurfacing lower lift on Thickson Road in Whitby, Ontario in 1993.

Figure 4 – Application of microsurfacing on Thickson Road in Whitby, Ontario in 1993. The close up compares the microsurfacing surface texture with (A) the existing polished HMA surface texture (B).

Figure 5 – Condition of microsurfacing on Thickson Road in Whitby, Ontario in 2004.

A skid resistance survey was carried out on Bloor Street (Regional Road 22) in Ajax in the Region of Durham. The SN values on the existing asphalt pavement in 1994, before a microsurfacing application, ranged from 27 to 30. The post construction SN values ranged from 58 to 63. In the survey completed in October 1995 the SN values ranged from 54 to 58.

2.4. Metro-Mat(TM)

Metro-Mat(TM) is a relatively new pavement preventive maintenance treatment gaining more attention in Ontario [10]. It is a combination of polymer modified asphalt emulsion, premium high quality aggregate (trap rock), mineral filler (typically Portland cement) and water applied by a mobile continuous mixer paver. Liquid additives (accelerators or set retarders) can also be added. Typical application speed is 5 km/day.

Metro-Mat(TM) is suitable for pavements in good structural condition (with no severe alligator cracking or rutting) but which may be exhibiting raveling, minor longitudinal and transverse cracking and other environmental and material related distresses.

Metro-Mat(TM) provides good skid resistant texture, added durability, resistance to sunlight, and it adheres well to the pavement surface. After a quick application in a single pass, the pavement can be opened to traffic in about 1 hour. The projected life of Metro-Mat(TM) is 7 years; however it is a new system and more widespread experience will be needed to confirm actual life expectancy. A typical cost is $\$2.25/m^2$. Currently, Metro-Mat(TM) is supplied in Ontario by only one contractor.

Metro-Mat(TM) was applied on a 5.3 km long section of Wellington County Road 42 about 20 km west of the City of Brampton, Ontario. Metro-Mat(TM) was applied over an 8 year old high float surface treated pavement exhibiting some raveling, longitudinal cracking and loss of aggregate. The rate of application was 8 to 10 kg/m^2, which is about 50 to 60 percent higher than the rate required by OPSS 337 for conventional slurry seal. The performance of this road section to date, some 3 years after application is very good.

Figure 6 – Application of Metro-Mat(TM) on Wellington County Road 42 about 20 km west of the City of Brampton, Ontario

2.5. Nova Chip

In the Nova Chip system, a layer of heavy polymer modified emulsion is applied to the road surface, and within seconds, a thin layer of HMA is placed on the emulsion using a screed [11]. The water driven from the emulsion cools the HMA, setting both materials and providing a bond to the underlying surface. Very

high quality aggregates are required. They must be 100 percent crushed and cubical (trap rock aggregates are typically used). Typical layer thickness is about 12.5 mm but it can be increased up to 40 mm. The placed mat is seated with a static roller. The laydown rate can be two to three times the rate of conventional HMA paving. Once the process has been completed, the road can be opened to traffic as soon as the mix has cooled down to ambient temperatures.

Nova Chip provides a very flexible surface layer (it is an open graded material with high air voids bound with soft polymer asphalt cement). It has been applied successfully on roads carrying medium to very heavy traffic (up to 100,000 vehicles per day). Nova Chip is not intended to improve the structural capacity of the road; it provides a flexible thin surfacing that greatly enhances ride quality.

This treatment provides very good frictional characteristics, seals the pavement surface, stops surface distresses, and reduces hydroplaning [11 and 12]. Nova Chip is considered to be quieter (almost 3 decibels lower) than a conventional HMA surface. It also provides excellent bond to the existing pavement surface and durability. The life of Nova Chip is anticipated to be 7 to 10 years. A typical cost ranges from \$4.50 to \$5.00/m^2. Nova Chip requires specialized dedicated equipment and has been applied by only one contractor in Ontario on a trial basis in the late 90's. It is understood that re-introduction of the technology into Ontario is currently being contemplated.

Nova Chip was applied on four road sections in the Region of Durham in 1998 and 1999. Figure 5 shows the application of Nova Chip treatment on Anderson Street, north of Highway 2 in Whitby, Ontario in 1998. The close-up compares the texture of the newly constructed Nova Chip surfacing with the conventional HMA surface. The Skid Number values on the treated section initially increased from about 30 to about 45. However, after about 6 months of traffic, when the asphalt cement film had worn off, the Skid Numbers increased further to about 53. Today, some 6 years later, the pavement is still in very good condition.

Figure 6 – Application of Nova Chip on Anderson Street, Whitby in 1998

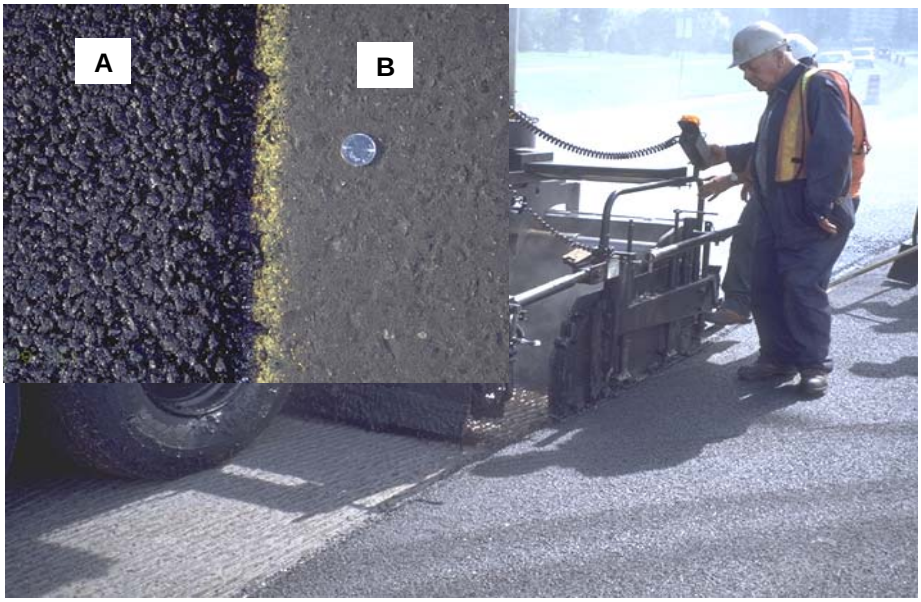

Figure 7 – Application of Nova Chip on Anderson Street, Whitby in 1998.
The close up compares the Nova Chip surface texture (A) with the conventional HL 1 surface course texture (B).

A skid resistance survey was carried out on Simcoe Street (Regional Road 2) in Oshawa in the Region of Durham. The SN values on the existing asphalt pavement in 1997, before a Nova Chip application, ranged from 29 to 31. The post construction SN values in October 1997 ranged from 42 to 44. In the survey completed in June 1998 the SN values ranged from 44 to 48.

2.6. Thin Hot-Mix Asphalt Overlays

Dense graded HMA mixes are typically used in thin overlays in Ontario to improve the functional condition of a pavement including smoothness, skid resistance and roadway profile correction. Gap graded mixes (such as Stone Mastic Asphalt) and open graded friction course mixes can also be used. Thin overlays add little or no structural improvement to the pavement [13]. Prior milling may be required if more severe surface distresses are present or where curb reveal needs to be maintained. Thin overlay thicknesses typically range from 20 to 40 mm. The mixes are sometimes modified with polymers for better field performance. Thin overlays will correct some small surface irregularities and low severity rutting; however, more severe irregularities should be repaired before the thin overlay application.

Thin asphalt overlays should be applied prior to the onset of fatigue-related pavement cracking. Candidate pavements may exhibit surface distresses such as moderate to severe raveling, and moderate longitudinal and transverse cracks with some secondary cracking. Isolated structural distresses, such as alligator cracking must be patched prior to overlay. Thin overlays are particularly suitable for high volume roads in urban areas.

Thin overlays provide a skid resistant surface for existing asphalt concrete pavements, restore surface profile, eliminate hydroplaning and improve smoothness. The life of a thin overlay ranges from 5 to 10 years with the average of about 8 years.

Depending on the thickness of the overlay, type of hot mix used and weather milling and/or tack coating are required, the cost of this treatment ranges from \$5.50 to \$8.00/m^2. Qualified contractors are readily available throughout Ontario; essentially the same contractors as for conventional hot-mix asphalt paving.

A thin asphalt overlay was applied on Taunton Road through Ajax Pickering and Whitby in 2001. Taunton Road is one of the major east-west arterials in Durham Region. The pavement was in fairly good condition prior to overlay, with no severe cracking. Thin overall was used as a preventive maintenance treatment to extend the life of the existing pavement, correct some minor rutting and irregular crossfall. The cost of the thin overlay, including shoulder adjustments was about $\$7.00/m^2$. In 2005, the pavement is still in very good condition.

Thin overlays skid resistance depends on the type of HMA mix used for the overlay. A skid resistance survey was carried out on Brock Road (Regional Road 1) in Pickering in the Region of Durham on sections with Stone Mastic Asphalt (SMA) and conventional HL 1 surface course mixes right after construction in 1999. The SMA section had an average SN of 42 while the average SN for the HL 1 section was 38. It is anticipated that when the asphalt cement film wears off, the SN values will increase by about 4 to 6.

Figure 7 – SMA paving on Simcoe Road in the Region of Durham, Ontario in 1999.

3. CONCLUSIONS

Six types of thin road surfacings have been successfully used in Ontario for a number of years. They include:

- chip seal;
- slurry seal, including cape seal;
- microsurfacing;
- Nova Chip;
- Metro-Mat$^{(TM)}$; and
- thin asphalt overlays.

For successful application of a thin surfacing, the characteristics and limitations of that particular type must be known. Candidate pavements must be in good structural condition for a thin surfacing to produce the anticipated benefits.

The unit costs of thin surfacings range from as low as $\$1.40/m^2$ for some types of surface treatments to about $\$5.00/m^2$ for thin asphalt overlays. By comparison, conventional mill and hot-mix asphalt treatments can cost $\$8.00/m^2$ or more.

Proper application of some of the thin surfacings can significanly improve road safety by correcting surface irregularities, including minor transverse profile corrections and low severity rutting, and improving pavement skid resistance and surface texture.

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