JULY/AUGUST 1990

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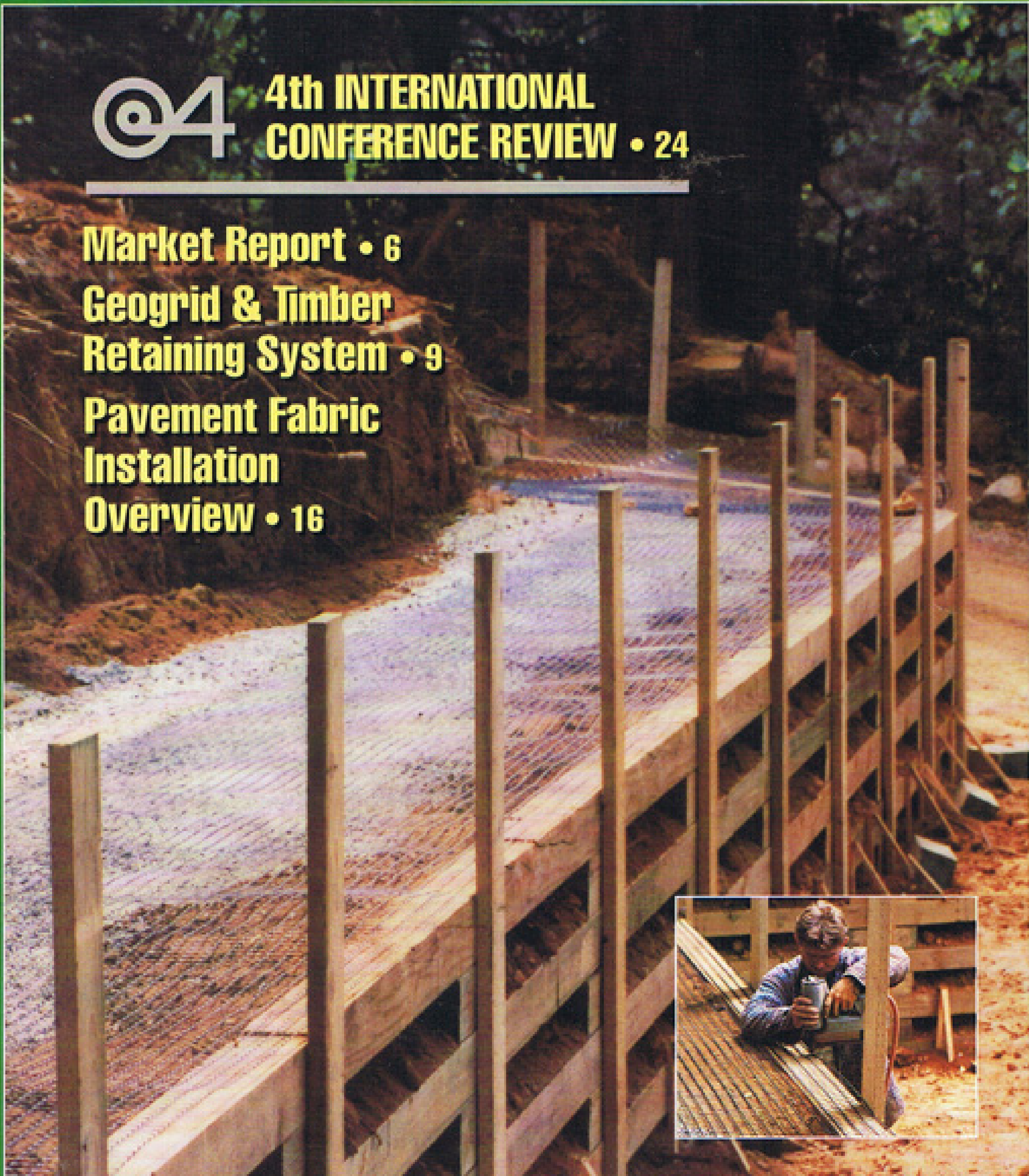
GEOTECHNICAL FABRICS REPORT



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GEOTECHNICAL FABRICS REPORT
ENGINEER'S GUIDE TO GEOSYNTHETICS

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EDITORIAL

The Industry's Forum

Newly elected President of the International Geotextile Society, R. Kerry Rowe, challenges the industry (see page 30), to disseminate knowledge concerning the benefit and correct use of geosynthetics in a broader range of potential uses.

Geotechnical Fabrics Report is doing its part in meeting this challenge. We keep our readers informed on their colleagues' use of geosynthetics to solve complex engineering problems in roads, reservoirs, dams, erosion control projects, waste containment and other uses. Our readers also look to us for the latest in government and industry regulations.

This is not as easy as it sounds. Though edited mainly for civil engineers, GFR is read by all members of the vertical geosynthetic industry. The view people take toward an article in the magazine usually reflects their link in the industry chain.

Reporting the needs or views of one segment may indirectly call another segment to task. In the short run, we get some urgent and sharply worded letters from those industry members with differing points of view. In the long run this benefits the entire industry, because all points of view are put out on the table for discussion and, hopefully, resolution.

In addition to serving as an educational tool, GFR should serve as a forum for presenting different views to benefit all levels of the geosynthetic industry.

Case in point: What temperature should oil be before pavement fabric is laid into it? On page 16, Mounque Barazone, pavement fabric installation equipment manufacturer, discusses the evolution of pavement fabrics in the past 20 years. He cites some oil temperatures that may be controversial among other segments of the industry. Specifications incorporating these temperatures are currently being developed. Is this the way to the future? Should it be?

Your comments and letters to the editor are welcome.

Danette R. Fettig

DANETTE R. FETTIG, EDITOR

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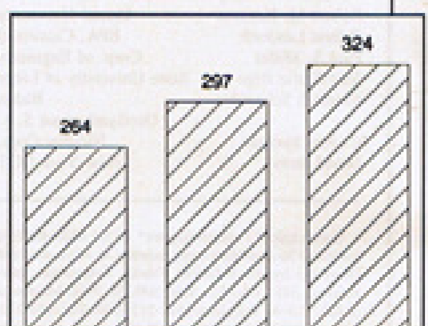

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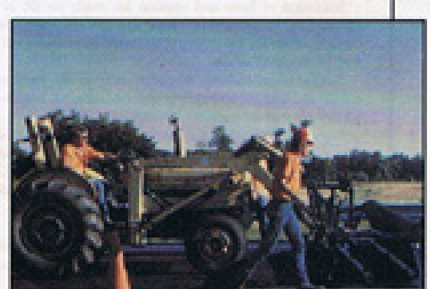


BY MOUNQUE BARAZONE

Paving Fabric Interlayer Membranes and Installation Procedures Over the Past 20 Years

Figure 1: The use of paving fabrics in asphalt concrete overlay systems is far more established than it was 20 years ago.

Paving fabric has been used in asphalt concrete overlay systems since the late 1960s as a waterproofing membrane and to reduce and/or delay reflective cracking (Figure 1). Most recently, paving fabric has been tried with chip and slurry seals. Performance results of extensive field trials throughout the United States from the late 1970s and 80s have varied from poor to excellent. The majority of failures are either from very early experiments prior to the development of proper installation procedures, or from attempts to reduce transverse (thermal strain) cracking.

As a manufacturer, former installer and patent holder of installation equipment for paving fabrics, the author has collected volumes of research materials and bases his knowledge on field experience. The knowledge contained in this paper is to assist field engineers and other installers, and give perspective on specifications and installation procedures to specifiers of paving fabrics.

Installation of paving fabrics is far more established than it was 20 years ago, because of specification guidelines produced by numerous organizations. But it is by no means a closed science in the respect that everything has been learned and individuals in all levels of the industry agree on all points. Quite the contrary is true. The author has seen specifications for paving fabric installation take some surprising turns in the past year, a trend that will continue.

Many states have published volumes of reports with the Federal Highway Administration (FHWA) since 1975, about the installation and performance of pavement fabrics under different climatic conditions. Most of these reports conclude that fabric is an exceptional water proofing (or perhaps more precisely water resistant) membrane, significantly reduces reflective cracking over alligatored pavements, and can reduce the thickness of the asphalt wearing course, depending upon deflection and traffic index calculations. Reports on test sections and laboratory experiments show excellent performance in mild climates and debatable improvement in cold climates. Temperature ranges were in excess of 104°F (40°C), and as low as -30°F (-86°C). [2,7,9,13,14,15]

The concept in using paving fabrics is to bond the new asphalt to the old asphalt through a membrane system. The system consists of a bituminous oil (tack coat), which is of sufficient quantity to impregnate the fabric while penetrating the old and new asphalt forming one integral, flexible structural system with a membrane in between.

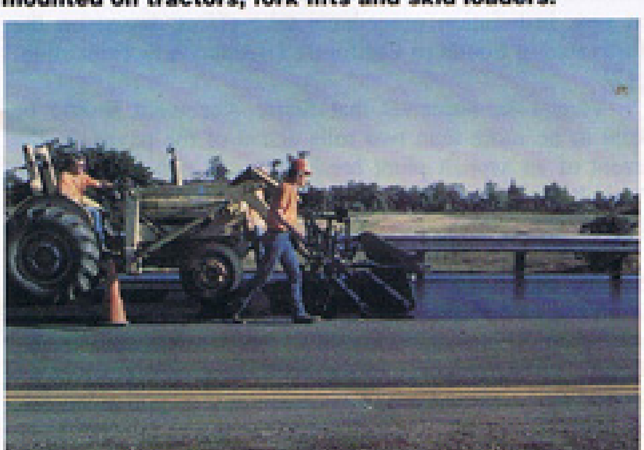
Various names have been given to the fabric used in these membrane systems, the most common being pavement reinforcement fabric. This is, in reality, imprecise terminology. Smith showed in laboratory testing that a fabric interlayer is not a significant tensile reinforcing element in an asphalt concrete (AC) pavement. [18] Reinforcement is obtained from high modulus materials. Nonwoven fabrics are low modulus materials, which permits them to remain flexible within an asphalt system. The preferred terminology is changing to pavement fabric membrane interlayer, often shortened to paving fabric, since little or no reinforcement is derived from the fabric.

Test Findings

Findings from three California Department of Transportation (Caltrans) reports by Predoehl [13,14,15] studied 24 test and control sections with 12 years of service. The reports conclude "AC overlays incorporating paving fabric interlayers (PFI) had less alligator cracking that conventional AC overlays that were up to 0.10 foot thicker" and recommends that "PFI be used to replace approximately .10 foot (3.0 cm) of asphalt concrete where additional tensile and flexural stiffness is not required." This results in savings as much as \$1.13 Yd² (\$0.95 M²) over a thicker overlay. [13] Thinner overlays may not benefit as much. It is noted that the thickness cannot be reduced below the thickness calculations for deflection based on traffic indexes and wheel loads.

The reports further conclude that "PFI appears to reduce transverse cracking in thinner overlays (.20-.40ft.) ,(6cm-12cm) over distressed PCC (portland concrete cememt) pavement by approximately one transverse crack/100 ft. after eight years of service." [14] "The data indicates that PFI are no more effective in reducing transverse cracking (thermal strain) than conventional AC overlays." Paving fabric reduces alligator cracking but does not work effectively over large transverse or longitudal cracks.

Figure 2: Fabric installation equipment has been mounted on tractors, fork lifts and skid loaders.



"In a comparison of performances of AC overlays incorporating twelve different proprietary fabrics in 24 test sections over distressed PCC pavements, there were no significant differences in cracking between any of the fabrics." [14] Predoehl notes crack and seating (C&S) has been very effective in retarding and/or reducing reflection cracking of transverse joints and cracks through AC overlays placed over C&S PCC pavements. After five years of service, there were no significant differences in cracking frequencies between C&S sections with or without PFIs. [15]

The data in these reports will be included in an upcoming Federal Highway Administration (FHWA) - Caltrans report, currently under review and due to be published in late 1990.

Button and Epps (Texas Department of Transportation) made observations similar to Predoehl's, except where installation problems in wheelpaths from wrinkles or overlaps were noted. [4,5,7,8]

The Caltrans and Texas DOT reports conclude that placing fabric properly is the most important single part in the performance of the interlayer system. That conclusion also has been confirmed by the author's field experience. Improperly placed fabric will reduce the long term benefit of the membrane system, resulting in less waterproofing, asphalt stripping (peeling away of the asphalt from the fabric) and cracks from heat damage, at wrinkles, overlaps and in wheel paths.

Placement of the fabric can be accomplished by hand rolling the fabric and brooming it in place. This is time consuming and requires an additional labor force to do the brooming. Numerous manufacturers market commercial fabric installation equipment (Figure 2). Some of the units are patented. The equipment has been mounted on tractors, the backs of trucks, jeep pickups, fork lifts and skid loaders.

Different manufacturers' fabrics have been used in test sections over 15 years with various installation problems observed when non-heatbonded and dual-sided heatbonded fabrics were used. Recently, fabric specifications have been changing due to these installation problems.

Caltrans' revised 1989 paving fabric specifications permit only nonwoven, needlepunched, heatbonded on at least one side fabrics. This specification revision came about after 10 years of field installation evaluation on the three manufacturing processes for nonwoven fabrics: heatbonded both sides, needlepunched and heatbonded on one side, and needlepunched, non-heatbonded. Woven fabrics were found to be ineffective since they had no interior plane to hold bituminous oils to form a membrane.

Dual-sided heatbonded fabrics were difficult to place

Figure 3: The heatbonded side is placed on the top. If the fabric is installed upside down, delamination and fuzzing may occur.

smoothly, the wrinkles and folds transverses the full width of the fabric. Limited oil absorption due to their thinness caused excessive oil bleed through the fabric. Oil got on the equipment, trucks and workers. This posed health, installation and accident hazards.

Non-heatbonded fabrics had delamination and fuzzing problems during installation (Figure 3). The fabric stuck to the oil, on the tires of the equipment, and shoes of the workers. The fabric was worn away in the equipment wheelpaths, damaging the fabric membrane integrity. In some cases, the fabric was completely worn through to the old pavement, rendering the fabric membrane useless. Texas DOT and Los Angeles County DOT Materials and Construction Division reports mention similar delamination and fuzz problems with non-heatbonded fabrics. [5,7,8,20]

Single-sided, heatbonded, needlebunched fabrics have not experienced the delamination, severe wrinkling or heavy oil bleed through problems during construction. The fabric is placed with the fuzzy side next to the asphalt oil on the old pavement surface and the heatbonded side up to the traffic and new asphalt. Button and Epps state "the fuzzy side provides reinforcement at the interface and a greater effective surface area of the fabric which offers better adhesive and shear strength." [3,4,5,7,8] Dual-sided heatbonded fabrics have no fuzzy side and are prone to slippage problems, shifting of the asphalt under load causing, cracking problems.

Care must be exercised to make sure the heatbonded side is placed on the top. If the fabric is installed upside down, fuzzy side up, delamination and fuzzing will take place.

The quantity and temperature of the oil during construction is very important in the final membrane system. Various fabrics will absorb different amounts of oil, depending upon weight and thickness. A typical 50 mil, 4 ounce/yd² (1.270 mm, 113 g/yd²; 140g/M²) will absorb .20 gal. of oil/yd² (0.9 liters/M²). An additional .05 gal/yd² (.02 liters/M²) of oil must be included for penetration into the old and new asphalt. Too much oil will bleed through the new asphalt, while too little oil will fail to complete the bond. The proper quantity of oil is based on the thickness and weight of the fabric and the condition of the old asphalt. There are different test methods to determine the asphalt retention of fabric. Currently Caltrans uses the values shown in Table 1 for various thicknesses of fabric, based on an equation developed by Smith. [18]

Button and Epps developed the following equation to obtain pavement fabric oil quantities:

$$Qd = .08 +/- Qc + Qs$$

where

Qd = design tack quantity, gal/yd²

Qs = fabric asphalt saturation content, gal/yd²

Qc = correction based on asphalt demand of the old surface, gal/yd²

Table 1: Values for oil quantities in relation to thickness of fabrics.

U.S. Measurements		Metric	
Thickness (Mils.)	***Quantity (gal/yd²)***	***Thickness (millimeters)***	***Quantity (liters)***
>50	.25	>1.270	1.1
50–60	.30	1.270–1.524	1.4
60–70	.35	1.524–1.778	1.6
70–80	.40	1.778–2.032	1.8
80–90	.45	2.032–2.286	2.0
90–100	.50	2.286–2.540	2.3

The .08 is an average value based on field experience for overlays with no fabric.

Current specifications are leading towards a limited specification in regards to thickness and weight. Los Angeles County and Southern California Public Works Association Materials Greenbook now limit thickness to between 30 and 50 mils (.9-2.3 mm) and weight to between 3.5 and 5 ounces/yd² (99-142 grams/yd²). AASHTO-AGC-ARTBA's Task Force 25 Test Method No. 8 has been developed to address both the asphalt retention and area change (heat shrinkage) of paving fabrics.

Heat Shrinkage

The most serious shrinkage problems as observed in the field by the author have occurred when the fabric is placed into a hot oil which exceeds the fabric shrinkage temperature, rather than the melt point. Texas, Los Angeles County and Caltrans have also documented shrinkage of polypropylene fabrics when placed in hot oils over 250°F (121°C) (Figures 4, 5). Heat from the asphalt to 300°F has been tolerated by polypropylene fabric. It is believed that the impregnanted fabric is insulated by the oil allowing it to withstand the asphalt's higher temperature. Polyester fabrics have not been prone to these problems since polyester's shrinkage and melt points are higher.

Los Angeles County has completed laboratory testing fabrics for heat shrinkage and damage due to heat exposure. No problems were noted with fabrics at 240°F (115.5°C). Shrinkage began at 250°F (121°C) and serious shrinkage and damage occurred at 280°F (137.77°C). [11,12]

Los Angeles County recently developed a new specification (as yet unpublished) for fabric placement that reflects these data. This specification also requires the use of a surface temperature gun to determine the appropriate oil temperature for placing the fabric, or requires a delay between oil and fabric placement. This specification is being proposed to the Southern California Greenbook Specification Committee.

Caltrans found over a 50 percent shrinkage in samples soaked in 275°F oil for 30 minutes. [18] Texas DOT noted shrinkage problems on some test sections [5,8], as did Los Angeles County. [12]

Both hot asphalt cements and emulsions have been used with success. Joseph Vicelja, retired Los Angeles County construction and materials engineer, reported that hot asphalt cement facilitates fabric placement, permitting faster construction, and has been the predominate choice by contractors and agencies for this reason. [20] This may change as new installation procedures take effect, based on the forthcoming Southern California Greenbook Specification. [12]

Vicelja recommends that fabric placement should be kept to no more than two rolls ahead of the paver. In the event of an asphalt plant breakdown, or non-specification asphalt, the fabric can be paved upon and not left to exposure of traffic.

Rapid set emulsions work well in the membrane system, but the emulsion must break completely before the fabric is placed in the emulsion. Breaking is the term for the oil setting up, when evaporation of all moisture has taken place. Runoff problems occur in the application of emulsions on sloped and crowned roadways making the application rate difficult to control. Under no circumstances can fabric be placed in the emulsion until all water has evaporated from

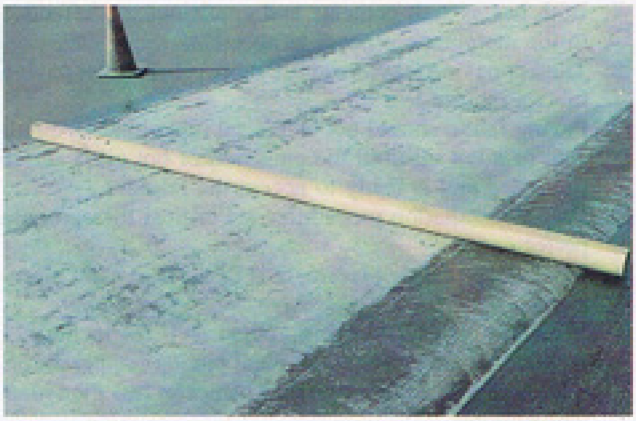


Figure 4: Roll core shows amount of fabric shrinkage observed in Los Angeles County.

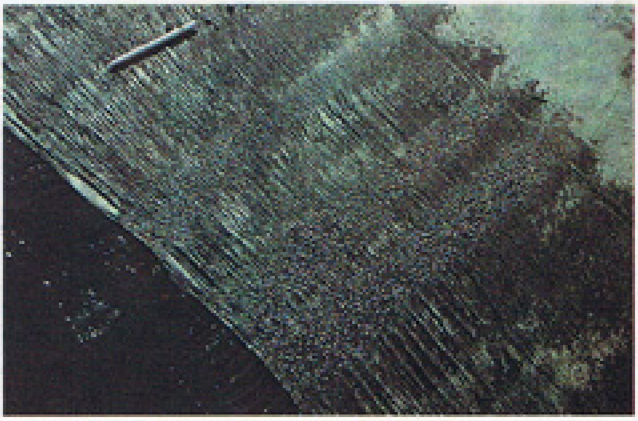


Figure 5: A specification developed by Los Angeles County requires the use of a surface temperature gun or a delay between oil and fabric placement.

the emulsion. Button and Epps reported that steam from the water can create bubbles in the overlay, and Smith reported that moisture can cause stripping problems of the asphalt after a short period of time. [3,5,7,8,18]

Since a 4 ounce (113 gram) fabric absorbs .20 gal/yd^2 (.9 liters/M^2) as a residual, cut back emulsion (oil and water mixture) must be spread at a thicker rate. If a 50 percent mixture or cutback is used, the spread rate must be .50 gal/yd^2 so that after evaporation there is a .25 gal/yd^2. Once the oil has broken, the residual must be sufficient to saturate the fabric, the old and new asphalt and make a bond. Button and Epps found that petroleum based solvent cutbacks should never be used as tack or to secure overlaps. They are damaging to most synthetic fabrics. [3,5,6,7,8]

The overlay thickness must not be less than 1 1/2 inches (3.81cm; if installed under ideal climatic conditions, 70°F (21°C) or above. For temperatures between 50°F and 70°F (10°C-21°C), overlay thickness should not be less than 2 inches. [8,18,20] Overlays should not be attempted with temperatures less that 50°F (10°C). The heat from the overlay draws the oil up through the fabric making a bond. Smith found that "if sufficient residual heat is not present to complete the bonding process, the results will be slippage, stripping and eventual overlay failure." [7,10,18,19,20]. Rubber tire rolling of the fabric to seat it into the oil is one installation method that has been used by many agencies [5,8,18] Rolling the asphalt immediately after placement helps to concentrate the heat and supply pressure to start the process of the oil moving up into and through the fabric. [5,7,8]

Numerous published reports, including Task Force 25 Guidelines for Pavement Fabric and Installation, caution that wrinkles and overlaps in the fabric can cause cracks in the new overlay if not properly handled during the construction process. The author's field experience supports these conclusions. Wrinkles twice the thickness of the fabric (or 1 inch, depending upon the source) should be slit with a knife at the bottom of the wrinkle and laid flat. Excess overlaps at transverse joints should be removed. Overlaps and slit wrinkles should be shingled (laid on top of each other) in the direction of the paving. If shingled in the wrong direction, the paver is likely to lift or tear the fabric during construction. The overlapped wrinkles and all joint overlaps in the fabric should have additional oil placed to twice the spread rate. The tack must be sufficient to saturate the two layers of fabric and make a bond. If this is not done, a slip plane will exist at each slit wrinkle or overlapped joint, resulting in a crack and potential stripping of the asphalt from the fabric. Overlaps should be no more than 6 inches on longitudinal joints, and 1 foot at transverse joints. When paving multilane roads where the first lane is to be paved prior to placing fabric in the second lane, care must be taken to leave a 6-inch overlap at the end of the asphalt. [7,8,10,18]

One common installation problem documented in the literature and observed by the author, is excessive oil bleed through the fabric on hot days immediately after placement. The oil sticks on workers and truck tires, tearing or delaminating non-heatbonded fabrics and lifting, wrinkling and shifting all fabrics.

A popular practice at job sights has been for the engineer to cut back on the quantity of oil being placed. This should not be done. If the quantity of oil is reduced so there is insufficient amount to complete the bonding process between old asphalt, fabric and new asphalt, slippage and stripping will occur. Construction procedures such as hand spreading of a light layer of asphalt on the wheelpaths prior to equipment moving over the fabric, is one way of protecting the fabric.

Fabric in cold climates has not performed as well as in mild climates. Referenced reports are split as to the benefit derived in cold climates, although some reports indicate marked improvements in test sections in cold climates with temperatures as low as -30°F.

Donnelly reported five years better performance with an overlay in Colorado on an interstate between Eagle and Dowd. [9] In an FHWA report, Wyoming experienced considerably less cracking in the fabric overlay than in the control section with no fabric after one severe winter. Cracking eventually evened out in three years. [3] Caltrans test sections in the mountains have shown a delay in the cracking of fabric overlays as compared to the non-fabric control sections. [13] Texas reported significant improvement in the asphalt with fabric after three winters. [5]

Scrimscher found fabrics to be recyclable during Caltrans experimental milling research. [17] Cohesion values for both the hot and cold recycle briquettes with fabric exceeded the cohesion values of the control mixes. The fabric seemed to provide some tensile reinforcement to the AC mix. The surface abrasion test results showed a significant improvement in the hot recycle briquettes and no detriment in the cold recycle briquettes. Colorado reported similar findings. [16]

Summary

In the past, paving fabric has been controversial as an effective material for asphalt overlays. It has taken nearly 20 years for agencies such as Caltrans and the Texas DOT to evaluate fabric performance. There is no question that fabric improves the performance of overlays and will continue to grow in volume of usage. The fact that paving fabric has been found to be effective in test sections is largely due to tightly controlled, proper installation procedures rigidly adhered to for oil temperature, spread rate, fabric placement, wrinkles and overlaps. To assure the continued excellent performance record for paving fabric the most important factor will be the enforcement of installation specifications and guidelines.

Conclusions

1. Paving fabric interlayer membrane systems have a 20 year track record of success in the United States in mild climates, with debatable results in cold climates.
2. Paving fabric provides an effective moisture barrier.
3. Paving fabric retards reflection of alligator cracking in new AC overlays.
4. Paving fabric is not effective in reducing transverse (thermal strain) reflective cracking.
5. Paving fabric will lengthen the life of an equivalent thickness overlay or permit the reduction by as much as 0.10 foot (3.0 cm) of the new AC wearing course, but not less than the deflection calculations.
6. Only nonwoven, needlepunched, heatbonded on one side paving fabric should be specified.
7. Both hot asphalt cements and emulsions are effective in the membrane process as an oil.
8. Thicker paving fabrics require more oil. Thinner paving fabrics require less oil.
9. Paving fabric should not be placed into either an emulsion or a hot oil until the emulsion or hot oil is set up or cooled and is ready to accept the fabric.
10. Proper installation procedures are critical for optimum performance.
11. Mechanized fabric placement is faster than hand placement.
12. Minimum asphalt wearing course is 1 1/2 inches - 2 inches (3.81cm-5.08cm) in ideal paving temperatures, and should be a minimum of 2 inches in less than ideal temperatures.
13. Paving fabrics are recyclable in both hot and cold milling processes.
14. Paving fabric can save or stretch available construction dollars.

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About the Author:

Mounque Barazone is president of Geotextile Apparatus Co. He has been involved in the use, installation, distribution and consulting of geotextiles for 15 years. He is an inventor who holds six U.S. patents with international patents pending on paving fabric installation machines. He has other patents pending for fabric unloading roll pullers.