Technical Note No. 4

AMOCO GEOTEXTILES

Amoco Fabrics and Fibers Company

Petromat® As a Pavement Moisture Barrier

Introduction

This technical note is a summary of a more detailed paper prepared for the Transportation Research Board (TRB) *(1)*. The original paper, which contains a compilation of research and references related to pavement moisture problems and paving fabric interlayer systems, may be obtained from Amoco Fabrics and Fibers Company. As an alternative, the paper is posted on the TRB website at http://www.nas.edu/trb/publications/ec006.html

Paving Fabric Functions

The Petromat® paving fabric system has been used for a many years to enhance the performance of asphalt concrete overlays. The system accomplishes this end result through two mechanisms. First, it acts as a stress absorbing interlayer to retard the progression of cracks up through an overlay. Second, the Petromat system forms a moisture barrier to limit infiltration of water through the pavement and into the base and subgrade materials. With less exposure to moisture the base and subgrade become stronger increasing the support provided to the pavement and improving pavement performance. The asphalt cement tack coat used in installation of the paving fabric provides the waterproofing and the paving fabric stabilizes and holds the tack coat in place, providing it with the durability to provide the waterproofing for years to come.

Water Related Problems in Pavements

Past research has consistently shown that up to two-thirds of the water falling on a pavement can percolate through the pavement into the base and subgrade materials *(2)*. Excess water results in poor support for the pavement. This loss of support can be the result of excess pore pressures within the base materials, softening of cohesive subgrades, jetting of fines through cracks in the pavement, and freeze-thaw related factors. Recognizing this fact, the most commonly used pavement design procedure, AASHTO, 1993*(3)*, applies significant pavement thickness increases to compensate for poor drainage conditions. AASHTO accomplishes this through the use of drainage coefficients which range from 1.2 to 1.4 for excellent drainage to 0.4 to 0.95 for poor drainage. These coefficients are multiplied times the strength value of a base or subbase improving or lowering the design structural strength of those layers. In other words, a free draining aggregate base layer could be assigned more than twice the structural design strength as the same thickness of an aggregate base which drains poorly. This translates into the need for proportionately thicker pavements where drainage is not properly addressed. Commonly used base materials do not provide adequate drainage for the pavement and result in essentially a poor to fair drainage condition as defined by AASHTO. The limit at which a base will drain appears to be about 7% passing the #200 sieve. With fines content greater than this, the permeability of the base drops off to levels that provide an insignificant degree of drainage. Since most existing bases and base courses being built have this low permeability, the prospect of improving support of these pavements by improving drainage is difficult, even if edge drains are employed.

Improving Pavement Drainage

Where existing pavements require improvement, there are a limited number of approaches available. The overlay can be thickened to provide a higher structural capacity or drainage can be improved to gain more support from the existing structure. In some cases, retrofitting of edge drains have been used to improve the drainage of pavements. This works by essentially shortening the seepage path to get the water out of the base faster. However, the permeability required of the base to accomplish this is generally greater than that available in the pavement structures. The Petromat paving fabric system is a viable alternative method to increase the relative drainage of the base. It performs this function by forming a moisture barrier to reduce the amount of water percolating into the base. By sufficiently reducing the amount of water getting through the pavement, it essentially cuts down on the length of time that the base is saturated. The reduction in saturation time translates into improved support. Thus, by allowing less water to get into the base, the paving fabric moisture barrier accomplishes the same end result as improved drainage--keeping the water out of the pavement layers. Therefore, the use of a paving fabric membrane interlayer system should provide the same AASHTO design benefits as improved drainage.

There are pavement situations which could benefit from edge drains such as where water is primarily entering the roadbase as groundwater from the roadsides or if the water table is extremely high and needs to be lowered. However, by far, most roads develop base moisture problems due to direct infiltration through the pavements.

Petromat Moisture Barrier

The requirements for a hydraulic barrier within a pavement can be evaluated based on the typical infiltration rates observed and the approximate time it takes to saturate the base. Although any water in the base can weaken subgrade soils, saturation of the base causes the greatest structural failure. A pavement with a base saturated even 10% of the time will achieve only 50% of its design life *(2).* Typical pavement infiltration rates might be on the order of 0.25 to 0.75 in./hr. As an example, for typical pavement widths, slopes, base thicknesses and base porosities, initial saturation of the base material may take about 1 to 5 hours. At the low permeabilities common for bases, it may then take from 60 days to more than a year for the base to drain back down to 50% saturation. In this period it is likely that an additional rain may occur and even shorter rain periods would resaturate the base. Many bases never fully drain back to 50% saturation *(4).* A moisture barrier that can reduce the infiltration rate by an order of magnitude (one tenth the original) would also increase the length of time that it takes to initially saturate the base by an order of magnitude (ten times as long). For the example cited, that would increase the length of time that it must rain to saturate the pavement base to on the order of 10 to 50 hours. By extending the time to saturate the base, it becomes less likely that the pavement will experience a rainfall event of sufficient length and intensity that the base will become saturated and even less likely that rainfall events of that duration will recur frequently enough that the base cannot drain. Thus to be effective, a moisture barrier should reduce the pavement permeability by at least one order of magnitude. Changes in the actual asphalt concrete mixes using polymers or rubber and increasing densities can slightly reduce pavement permeabilities but fall short of effectively limiting infiltration.

There have been a number of studies performed both in the laboratory and field on the effectiveness of the Petromat paving fabric interlayer system in lowering the permeability of pavements and reducing the amount of water getting into the base. There have been at least four studies performed in the laboratory evaluating the reduction of water percolation through a pavement when paving fabric is used. Some studies used cores cut from actual streets and others used laboratory prepared samples. These programs consistently showed that paving fabric interlayer systems reduced water percolation through pavements by one to three orders of magnitude. Another valuable observation was that where cracks do reflect through the overlay in asphalt pavements, the paving fabric will stay intact and provide waterproofing.

A number of field investigations have also shown moisture barrier related improvements when a paving fabric system was used. In a 1989 study in Texas, performance of paving fabric in several locations was examined and compared to control sections. At a section near Amarillo, five different paving fabrics as well as control sections for comparison were installed. After rains, sections containing 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 contents than in the control sections. This benefit was still realized even after some cracking in the thin overlay treatment.

A 1996 study was performed in Oklahoma to evaluate the effectiveness of drainable bases and edge drain systems. Five pavement sections were monitored for up to three years. The five sections of pavement had varying degrees of permeable bases and had some differences in edge drain systems. In the sections with free draining bases, the flow through the pavement and out of the edge drains was up to about 80 percent of the rainfall but generally about 20 percent to 40 percent. One of the pavement sections consisted of a break and seat PCC pavement with broken sections averaging in the 4 to 12 inch size. Over the broken and seated concrete, a leveling course was placed followed by the Petromat system and a surface course. The edge drains in this section of highway showed almost no response to rainfall. In 1997, the state of Oklahoma returned to this site to determine why water was not draining from the pavement. In their investigation, they cored through the paving fabric system to the top of the break and seat base layer. A percolation flow test was then run by pumping water into the hole 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 the paving fabric system restricting the infiltration from reaching the base layer. When a properly installed paving fabric interlayer system keeps the water from the base, this equates to at least the good to excellent AASHTO drainage classification since there is limited water dwell time in the pavement base. Therefore, it is reasonable to apply a structural credit, normally used for improved drainage, where a Petromat paving fabric system is used.

Ground penetrating radar (GPR) was employed to detect the presence of moisture beneath pavements with and without paving fabric membrane systems in a 1997 investigation. Two roads were evaluated in North Carolina. Each road had sections with and without the Petromat paving fabric membrane system. Microwave signals penetrated the pavement and the reflectance or absorption of these microwaves were monitored as an indicator of moisture. The results of the testing on both roads showed significantly higher moisture levels in the road base and subgrade in the sections without the paving fabric interlayer system.

Another finding from all of these studies was the sensitivity of the paving fabric system to proper installation. Generally, for Petromat paving fabric, a tack coat application rate of 0.25 gallons per square yard is recommended. This anticipates that about 0.05 gallons per square yard will be absorbed by the existing pavement and the new overlay. This implies that 0.20 gallons per square yard will be available to the paving fabric. If a tack coat rate of only 0.20 gallons per square yard is applied to a pavement the results of tests indicate that the fabric would be allowed to absorb only about 0.15 gallons per square yard. The results of permeability tests performed on specimens cut from the asphalt absorption tests are shown in Figure 1. Asphalt tack coat numbers shown on Figure 1 include the amount of asphalt actually absorbed into the paving fabric during these tests plus 0.05 gallons per square yard which is typically required to bond the interlayer to the pavement layers. From Figure 1, it can be seen that very little improvement in waterproofing can be expected until the tack coat is at levels above 0.21 gallons per square yard. At tack coat levels above 0.23 to 0.24 gallons per square yard, the paving fabric starts to achieve permeabilities of 10^{-5} mm/sec or less which will greatly enhance the waterproofing of a pavement.

Summary

Past studies have consistently shown that rainfall infiltration through pavements is the principal source of water entering pavement bases and subgrades. By rapidly removing, or preventing this water from entering the base and subgrade, significant structural benefits can be assigned and substantial increases in pavement and overlay design life can be gained. Both laboratory and field pavement cores indicate that the presence of a properly installed paving fabric interlayer system reduces the permeability of a pavement by one to three orders of magnitude. Pavement base drainage improvement is only a viable option for rehabilitation if pavement bases have a permeability greater than 10^{-1} to 10^{-2} cm/sec. Since drainage improvement is not generally a viable option, placement of a paving fabric moisture barrier should be considered. By reducing the infiltration by one or more orders of magnitude, the system becomes an efficient moisture barrier to enhance pavement performance. To provide a continuous moisture barrier, sufficient asphalt cement tack coat quantity must be used to saturate the paving fabric and bond the interlayer system, generally about 0.23 to 0.25 gallons per square yard. Lesser amounts of asphalt cement diminish the waterproofing effect. The tack coat must also be uniformly applied. Field installation quality control is critical to the performance of the paving fabric. By using Petromat in new and rehabilitation projects and following good installation practice, substantial improvement in pavement performance can be obtained from its moisture barrier function. Petromat fabric interlayer system should be designed into new pavement structures to minimize water access into the base from the beginning, particularly if an open, free draining base layer and edge drain system is not included in the original design. It is suggested that inclusion of a paving fabric system be equated to improved drainage coefficients as per AASHTO pavement design methodology.

(1) Marienfeld, M.L. and Baker, T.L., *Paving Fabric Interlayer System as a Pavement Moisture Barrier*, Transportation Research Board Paper # 981112, 1998.

(2) Cedergren, H.R., *Drainage of Highway and Airfield Pavements*, John Wiley and Sons, Inc., New York, 1974.

(3) *AASHTO Guide for Design of Pavement Structures*, American Association of State Highway and Transportation Officials, 1993.

(4) Ridgeway, H.H., Pavement Subsurface Drainage Systems, *National Cooperative Highway Research Program Synthesis of Highway Practice 96,* TRB, National Research Council, Washington, D.C., 1982

PAVING FABRIC PERMEABILITY AS FUNCTION OF TACK COAT APPLICATION

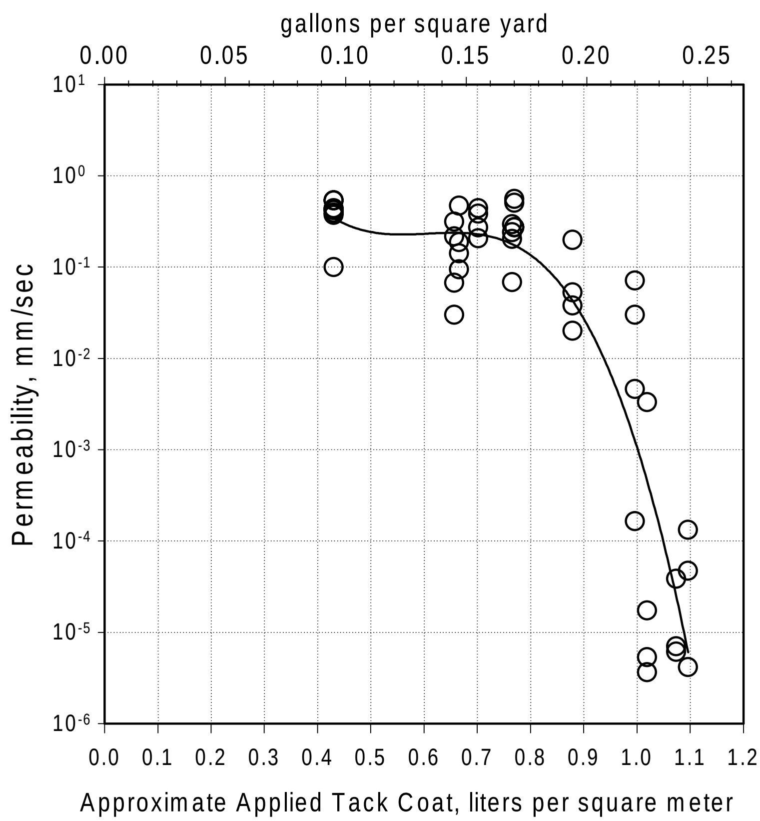

Figure 1 - Results of permeability tests on paving fabric specimens cut from melt through asphalt absorption tests. The asphalt quantity is the amount absorbed by the paving fabric plus the required 0.23 l/m2 (0.05 gal/yd2) for interlayer system bonding.

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