Extending Pavement Life by Forestalling Crack Reflection

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ABSTRACT

It is commonly accepted that cracks in aged asphalt pavement will reflect through seal coats and overlays. Pavement fabrics placed under overlays will slow this crack reflection, but not stop it. One contractor’s experience over 25 years of working with this same fabric under a double chip seal, using a modified technique developed through trial and experimentation, has added substantial pavement life at a reduced cost over typical methods of repair used in the industry. In addition, pavement deterioration due to oxidation and stripping has been eliminated due to the inability of air and water to penetrate the surface. This method reduces crack reflection by more than 90% over other alternate methods mainly due to the increased flexibility of the surface through the use of a higher percentage of oil in the total mix. The most surprising aspect of this process is its ability to repair alligatored pavement without removing and replacing the damaged pavement.

TYPICAL PAVEMENTS

Budgetary constraints sometimes cause agencies to ignore pavement needs to a point beyond the most opportune times to maintain good surfaces. It has been shown that asphalt pavements should be seal coated by the seventh year on secondary roadways to preclude the loss of fines around the larger aggregate, which increases surface porosity resulting in increased oxidation and stripping. Primary roadways usually have an increased amount of traffic, which actually helps maintain the continuity of the surface, forestalling early oxidation. In addition, primary roadways normally have an increased asphalt concrete thickness. This additional thickness requires more time to cure and helps keep the surface flexible due to the volatiles traveling upward and out the top. The deterioration caused by oxidation (hardening of the asphalt cement and the loss of flexibility) begins to accelerate between the seventh and tenth year of life (sooner if adequate densification of the asphalt concrete is not achieved during installation).

Often, maintenance is ignored until the pavement is in a distressed condition (usually due to budgetary constraints along with “worst first” maintenance procedures). The normal method of repair at this juncture usually consists of an overlay with asphalt concrete adding pavement fabric if cracking is evident. Sections of pavement with major alligator cracking should be removed and replaced with new pavement prior to the overlay. My personal experience with using this fabric on one half a road width having severe cross cracks and then overlaying the entire width with two inches of asphalt concrete had the following results: hairline cracks
appeared through the unmatted side after the first winter, stopping at the centerline. By the end of the second season, the cracks went all the way across the road. The fabric, in this case, added one extra season to the road. The value (for this type of crack mitigation) is questionable. On minor alligator cracking the fabric performed better, with some cracks becoming evident only after four years. The cost of this process is considerable due to the high cost of asphalt concrete, key cut grinding at gutters and approaches and the raising of utilities to the new surface elevations.

Chip or slurry sealing the cracked roadways fared about the same as overlays without fabric. Cracks were evident within the first year (six months on slurry seal coats) and water intrusion was evident. Surface oxidation and stripping was precluded, however, as the seal coats completely blocked the air, water and sunlight from affecting the asphalt surface below the seal coat. In the instance when the seal is placed between the seventh and tenth year, additional life can be expected from the pavement structure. The asphalt hardening due to oxidation is reduced, allowing stable flexibility over time and forestalling increased cracking caused by this process. This time period should be accelerated in harsh climates. The damage caused by brittle pavements in their latter years of life brought about the experimentation and the process described below to extend life of pavements that basically should have been replaced, but due to budgetary constraints, were not.

The goal was to develop a process that could be used on pavements approaching the end of their useful life that was less expensive than the fabric under an asphalt overlay, while affording the additional flexibility necessary to accommodate minor horizontal and vertical movement of individual blocks of cracked roadway.

**SURFACE PREPARATION**

As with all seal coating and asphalt concrete overlays, the surface to be worked on must be clean and dry. Cracks wider than 1/4 inch should be filled with suitable crack filler material. Since this material will be underneath the final surface, its primary purpose is to prevent the fabric from spanning a void. Inexpensive fillers work just as well as the more costly hot pour variety, although the additional flexibility and compressibility of the rubberized or polymerized hot pour crack seal material adds value. Any dust, dirt or loose materials must be cleaned from the surface prior to the first binder application. Above all, no moisture can be present on the surface if hot oil is chosen for the fabric installation.

**PLACING THE FABRIC/SERENINGS**

Four oz/sy (140g/m2) fabric can be placed in hot oil (PG64-10 or 70-10) or polymerized emulsion. The hot oil process is easiest as the fabric adheres immediately to the oil. The application rate for this binder necessary for complete immersion of the fabric is normally .30-.35 gallons per square yard (g/sy) (1.38-1.61L/m2), depending on the amount of surface cracking and other pavement conditions, ambient temperatures, and how quickly the fabric can be placed into the binder. The fabric is immediately rolled with pneumatic tire rollers for complete embedment. It is very important that the entire fabric is saturated with oil. If it is not, the first application of chip binder will partially soak into the fabric negating the film thickness necessary to retain the chip and accelerating potential chip loss. As excess binder will tend to stick to the tires, it is advisable to use rollers with anti-stick tires or coat the tires periodically with a light oil-parting agent. Either the boot truck applicator or a tractor applicator can be used to place the fabric. The boot truck applicator will probably need less binder to saturate the fabric since the mat is placed directly into the binder. It is mandatory that the mat be placed very tight (without stretching) with minimal wrinkles, as wrinkles will surface through the layers of the chip seals. If a tractor applicator is used, the tractor must stay as close to the boot truck as possible.
as it is critical that the mat be placed into the binder before cooling below 250 degrees F. I would not recommend that this operation be attempted during air temperatures below 70 degrees F. or pavement temperatures below 75 degrees F. Rolling should continue until the fabric is entirely immersed into the binder. If there is excess binder on top of the fabric, sanding at a rate of 2-4 lbs/sy (.9-1.8kG/m2) may be necessary prior to the use by traffic or the application of emulsion binder for the chips. Excess sand must be swept off prior to chip binder application.

Placing fabric into emulsion (PM or LMCRS-2 or 2H recommended) has its positives and negatives. The fabric will need to be placed with a tractor, normally from three to seven minutes after the binder is applied to allow some water to escape the emulsion. There is more time to roll the fabric into the emulsion allowing full embedment at a more leisurely pace, but the joints can be a problem. Sometimes the fabric will stick to the roller tires and pick up a joint, wrapping itself around the tires. This can be avoided by nailing down the transverse joints with a nail gun, using large washers under the nails in two foot increments across the joints. The binder application should be .43-50 g/sy (1.98-2.3L/m2). As with the hot oil application, pneumatic rolling should continue until full embedment is achieved. Light traffic can be allowed on fabric prior to placement of the first coat of chips, regardless of the oil type used, provided that the ambient temperature does not warm the surface to the point that the oil begins to stick excessively to tires. If this happens, a joint might pull and wrap mat around a tire. If it were necessary to have traffic on the fabric in warm conditions, a light coat of sand as described above would solve the tackiness problem. If sand is not available, a very light coat of chips can be used over the mat at a rate of 3-5 lbs/sy (1.48-2.46kG/m2). Although it is recommended to sweep off excess sand, it is not necessary to sweep chips off the mat prior to application of the chip emulsion. This application is often used prior to the first application of chip binder to preclude the boot truck tires from pulling the mat. Under no circumstances, should public traffic be allowed on the fabric prior to the first chip seal if rain is imminent. Water on this oil- immersed fabric will reduce the coefficient of friction to that approaching ice, severely reducing traction.

I recommend that latex or polymerized cationic rapid-setting emulsion (LM or PMCRS –2 or 2H, depending on typical ambient pavement temperatures) be used for the chip binder, applied at a rate corresponding to the degree of fabric/oil embedment achieved and the size of chip used for the first course. If good embedment is accomplished and a 3/8x#6 (9.5x3.35mm) chip is used, the recommended application of binder would be .33- .40g/s.y (1.52-1.84L/m2). The screenings should be placed at a rate of 18-22#/s.y (8.85-10.83kG/m2). The ideal application would achieve complete coverage with minimal excess loose chips at the surface following pneumatic rolling. A minimum of five complete passes of pneumatic tired rollers are required at a speed not to exceed 5mph (8kph) for good orientation of the chips. More passes are better. The second course of chips can be applied as soon as the first coat of emulsion has completely broken down (no brown oil is present throughout). A minimum wait of at least four hours before attempting the second coat is recommended. This coat is best applied the second day if the project is large enough for good economics. If excessive chips are present on the surface, a light sweeping is advisable prior to the second seal, provided that this is done the morning following the first seal coat.

It is good practice to step down the size of screenings applied on the second layer of a double chip seal. This will allow this smaller chip to “key in” to the crevices allowed by the larger chip. The amount of oil applied for this layer will depend on the size of screenings chosen and the relative tightness of the first layer. It is important to realize that the surface area of a 3/8x#6 (9.5x3.35mm) chip seal is usually considerably more than the surface area of the typical underlying pavement. All of the chips have not yet received adequate traffic to completely re-orient themselves to their final resting position, making the surface very coarse. This will correspondingly require more emulsion to coat this area sufficiently and allow enough film thickness to hold
the chip. A smaller chip size, such as 5/16 x #8 (8.0 x 2.36 mm) is recommended for this final course. The binder application generally used for this will be .32-38 g/s. y (1.47-1.75 L/m2). I have attempted a lighter application of binder for this layer, only to find the results less than satisfactory the following year. Most of the top layer of chips had moved off to the shoulders and the remaining rock that was still attached was black on top. This fact (the rock being black on top) verified that it had received the second shot of emulsion, but the top layer of chip had not adhered to this surface. This confirmed that I was looking at the first layer of aggregate. Although this sometimes happens in corners and intersections due to excessive tire forces, when it happens in tangent sections the cause is usually too light of a binder application to allow the necessary film thickness to hold the chip. It is important to note the shapes of the chips to be used to determine whether they are more cubical or tend to be flat. Chips that tend to be flat do not stand as high as those more cubical and therefore require less binder to achieve a film thickness resulting in roughly 65% of the total height of the chip recommended for good adhesion.

Final sweeping should be delayed until complete chip reorientation is achieved. This can be accomplished by additional pneumatic rolling or normal traffic controlled to a speed to prevent damage to the surface or opposing vehicles via flying chips.

If the anticipated traffic is light, combined with a project at an altitude where shaded pavements, freeze/thaw conditions and snow are likely before final reorientation has concluded, continued pneumatic rolling is mandatory or excessive chip loss and complete failure is possible under tire chains and snowplows. Additionally the PMCRS-2H binder should not be used, selecting PMCRS-2 for better chip adhesion.

**COST COMPARISONS**

A mile of roadway, 24 feet (7.31 M) wide is used for a typical project for cost comparison purposes. The conventional method used to rehabilitate distressed pavement is to apply a two-inch asphalt concrete overlay on a pavement fabric. This process requires key cutting along curbs, gutters and intersections to allow for the added thickness, placing the fabric and asphalt concrete, and raising the utilities (manholes and valve boxes). For the purposes of this comparison, no allowance was made for crack filling, as the cost should be the same for both types of repair. The cost to perform this work will range from $180,000 to $200,000 ($90,000 to $100,000 per lane mile) depending on the cost of crude oil, traffic conditions, number of utilities to be raised, proximity to hot plants, competition in the locale, etc.

The alternative method would be to use the same fabric followed by a double chip seal. Using the technique described above, the costs to perform one mile should not exceed $80,000 to $100,000 ($40,000 to $50,000 per lane mile). The savings realized includes the fact that key cutting and raising utilities would not be necessary since the total added thickness would approximate one-half inch. There would be additional savings if the project were a considerable distance from aggregate sources, as aggregate transportation costs are reduced by 75% using this technique as opposed to the asphalt concrete overlay.

**PICTURES OF WORK PERFORMED**

This method of asphalt repair has proven on roads such as this to result in a surface that should allow additional decades of use without further repair. The first three pictures show the result of surfacing a road having extensive cracks on a road near Rancho Cordova, California. Picture 1 is a portion receiving an asphalt concrete overlay performed in 1982, one lane over fabric. Picture 2 is another portion of the same road receiving the double chip seal over fabric performed in 1983. Picture 3 is where the two different treatments meet.

Picture 2. Rancho Cordova 2006
(Double Chip Seal over Fabric 1983)

Picture 3. Rancho Cordova 2006
(Location where both processes meet)
Notice the crack in the asphalt stopping where it goes under the chip seal over fabric.

These pictures were taken in 2006. No further work has been performed over either process of repair to date. The asphalt concrete overlay portion shows extreme surface degradation in addition to the extensive crack reflection. The double chip over fabric is still working without reflective cracking or surface degradation after 23 years. There is not another process used in the asphalt industry that compares to the long term performance of this method of pavement maintenance for providing a new wearing surface that forestalls crack reflection.

The next two pictures show a road in Clear Lake, California. Picture 4 was the existing condition of the pavement showing extensive alligator cracking taken in 1996. Picture 5 shows the same pavement ten years following the application of the double chip over fabric. There is no reflective cracking and the alligator cracking has been repaired without removing and replacing the damaged pavement.

This process has opened up a whole new concept of pavement maintenance. The notion of not having to replace damaged pavement prior to a surface treatment can be only considered as ground breaking. Nevertheless, the pictures speak for themselves.
CONCLUSIONS

The goal was to develop a process that would extend the life of pavements approaching their end of useful life by reducing air and water intrusion while providing a new wearing surface that would remain flexible enough to handle the movements of separate blocks of underlying pavement. This process accomplishes these goals. The completed product completely blocks sunlight, air and water intrusion (stopping the oxidative hardening and stripping caused by these elements). In addition, due to the heavy amount of binder used, a high degree of flexibility remains for an extended period of time (23 years on one project) retarding crack reflection from underlying pavements. As a comparison of the binder retained in the two alternate methods of repair, a typical asphalt overlay on fabric will have a total binder content of 6–7% by weight of total product. The fabric/double chip seal process uses a total oil content of 16–17% by weight. This is the major determinant of the added flexibility and extended life of the pavement.

Are there places where this process would not be advised? Definitely. Due to the high oil content, this process would not be advisable in climates where typical ambient temperatures are above 90 degrees F along with Average Daily Traffic above 10,000. Bleeding and shoving will probably occur due to the excessive flexibility provided. It has been used in climates above 100 degrees, but on low volume streets. It should not be used where water is present from beneath the surface, as this water trapped under the mat will separate the fabric from the surface, resulting in total failure at that location. This process is also not recommended where temporary loose chips cannot be tolerated for a short period of time.

In the 44 years I have been in this industry, I have never seen a product or process that offers similar short and long-term benefits. I have used this process on pavements that should have been replaced and these pavements are still functioning, some after 25 years without additional expenditures. The extension of life is directly attributable to the complete blockage of sunlight, air and water from the underlying pavement, along with the flexibility provided by the high oil content. The chips provide the new wearing surface while the fabric allows for the individual movement of the blocks of pavement underneath without directly affecting the chip seal matrix on top. Additionally, the prevention of sub grade saturation from water penetrating the cracked pavement allows this sub grade to regain strength and load carrying capacity. One project in Sacramento County, California had a Pavement Condition Index (PCI) of 53 prior to this process. Six years later, this same pavement rated 83. When combined with a savings approaching $50,000 per lane mile, the decision as to the best choice for pavement maintenance becomes easy.

REFERENCES


