ABSTRACT

The ultimate responsibility of public agencies is to recognize they are the trustee of the taxpayers’ money and are required to use sound engineering judgment in determining what is best, in the short term and long term, for preserving the public road system.

The current demand is to go “going green”; some practitioners address this need by recycling materials whenever possible - in some cases this may be the best solution. Other practitioners are considering other ways to preserve the existing pavement, including material and natural resources, as another and possibly better alternative. In either case, practitioners realize the need to “go green” and are considering numerous alternatives to identify sound engineering judgments in their effort to preserve roadways.

Textile interlayers (paving fabrics) have existed since the mid-1960s and private industry has introduced a “green paving fabric” to meet the current demand facing public agencies. Textile interlayers are recognized as a viable product and AASHTO and State DOTs have developed guidelines to assist agencies, at all levels, in its proper use and selection.

This paper will help public agencies evaluate how the use of paving fabrics (conventional and green) can be used as a pavement preservation strategy because of its ability to address distresses in a pavement surface, and also preserve the structural integrity of a roadway. The reader will also learn how the use of paving fabrics are environmentally sensitive from manufacturing to placement, preserve material and natural resources, and are a recyclable product as well.

KEYWORDS

Benefits, bottles, conventional, green, paving fabric
INTRODUCTION

Presently it is common practice for public agencies to consider recycling an existing pavement, in lieu of resurfacing. This is done in an effort to reduce demand of natural resources, energy consumption associated with resurfacing (e.g., manufacturing, hauling and placement), and placing a negative impact to the roadway’s profile and surrounding structures. However, practitioners are meeting the demand to preserve pavements by not only recycling, but by also considering other ways to preserve the existing pavement as a better alternative.

For example, when milling of an asphalt concrete pavement is being considered, engineers evaluate the roadway’s structural section and determine how much asphalt concrete is required in order to restore or increase the structural integrity of the roadway. The pavement structure is characterized by the Structural Number (SN) expressing the structural strength of a pavement required for given combinations of soil support, total traffic expressed in equivalent single axel loads (ESAL), terminal serviceability and environment.

The thickness of asphalt concrete pavement necessary can be reduced by introducing a paving fabric on the milled surface prior to resurfacing. The paving fabric will not only reduce the amount of asphalt concrete resurfacing required, thus saving material resources and energy consumption, but will also extend the service life of the roadway.

Agencies realize the demand to “go green” is with any construction operation. Engineers are environmentally sensitive and are considering numerous alternatives to identify sound engineering judgments to meet this demand. Private industry is partnering in this cause as well. Industry is continuously trying to find ways to meet agencies demands and other pressures facing agencies. The National Asphalt Pavement Association identifies the following as the current pressures:

- High material costs
- High fuel costs
- Increased environmental pressure
- Decreased funding
- Increased traffic demands

RECYCLING SOFT DRINK BOTTLES THROUGH PAVING FABRICS

Conventional paving fabrics have been manufactured since the mid-1960s and are manufactured with polypropylene and polyester. Industry has introduced a “green paving fabric” which is currently being used by agencies because of its environmental benefits. Green paving fabrics are still manufactured with polypropylene and polyester; however, its environmental benefit is the polypropylene is blended with waste polyester. The waste polyester is obtained from recycled plastic soft drink bottles.

Plastic soft drink bottles are originally manufactured from a high resin grade of polyethylene terephthalate (PET), more commonly called “polyester”. PET is one of the most commonly used consumer plastics used, thus recycling these commonly used bottles is essential. The discarded PET bottles are collected, baled and delivered to recycling plants where the bottles are then color sorted, washed, granulated and rewashed. The bottles are heated to produce a high grade of ultra violet (UV) polyester plastic pellet. The polyester pellets are then extruded and converted into a staple non-woven fiber that is used to manufacture green paving fabrics.

The green paving fabrics meet AASHTO specifications for conventional paving fabrics, including installation. Table 1 represents the life cycle of a soft drink bottle from the manufacturing of the bottle, to the recycling of the bottle into a polyester product, then into a roadway’s structural section, and the recycling of the roadway itself.
Green paving fabrics contain over 25 percent of post-consumer waste as defined by Leadership in Energy and Environmental for New Construction (LEED), primarily obtained from recycled plastic soft drink containers; 90 percent of these bottles are collected from landfill sites. The increased number of containers recycled by consumers would increase the recovery of bottles that are sold.

Table 1. The Life Cycle of a Soft Drink Bottle

<table>
<thead>
<tr>
<th>Conventional and Green Paving Fabrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the Difference between Conventional and Green Paving Fabrics?</td>
</tr>
</tbody>
</table>

Conventional paving fabrics have been around since the mid-1960s. The manufacturing process begins with a pelletized chip of polypropylene or polyester resin that is extruded into fiber and processed through a carding system with needling (needle punching) to follow, or a spun-bonded process. The fabric is then heated on one side as a constructability benefit for applying to pavements.

In contrast, green paving fabrics use the extruded fiber from the polypropylene process and blend the extruded fiber with a polyester fiber from a recycler. The fibers are then processed through the carding system which requires some adjustment prior to needling (needle punching). The heating application is altered in order to provide constructability for applying to pavements.

The recent development of the green paving fabric is an example of how industry addresses the ongoing needs of public works agencies – develop a product that preserves natural resources by not only manufacturing the fabric from recycled products, but saves natural resources over other methods used to preserve roadways, and is recyclable itself.

Green paving fabrics also meet the standards set for the Comprehensive Procurement Guidelines Program, Office of Resource Conservation and Recovery (5306P) U.S. Environmental Protection Agency by providing a minimum of 25 percent post consumer waste of materials used in the product.

The installation process for green paving fabric is the same for a conventional paving fabric. Successful installations have occurred in the field including with the increased amount of liquid paving asphalt (fabric binder) (Photograph 1).
GREEN ATTRIBUTES OF CONVENTIONAL PAVING FABRICS

Manufacturing Savings

Savings are realized in the manufacturing of paving fabrics because most manufactures recycle 10 percent of post industrial waste when manufacturing conventional paving fabric – the 10 percent recycled is allowed under Leadership in Energy and Environmental for New Construction Design (LEED) MR 4.1. The recycled post industrial waste is graded by strict quality control measures and is extruded into fiber which is a needed component for the manufacturing of paving fabrics.

BTU Savings

Paving fabric interlayers have successfully been used in the United States, and contributed to the environment, for over 40 years and have made a significant contribution to the environment by reducing the need for energy (BTUs) to produce, transport and place hot-mixed asphalt concrete (HMAC) used to maintain roadways. Jim Dykes reported in Phillips 66 Paving Information Bulletin Number 110, that the use of a paving fabric with a HMAC overlay will save 1,170,709,700 BTU/mile. This is possible because the use of paving fabrics reduces the required thickness of HMAC required to resurface a roadway. By reducing the quantity of HMAC to resurface a roadway, BTU savings are realized with the production, transport and placement of HMAC needed to resurface the roadway.
Material Savings

In December 1997, Maxim Technologies, Inc. of Austin, Texas did a study of the structural requirements for resurfacing a pavement with asphalt concrete pavement, with or without a paving fabric interlayer; Table 2 reflects those findings. This study shows that, depending on the proposed thickness to resurface a roadway, incorporating a paving fabric interlayer can reduce the proposed thickness as shown in Table 2. The incorporation of a paving fabric interlayer will also reduce the amount of HMAC resurfacing required to address reflective cracking from the underlying pavement.

Table 2. Structural Requirements in Dry and Wet Environments

<table>
<thead>
<tr>
<th>Existing AC Thickness (Inch)</th>
<th>Proposed AC Thickness Without Fabric (Inch)</th>
<th>Proposed AC Thickness With Fabric (Inch)</th>
<th>Reduction In AC Thickness (Inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.00</td>
<td>4.50</td>
<td>2.50</td>
<td>1.75</td>
</tr>
<tr>
<td></td>
<td>3.50</td>
<td>2.38</td>
<td>1.12</td>
</tr>
<tr>
<td></td>
<td>2.50</td>
<td>2.00</td>
<td>0.50</td>
</tr>
<tr>
<td>3.00</td>
<td>4.50</td>
<td>3.00</td>
<td>1.50</td>
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<tr>
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<td>3.50</td>
<td>2.50</td>
<td>1.00</td>
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<td></td>
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<td>2.00</td>
<td>0.50</td>
</tr>
<tr>
<td>4.00</td>
<td>4.50</td>
<td>3.25</td>
<td>1.25</td>
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<tr>
<td></td>
<td>3.50</td>
<td>2.62</td>
<td>0.88</td>
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<td></td>
<td>2.50</td>
<td>2.00</td>
<td>0.50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Existing AC Thickness (Inch)</th>
<th>Proposed AC Thickness Without Fabric (Inch)</th>
<th>Proposed AC Thickness With Fabric (Inch)</th>
<th>Reduction In AC Thickness (Inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.00</td>
<td>4.50</td>
<td>3.12</td>
<td>1.38</td>
</tr>
<tr>
<td></td>
<td>3.50</td>
<td>2.62</td>
<td>0.88</td>
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<td>2.50</td>
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<td>3.00</td>
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<td>3.25</td>
<td>1.25</td>
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<td></td>
<td>3.50</td>
<td>2.12</td>
<td>1.38</td>
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<tr>
<td></td>
<td>2.50</td>
<td>2.00</td>
<td>0.50</td>
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<tr>
<td>4.00</td>
<td>4.50</td>
<td>3.50</td>
<td>1.00</td>
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<tr>
<td></td>
<td>3.50</td>
<td>3.25</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>2.50</td>
<td>2.00</td>
<td>0.50</td>
</tr>
</tbody>
</table>
Another benefit of paving fabric is to lower the permeability of an asphalt concrete pavement by reducing the amount of water entering the road base via the pavement surface. When paving fabrics are used to keep water from the road base this equates, at a minimum, of good to excellent AASHTO drainage classification. Because there is limited water dwell time in the road base, a structural credit used for improved drainage can be applied to the drainage reduction coefficient of 1.0 to 1.3.

When the existing pavement is structurally sound and the design considerations are primarily to delay reflective cracking, a paving fabric interlayer becomes an obvious consideration because the paving fabric will delay reflective cracking when placed with as little as 1-1/2 inch of HMAC. As a result, a savings in the quantity of natural resources needed to produce HMAC.

According to the National Asphalt Pavement Association (NAPA), there are two basic ingredients in HMAC. The first is aggregates (crushed stone, gravel, and sand). The aggregates used are almost always locally available stone and account for approximately 95 percent of the total weight of an asphalt pavement. The remaining five percent is asphalt cement. Using these percentages, and 145 pounds per cubic foot for HMAC, the following savings can be realized with the reduced amount of HMAC required when combined with a paving fabric interlayer (Table 3):

<table>
<thead>
<tr>
<th>Existing AC Thickness (Inch)</th>
<th>Proposed AC Thickness Without Fabric (Inch)</th>
<th>Proposed AC Thickness With Fabric (Inch)</th>
<th>AC Thickness Reduction (Inch)</th>
<th>Aggregate Savings Per Lane Mile (Ton)</th>
<th>Asphalt Cement Savings Per Lane Mile (Ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.00</td>
<td>4.50</td>
<td>2.50</td>
<td>1.75</td>
<td>636</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>3.50</td>
<td>2.38</td>
<td>1.12</td>
<td>407</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>2.50</td>
<td>2.00</td>
<td>0.5</td>
<td>182</td>
<td>10</td>
</tr>
<tr>
<td>3.00</td>
<td>4.50</td>
<td>3.00</td>
<td>1.5</td>
<td>545</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>3.50</td>
<td>2.50</td>
<td>1</td>
<td>364</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>2.50</td>
<td>2.00</td>
<td>0.5</td>
<td>182</td>
<td>10</td>
</tr>
<tr>
<td>4.00</td>
<td>4.50</td>
<td>3.25</td>
<td>1.25</td>
<td>455</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>3.50</td>
<td>2.62</td>
<td>0.88</td>
<td>320</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>2.50</td>
<td>2.00</td>
<td>0.5</td>
<td>182</td>
<td>10</td>
</tr>
</tbody>
</table>

**DELAY OF REFLECTIVE CRACKING**

Paving fabric interlayers have been in existence for decades and advancements are continually being made to meet the needs of public works agencies. Presently, there are many pavement preservation strategies involving paving fabric interlayers which are reducing the cost to maintain or rehabilitate pavements. As shown in the following tables, both laboratory and field testing have proven that a paving fabric interlayer system is effective in delaying reflective cracking in an asphalt pavement (Tables 4 and 5):
Table 4. 2008 Beam Testing
Asphalt Technologies, Inc. Testing Laboratory, Florida

Table 5. 2008 Overlay Testing
Texas Transportation Institute
REVIEW OF DATA SUPPORTING WATER CONTROL BENEFITS

Pavement engineers agree there is a need to reduce a pavement’s exposure to surface water penetration because prolonged exposure is harmful to the roadway’s structural section and can reduce the bearing capacity of a loaded pavement. There are concerns which design method is best to limit and control a pavement’s exposure to surface water.

Pavement engineers need to evaluate a roadway’s demographics, identify the various design options in constructing or maintaining a pavement, and evaluate the risks and benefits of each design before making a final selection. In evaluation of a paving fabric as a moisture barrier, basic principles apply to both the use in new roadways and pavement resurfacing.

When designing a new roadway, the consideration of handling water flow and runoff will determine the applicability of a paving fabric as a moisture barrier.

There is a difficulty in measuring permeability in the laboratory and achieving a direct correlation of water flow in pavements, and the damage caused to the pavement or the road base. Studies have included the permeability of a paving fabric when saturated with liquid asphalt—these studies addressed the paving fabric’s saturated state and testing between the asphalt layers. Testing was also done on field samples of asphalt with and without cracks. Studies were performed in the laboratory and in the field on the effectiveness of the paving fabric. These studies confirmed that the use of paving fabrics do lower the permeability of asphalt pavements and reduce the amount of water entering into the road base.

An important benefit of a nonwoven paving fabric is that it is an effective moisture barrier throughout the life of the pavement. This is possible because the asphalt saturated paving fabric will continue to perform as a moisture barrier during the ageing process of the pavement because of its ability to flex within the asphalt concrete pavement. The asphalt saturated paving fabric will continue to provide waterproofing benefits even when the pavement is resurfaced with future asphalt overlays or even surface treatments, such as chip seals. Therefore, it is beneficial to an agency to utilize paving fabrics early in the life of the pavement to realize the benefits of an effective moisture barrier.

Studies were performed in the field and laboratory to evaluate the reduction of water percolation through a pavement where a paving fabric was used. Some studies used asphalt core samples from roadways, and others used laboratory prepared samples. These studies consistently showed that the presence of a paving fabric interlayer system reduces water percolation through asphalt concrete pavements. Other observations show that where cracks do reflect through the resurfacing material (asphalt concrete or chip seal), the paving fabric will stay intact and continue to provide a waterproofing moisture barrier. The following testing was done to support this evaluation:

Field Testing

Los Angeles County Permeability Test Results

In 1994, Los Angeles County performed falling head permeability tests on 4-inch cores from Olympic blvd. with the following results: Cores with a rubber asphalt content of 7.6 percent resulted in a permeability of about $10^{-4}$ to $10^{-3}$ mm/sec, depending on the degree of compaction. Permeability on highly compacted asphalt cores using 5.6% AR4000 liquid tack coat generated results of $10^{-4}$ mm/sec. Cores containing paving fabric with AR4000 liquid tack coat resulted in a permeability of $10^{-5}$ mm/sec.
Texas

In a 1989 study in Texas, test sections consisting of HMAC over paving fabric was examined and compared to control sections, to determine moisture related improvements associated with the paving fabric interlayer system. At a section near Amarillo, five different paving fabrics as well as control sections for comparison were installed. After rains, sections containing paving fabric exhibited less pumping deformation than control sections. This implies that the subgrade support was better in the paving fabric sections due to lower base and subgrade moisture content than in the control sections. This waterproofing benefit was still realized even after some cracking appeared on the surface of the thin asphalt concrete resurfacing treatment.

Oklahoma

In 1996, a study was performed by Oklahoma DOT to evaluate the effectiveness of drainable bases and edge drain systems when using paving fabric interlayers. Five pavement sections were monitored for approximately three years. The five sections of pavement had varying degrees of permeable bases and had some differences in edge drain systems.

In 1997, Oklahoma DOT returned to this site to determine why water was not draining from the pavement. In their investigation, they cored through the paving fabric interlayer system to the top of the break-and-seat base layer. A percolation flow test was then run by pumping water into the core to see if it would flow to the edge drain system. The water did flow and the break-and-seat base was determined to have an AASHTO drainage capacity of “good”. Therefore, since the base was drainable, the most probable reason that water was not flowing from the pavement after a rain was because the paving fabric interlayer system was restricting water infiltration from reaching the road base.

When a properly installed paving fabric interlayer system keeps the water from the road’s base, this equates to at least the “good to excellent” AASHTO drainage classification since there is limited water dwell time in the road base. Therefore, it is reasonable to apply a structural credit, normally used for improved drainage, where a paving fabric interlayer system is used.

Georgia

George DOT evaluated a four-year old installation of HMAC overlay over paving fabric on Highway I-85. A six-inch diameter core sample was removed and tested to determine the amount of water that could penetrate through the paving fabric. The core was subjected to a three-inch head of water for 16 hours; test results showed there was less than 10 percent of water that penetrated through the paving fabric.

California

The State of California Department of Transportation (Caltrans) constructed control and test section to determine the permeability of cracked asphalt concrete resurfacing placed over paving fabric (Caltrans Memorandum, May 8, 1984).

Test Site: 03-PLA-80-31.33/33.18, Colfax. Field data and cores for this investigation were obtained. Test sections were placed in July 1974 over an asphalt concrete roadway that was built in 1959. The original structural section consisted of 0.30-feet HMAC over 0.67-feet cement treated base over 0.67-feet aggregate base.

Asphalt concrete resurfacing occurred July 1974 and cores were taken March 1984. The results of the permeability testing are shown in Table 6.
Laboratory Testing

Laboratory testing, for these purposes, is defined as testing with laboratory prepared hot mix samples, using various paving fabrics. The permeability advantage of paving fabrics in the laboratory is confirmed by Asphalt Technologies, Inc., Phillips Petroleum and PRI.

PRI 2008 Study

The objective of PRI Study of 2008 was to determine hydraulic conductivity according ASTM D5084 on select core samples with and without cracks, and with and without paving fabric (TRB Circular #E-C006).

The sample cores were prepared by coring from the beam on elastic foundation slabs prepared for reflective crack testing at the crack, and away from the crack. As a result of this test, cracking is very slight and represents the beginning of the cracking process. The hydraulic conductivity of the control sample with a crack was one order of magnitude higher than the paving fabric sample with a crack (Table 7).

<table>
<thead>
<tr>
<th>Property</th>
<th>ASTM Test Method</th>
<th>Control No Crack</th>
<th>Control With Crack</th>
<th>Fabric No Crack</th>
<th>Fabric With Crack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Weight, grams</td>
<td>D3549</td>
<td>1,320.4</td>
<td>1,336.9</td>
<td>1,371.1</td>
<td>1351.5</td>
</tr>
<tr>
<td>Core Diameter, 0.1-inch</td>
<td></td>
<td>3.98</td>
<td>3.98</td>
<td>3.97</td>
<td>3.97</td>
</tr>
<tr>
<td>Core Thickness, 0.1-inch</td>
<td></td>
<td>2.6</td>
<td>2.6</td>
<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td>Hydraulic Conductivity, m/s</td>
<td>D5084</td>
<td>1.59x10^{-9}</td>
<td>2.43x10^{-5}</td>
<td>1.16x^{-7}</td>
<td>2.25x10^{-6}</td>
</tr>
</tbody>
</table>
Testing of Asphalt Saturation

Phillips Fibers Corp (Phillips Petroleum Co.) conducted studies to evaluate a paving fabric interlayer as a waterproofing membrane. Conclusion from the studies confirmed the success of a paving fabric interlayer system is dependent on proper installation.

The manufacturer’s installation guide recommends a tack coat application rate of 0.25 gallons per square yard. This is consistent with studies that show very little improvement in waterproofing can be expected until the tack coat is applied above 0.21 gallon per square yard. When tack coat levels are above 0.23 gallons per square yard, the paving fabric starts to achieve permeability of 10-5cm/seconds or less which will greatly enhance the waterproofing of a pavement. (Summations from TRB Circular # E-C006) (Table 8).

<table>
<thead>
<tr>
<th>Residual Asphalt (gal/yd²)</th>
<th>Flow of Water 3-Inch Head (ml/900 seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7,290</td>
</tr>
<tr>
<td>0.15</td>
<td>759</td>
</tr>
<tr>
<td>0.2</td>
<td>28.3</td>
</tr>
<tr>
<td>0.25</td>
<td>0</td>
</tr>
</tbody>
</table>

APPLICATIONS AND LIMITATIONS

The use of a conventional paving fabric or the new evolutionary green paving fabric can be used to extend the life of a pavement and can be applied using current pavement design criteria. The development of design thickness includes wheel loading, existing pavement strength, drainage and climatic conditions. Available data supports the use of paving fabrics when the manufacturer’s recommendations for fabric selection and application are followed.

The important properties of a paving fabric are weight, tensile strength, elongation and asphalt retention. Paving fabrics retain the applied liquid paving asphalt tack coat, and this combination results in a paving fabric interlayer system. Predominate fabrics used today are categorized as Light Duty, Standard or Heavy Duty. The properties for each category of paving fabric are identified by AASHTO designation (Table 9).
Table 9. AASHTO Designations for Paving Fabrics

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass Per Unit Area</td>
<td>D5261</td>
<td>ounce/yd²</td>
<td>3.5</td>
<td>4.1</td>
<td>6</td>
</tr>
<tr>
<td>Grab Tensile</td>
<td>D4632</td>
<td>pounds</td>
<td>90</td>
<td>102</td>
<td>150</td>
</tr>
<tr>
<td>Grab Elongation</td>
<td>D4632</td>
<td>%</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Mullen Burst</td>
<td>D3786</td>
<td>pounds/in²</td>
<td>180</td>
<td>200</td>
<td>290</td>
</tr>
<tr>
<td>Asphalt Retention</td>
<td>D6140</td>
<td>gal/yd²</td>
<td>0.2</td>
<td>0.23</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Industry has categorized paving fabrics as follows:

- Light duty paving fabrics are used in low-volume pavement in moderate climate and with slight distress. Used with HMAC or chip seals.
- Standard paving fabrics are the current AASHTO M288 specified in most state and local agency projects. Used with HMAC or chip seals.
- Heavy duty paving fabrics are those that exceed the AASHTO M288 specification and are recommended for severe pavement distress, heavy wheel loading and harsh climatic conditions. Used with HMAC.

When specifying a “green paving fabric”, the above requirements must include the fabric consists of a post consumer waste greater than 25 percent as calculated by LEED.

**Climate Considerations and Fabric Selection**

Paving fabrics interlayers are effective in most, but not all, climates of the United States. Laboratory and field testing has improved guidelines on the proper selection of a paving fabric which is dependent on the annual temperatures and roadway conditions.

General recommendations include Light Duty paving fabrics for warm and tropical regions with extreme variation with light traffic. Standard paving fabrics are best used in warm, tropical and moderate to severe climates. Heavy Duty paving fabrics are recommended in severe climates. In moderate climate areas, the paving fabric selected is not as critical as those considered for use in more severe climate conditions. Cold climates require more consideration for proper selection of the paving fabric including evaluation of the pavement, and the hot mix asphalt overlay intended for use.

Fabric selection is based on the annual low ambient temperatures, over a three-month average, in the climate area considered for use. Climatic regions where paving fabrics are used successfully are shown in Table 10.
Challenges

Experience has shown that reflective cracking caused by vertical and or horizontal movements in a pavement, due to extreme freeze-thaw conditions, provides a difficult challenge. The greater the temperature differential, this phenomenon accelerates the rate of crack growth in the existing pavement and new asphalt concrete overlay.

Freeze-thaw cycles cause the expansion and contraction of frozen water within the pavement and the roadway structural section. This situation warrants special consideration for asphalt pavement overlays including mix design, overlay thickness and asphalt binder.

Damage to the roadbed is accelerated when water is able to be present within the roadway structural section. When this occurs, common results are quick and severe fracturing of the pavement. In most cases, a paving fabric may not stop these thermal cracks from propagating through the pavement. However, paving fabrics have proven their ability to delay the cracking of the asphalt concrete pavement surface and also to minimize damage to the roadway structural section by greatly reducing water infiltration from the pavement surface.

Heavy duty paving fabrics should be considered for cold climatic conditions. Laboratory and field evidence has shown that since a thicker paving fabric requires a higher application of liquid paving asphalt as a binder, then a greater amount of liquid paving asphalt is saturating the paving fabric. As such, this is a benefit over Light Duty or Standard paving fabrics because the Heavy Duty paving fabric being saturated with a greater amount of liquid paving asphalt increases its ability to blunt the crack tip stress and enhance its waterproofing capabilities.

Modified Tack Coats

Success has also been demonstrated with the use of polymer modified liquid asphalt binder and a Heavy Duty fabric in cold climatic conditions. Test results confirm that polymer modified liquid asphalt adds strength at a lower elongation with high and low temperature ranges when applied with a paving fabric. The polymer modified liquid asphalt-paving fabric interlayer system has been used with PG 76-22 in several projects in the Chicago area.

The oldest site was built in June 2002 on a heavily traveled arterial in the industrial area of Libertyville Township. The existing pavement had an estimated PCI of 10, on a scale of 100. Full-depth asphalt patching was required for 40 percent of the arterial and the Township opted for a less expensive solution. The final design was to mill 2 inches and fill with a 3/4-inch leveling course, apply a heavy-duty paving fabric (6 ounce), then overlay with PG 76-22 asphalt consisting of a 2-inch binder course and a 1-1/5 inch surface course.

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Three-Month Average Low Temperature</th>
<th>Fabric Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm</td>
<td>&gt;42°F (&gt;6°C)</td>
<td>Light Duty or Standard</td>
</tr>
<tr>
<td>Moderate</td>
<td>&gt;24°F (&gt;4°C)</td>
<td>Standard</td>
</tr>
<tr>
<td>Cold</td>
<td>&gt;15°F (&gt;9°C)</td>
<td>Heavy Duty</td>
</tr>
<tr>
<td>Severe</td>
<td>&lt;15°F (&lt;9°C)</td>
<td>Not Recommended</td>
</tr>
</tbody>
</table>

Table 10. Climate Fabric Zones for Paving Fabrics
USING PAVING FABRICS TO MAINTAIN PAVEMENTS

Maintaining Rigid Pavements

The presence of cracks or joints in a portland cement concrete (rigid) pavement can be a problem if a HMAC (flexible) overlay is placed in order to improve serviceability. This is true when the cracked or jointed rigid pavement is subject to temperature drops that cause the rigid slabs to have a rocking action. The slabs rock as the traffic load transfer from one end of the rigid slab to the other.

Rigid slabs are often resurfaced with HMAC. HMAC pavements are flexible, but often are not flexible enough to bridge the upward and downward movement of the underlying rocking slab. The rocking action will cause the cracks or joints in the underlying rigid pavement to travel upward and through the flexible pavement. When the cracks reach the flexible pavement surface, this allows water to penetrate to the roadway’s structural section.

Designs in severe climatic conditions require an increased HMAC thickness as a mechanism for bridging the expansion and contraction of thermal joints. Designing for this condition is not used as often as it should be, primarily for economic reasons. Paving fabrics are not recommended for this application; however, if a thin HMAC overlay is the only alternative a Heavy Duty fabric may be used.

Caltrans “crack-and-seat” procedure is one of the most effective methods used to extend the serviceability of a rigid roadway by placing a flexible pavement over a rigid pavement. This method typically uses a Standard paving fabric beneath the flexible pavement, but able the cracked-and-seated rigid pavement, in an effort to address reflective cracking and provide a waterproofing moisture barrier.

Maintaining Flexible Pavements

Paving fabrics can be used to effectively reduce reflective cracks and provide a waterproofing mechanism for flexible pavements. Paving fabrics are not designed to correct a structurally inadequate designed structural section or overlay. Proper design is always required to determine the structural requirements for a new roadway, as well as resurfacing of an existing roadway. It is important to remember the design purpose and benefits of a particular paving fabric, and design accordingly. Paving fabrics are designed to be saturated with liquid paving asphalt, such as performance grade liquid asphalt, and are most effective for the following pavement conditions:

Block and Alligator Cracking

Paving fabrics are effective in addressing block cracking and slight to moderate alligator cracking on an asphalt surface (Figure 1).

Light Duty paving fabrics is commonly sued for less severe or slight alligator cracking on roads with less than 5,000 ADT.

Heavy Duty paving fabrics can be used for slight to severe alligator or block cracking where the asphalt pavement is intact and not loose. In these cases, the Heavy Duty paving fabric should be covered with a minimum of 2 inches of HMAC.


**Oxidized Pavement Surfaces**

Light Duty and Standard paving fabrics are the most economical paving fabric for oxidized or aged pavements. A minimum of 1-1/2 inches of compacted HMAC is required when placing over paving fabric. This method has proven to be an effective surface treatment in milder climates. Light Duty and Standard paving fabrics are also an excellent choice when placed prior to a single or double-chip seal. Such methods have been found successful for over 20 years on low and high speed roadways with less than 10,000 ADT.
RECYCLING PAVING FABRICS

Phillips Petroleum has proven that paving fabrics can be recycled when incorporated with hot mix asphalt concrete (HMAC). The current view of recycling of HMAC with paving fabric is that it is a difficult process – this is only true if the paving fabric is placed improperly or if improper recycling methods are utilized. This analogy is true with any construction process - use the proper tools and methodology to obtain the desired end product.

The current process of installing paving fabric has improved with knowledgeable agencies, contractors and fabric installers by using improved computer rate controlled distributor trucks to apply the fabric binder. This is done to insure the proper amount of performance graded (PG) asphalt binder is being placed to obtain the waterproofing benefit of the installed paving fabric, and insure enough binder is also present to allow adhesion of the HMAC resurfacing to the paving fabric and to the underlying pavement.

Milling of a HMAC pavement with a paving fabric interlayer present can be done if the appropriate milling equipment and technique is used. Milled HMAC with paving fabric can be processed through asphalt plants and recyclers that have the resources to effectively process these milled materials - these facilities are able to process these milled materials in large quantities. The following summarizes the successful recycling of conventional paving fabrics:

- Apply the proper amount of PG asphalt binder when placing paving fabric to insure adhesion of the HMAC to the paving fabric, and the paving fabric to the underlying pavement
- Use appropriate milling equipment and milling techniques
- Process milled material through asphalt plants or recyclers properly equipped to process properly milled HMAC with paving fabric

Green paving fabrics will give some improvement over conventional paving fabrics because of its blended construction. Green paving fabrics are expected to have a higher effectiveness as a waterproofing barrier because of its increased amount of PG asphalt binder applied during placement. The increased amount of PG asphalt binder retained, and its manufacturing with PET fiber properties, will be a benefit in its recyclability.

When is it Beneficial Not to Recycle the Paving Fabric Interlayer?

Users of paving fabrics with HMAC realize that paving fabrics provide the following benefits: controls reflective cracking, prevents surface water infiltration, stabilizes subgrade moisture content, allows wet subgrades to regain strength and load-carrying capacity, and extends the service life of a pavement.

When it is necessary to mill a HMAC pavement that has a paving fabric present, careful consideration should be done as whether or not to mill the paving fabric interlayer. Milling the paving fabric will remove the waterproofing benefits it provides and pavement distress may once again occur when the pavement is replaced without a paving fabric. As such, those that use paving fabrics realize the long-term benefits paving fabrics provide and are allowing the paving fabric to remain in the roadway. If the structural integrity of the roadway allows, practitioners are milling above the paving fabric interlayer in order to keep the waterproofing barrier and stress relief in place, and continue to perform, with the newly placed road surface.

LIFE CYCLE COST BENEFITS

The relative life cycle cost of placing paving fabrics with asphalt overlays, when considered to other types of rehabilitation processes, is truly an economical method in addressing a roadway’s maintenance needs. Pavement
preservation practitioners have also found the same benefits can be realized when paving fabrics are used with a surface treatment, such as chip sealing.

FHWA policy supports the fact that life cycle cost analysis (LCCA) is a decision support tool. As a result, the use of LCCA is encouraged in analyzing all investment decisions. Dr. Hicks and Dr. Epps reported that LCCA should be conducted early in the project development cycle as possible and that the level of detail in the analysis should be consistent with the level of investment. The current and future benefits realized from using paving fabrics are two of the steps that should be considered in the LCCA. Some of these benefits are:

- Extension of a roadway’s service life
- Reduction in subsequent roadway maintenance needs (e.g., crack filling, crack sealing or pothole repairs)
- Reduction in traffic disruption associated with road maintenance
- Reduced energy used to produce and place hot mix asphalt concrete or performance roadway maintenance operations

Life cycle costing for paving fabric with asphalt concrete overlays has been documented from field results of actual fabric installations. Caltrans developed the early data for cost savings and gave a value of 1.2 inches for paving fabric for the purpose of reflective cracking when used with asphalt concrete overlays.

In 1997, TRI Environmental, Inc. conducted a study to evaluate the most cost effective solutions for pavement maintenance in Greenville County, South Carolina. The study reviewed pavement condition index (PCI) records over a 15 year period. A review of the PCI revealed that when pavement conditions were between 10 and 30, reconstruction was the most cost effective solution. When the PCI was between 30 and 50, the most cost effective solution was an asphalt concrete overlay over paving fabric. When the PCI was above 50, an asphalt concrete overlay with or without paving fabric was about equal.

This study showed the maintenance options that were considered when a roadway had a PCI level of 40 the most economical treatment was an asphalt concrete overlay over paving fabric. The prices shown below are from the 1997 study, and do not reflect current prices:

- $0.20/yd² for cold mill recycling
- $0.16/yd² for asphalt concrete overlay
- $0.11/yd² for an asphalt concrete overlay with paving fabric

In 1997, Maxim Technologies reported that there is a consensus of opinion among literature searched and experts interviewed, that the addition of a paving fabric gives additional overlay performance equivalency of approximately 1.3 inches of asphalt concrete hot mix – assuming that the existing pavement, including the structural section, is stable.

**SUMMARY**

The ultimate responsibility of public agencies is to recognize they are trustees of the taxpayers’ money and are required to use sound engineering judgment in determining what is best in the short term, and long term, when maintaining or rehabilitating public roadways. This presentation will help public agencies accomplish this task.

Textile interlayers can now be manufactured with the use of post consumer waste, which with conventional paving fabric are recyclable and can assist practitioners in their efforts to preserve flexible and rigid pavements and “go green.”
In 2007 at the Hot Mix Asphalt Energy and Recycling Symposium, the keynote presentation made a statement that applies to public and private industries alike: “We must have the will to educate ourselves and the courage to innovate new solutions if we are to provide the transportation system our country needs to maintain economic leadership.” The incorporation of paving fabric interlayers is a valuable tool in preserving our natural resources, reducing energy consumption, maintaining our country’s transportation system with the economic diligence entrusted to us all from our constituents, the public taxpayer.

**REFERENCES**


