GUIDELINES FOR USING GEOSYNTHETICS WITH HOT MIX ASPHALT OVERLAYS TO REDUCE REFLECTIVE CRACKING

by

Joe W. Button, P.E.
Senior Research Fellow
Texas Transportation Institute
979-845-9965, 979-845-0278, J-Button@tamu.edu

Robert L. Lytton, P.E.
Senior Research Engineer
Texas Transportation Institute
979-845-9964, 979-845-0278, R-Lytton@tamu.edu

Texas Transportation Institute
The Texas A&M University System
College Station, Texas 77843-3135

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ABSTRACT

Complete guidelines for using geosynthetics with hot mix asphalt overlays to reduce reflective cracking are provided. Definitions of the various types of geosynthetics that are commercially available along with some of their advantages and disadvantages are provided. These guidelines address the following: when to consider a geosynthetic product, selecting and storing geosynthetics, cost considerations, pavement design with a geosynthetic, overlay construction with a geosynthetic, construction inspection, and potential construction problems.

INTRODUCTION

No current pavement rehabilitation techniques have been shown to *prevent* reflective cracking. Several techniques have demonstrated the ability to reduce/delay reflective cracking. Available methods usually fall under one or more of three categories:

1. Reinforcement of the overlay
   a. Thicker overlay
   b. Fiber-reinforced HMA overlay: polyester, polypropylene
   c. Modified asphalt in HMA overlay: tire rubber, neat rubber, polymer, sulfur, carbon black
   d. Compliant HMA mix: PFC w/crumb rubber or SMA
   e. High-modulus grid or composite: fiberglass or polymer
2. Stress relieving interlayers
   a. Stress absorbing membrane interlayer (SAMI): asphalt rubber seal coat
   b. Open-graded HMA interlayers
   c. HMA interlayer containing low-viscosity asphalt
   d. Stone dust bond breaker
   e. Fabric/asphalt interlayer
   f. Heavy-duty membrane
3. Restrengthening of cracked pavement before overlaying
   a. Heater scarification
   b. Spray applications of asphalt rejuvenator

Other methods to address reflection cracking might include: a seal coat applied to the existing pavement, thick large stone open-graded asphalt stabilized layer (Arkansas mix), saw and seal the HMA overlay, and cracking and seating or rubblizing of concrete pavements. This guideline will deal strictly with geosynthetics for reducing reflection cracking.

DEFINITION OF TERMS

"Geosynthetics" are defined herein as fabrics, grids, composites, or membranes. Grids and composites are newer generation materials developed for specific purposes by manufacturers.

Fabrics or geotextiles may be woven or nonwoven and are typically composed of thermoplastics such as polypropylene or polyester but may also contain nylon, other polymers, natural organic materials, or fiberglass. Filaments in nonwoven fabrics are typically bonded together mechanically (needle-punched) or by adhesion (spun-bonded, using heat or chemicals).

Grids may be woven or knitted from glass fibers or polymeric filaments, or they may be cut or pressed from plastic sheets and then post tensioned to maximize strength and stiffness. Grids typically have rectangular openings from 1/4 inch to 2 inches wide. Grids are designed to exhibit high modulus at low strain levels such that their reinforcing benefits begin before the protected pavement layer fails in tension.

Composites generally consist of a laminate of fabric onto a grid. For the composite, the fabric provides absorbency (primarily to hold asphalt) and a continuous sheet to permit adequate adhesion of the composite onto a pavement surface; whereas, the grid provides high strength and stiffness.

A heavy-duty membrane is a composite system, usually consisting of a fabric mesh laminated on one or both sides with an impermeable rubber-asphalt membrane. They are typically placed in strips over joints in concrete pavements or used for repair of localized pavement failures.

WHEN TO CONSIDER A GEOSYNTHETIC

Generally, geosynthetics will perform best when used to address load-related fatigue distress manifested by closely spaced random cracks or alligator cracks. To justify a full-coverage geosynthetic, significant random cracking should be prevalent on a significant portion of the project. No specific guidance is available. More widely spaced cracks and/or joints in PCCP can be addressed using a geosynthetic strip product (heavy-duty membrane). However, widely spaced transverse cracks and joints often exhibit large movements, making reflective cracking difficult to impede.

Geosynthetics can be effective in retarding reflection cracking from low-severity and medium-severity alligator-cracked pavements (Holtz et al., 1998). Geosynthetics and other types of interlayers will typically perform considerably better in warm and mild climates than in cold climates. There are three ranges of thermal crack opening: (a) from zero to 0.03 inch, where no geosynthetic is needed; (b) from 0.03 to 0.07 inch, which is the effective range of geosynthetics; and (c) greater than 0.07 inch, which is an opening movement that geosynthetics cannot normally withstand (Lytton, 1989).

The presence of cracks does not necessarily mean that ride quality is low. Cracks can be sealed and the pavement can continue to be used if ride quality is acceptable. The economics associated with existing techniques for reducing reflection cracking indicate that a crack-treatment program for pavements having light to moderate levels of cracking is usually more cost effective than other available methods (Barksdale, 1991).

Geosynthetic products should not normally be placed on a milled surface. A leveling course of HMA should be placed to provide a smooth surface on which to place the geosynthetic.

Strategies including a geosynthetic, like all others, must be carefully engineered and are not quick, easy solutions suitable for all pavements.

Hot Mix Asphalt Concrete Pavements

In order for geosynthetics to perform satisfactorily, the flexible pavement on which they are placed must be structurally sound. The pavement should have a remaining life of greater than 5 years.

Pavements for which cracking can potentially be delayed by using a geosynthetic exhibit fatigue cracks that are *not* caused by base or subgrade failures or delamination of existing pavement layers. Surface cracks should be less than 1/8 inch wide. No improvement in performance is likely if cracks are greater than 3/8 inch wide. Observations have shown that fabrics are not effective where wide transverse thermal and shrinkage cracks are present (Barksdale, 1991).

When an overlay and fabric are placed over an existing pavement, it often can no longer "breathe" and thus water may accumulate in the old pavement. It is prudent to evaluate the stripping potential of a pavement before placing a fabric/overlay system or any other sealing layer or interlayer. While the old pavement was able to "breathe," moisture susceptibility was not manifested (McKeen and Lytton, 1982).

Portland Cement Concrete Pavements (PCCP)

Jointed Concrete Pavements

In order for geosynthetics to perform satisfactorily, the JCP on which they are placed must be structurally sound. Measures should be taken to minimize joint and crack movements. The load transfer efficiency factor (LTEF) at joints should be 80 percent or greater. LTEF is computed as (AASHTO, 1993)

$$LTEF = (d_u / d_l) \times 100$$

where d_l = deflection on the loaded side
d_u = deflection on the unloaded side

Lateral movements at joints and some cracks in JCP are usually large, and stopping these reflective cracks is particularly difficult. Cracks should be sealed before overlaying. Geosynthetic strips, which have a thick membrane, may provide an effective seal for several years even after the cracks appear at the overlay surface.

The 1993 AASHTO Design Guide advises that the effectiveness of geotextiles in controlling reflective cracking in HMA overlays over jointed plain concrete and jointed reinforced concrete pavements is questionable. If a geosynthetic is to be used on JCP, this guideline recommends a high-modulus product (such as fiberglass grid) be placed in strips only over the joints. Ideally, the geosynthetic should not be placed directly on the existing JCP. The following should precede placement of the grid: cracks in the concrete larger than 1/8 inch should be filled with crack sealant. A Grade 4 (~1/2-inch maximum size) seal coat (underseal) should be applied to promote good adhesion to the concrete and assist in sealing smaller cracks in the slabs. A leveling course of HMA should be placed to provide a smooth surface on which to place the grid.

Cracks in JCP greater than 3/8 inch should not be treated with fabrics without previous crack treatment. Cracks/joints 3/8 inch or wider prevent asphalt tack from "wicking" into the fabric across a crack or joint. Thus, the crack or joint is left open to infiltration of surface water immediately after the old crack reflects through the overlay (Barksdale, 1991).

Continuously Reinforced Concrete Pavements (CRCP)

In order for geosynthetics to perform satisfactorily, the rigid pavement on which they are placed must be structurally sound. Since crack spacing in CRCP is usually small, slab movement at the cracks is usually small, and reflective cracks through a HMA overlay are not usually serious problems.

HMA-Overlaid Concrete Pavements

Geosynthetics are routinely used with new overlays on previously HMA overlaid PCCP, where the original pavement was JCP, JRCP, or CRCP. In addition to controlling reflective cracking, an asphalt-impregnated geotextile can help control surface water infiltration into the pavement and thus minimize associated damage. Moisture can cause loss of bond between AC and PCC, stripping in the AC layers, progression of D-cracking or reactive aggregate distress (in pavements with these problems), weakening of the base and subgrade (Holtz et al., 1998), and frost heave.

ADVANTAGES AND POTENTIAL DISADVANTAGES

Advantages

Moisture is frequently the main source of pavement damage and roughness. Asphalt-impregnated fabrics will control infiltration of surface water into a pavement. Fabrics may remain intact after the asphalt overlay has cracked and provide a moisture barrier. The fabric must be saturated with sufficient asphalt to provide a continuous moisture barrier; insufficient tack will diminish this waterproofing effect. Movement at cracks in some jointed concrete pavements may be large enough to rupture the fabric such that it no longer provides resistance to water flow. If a moisture barrier is justified, fabrics and composites offer this added benefit but grids cannot.

Disadvantages

An asphalt-impregnated fabric or composite can trap water in a pavement. A moisture barrier under a new overlay can be a detriment to its performance, particularly if the overlay is not compacted properly. Rapid premature failures have occurred when a moisture barrier (fabric, seal coat, etc.) was placed on an old pavement then the overlay is insufficiently compacted such that it is permeable to water (Better Roads, 2000; Roads & Bridges, 2000). Surface water enters the permeable overlay and is trapped by the impermeable layer. Subsequent kneading and scouring action by traffic in the presence of the water causes rapid failure of the overlay. This problem is compounded when the overlay is also an inlay (sometimes termed the "bathtub" effect). One paper (Marienfeld and Baker, 1999) stated, "The level of compaction is not as critical to achieving low permeabilities when a paving fabric moisture barrier is used." Based on personal observations, the authors disagree with this statement. Compaction of dense-graded HMA is always important for achieving proper density and minimum permeability. A permeable dense-graded HMA overlay over a moisture barrier can result in rapid failure, particularly during freeze-thaw conditions (Button, 1989).

In addition, water vapor rising from below due to evapo-transpiration can accumulate just under a moisture barrier and, if the HMA mixture in that vicinity is water susceptible, it can suffer significant damage. Distress will develop first in the wheelpaths due to repetitive loading by traffic on the weakened pavement layer and progress rapidly.

Fabrics have been found ineffective in reducing reflection of thermal cracks. Pavement overlay systems have had limited success in areas of heavy rainfall and regions with significant freeze-thaw cycles. (FHWA Manual, 1982)

SELECTION OF A GEOSYNTHETIC

Geosynthetics currently available include fabrics, grids, and composites. There are several widely varying products within each of the three categories. Fabrics made using polypropylene or polyester are most common. Fabrics have been made of other products (nylon, glass, combinations of materials) but they are usually more expensive. Polypropylene begins to melt at a temperature of about 325°F. Therefore, when using polypropylene products, the temperature of the paving mixture should not exceed 300°F when it contacts the geosynthetic.

When ordering geosynthetic products, the contractor should specify width of rolls to accommodate pavement lane width or his plans for geosynthetic placement. Improper roll width can result in significant lost time, excessive construction joints, and waste of material. The contractor should also consider the maximum roll weight that the application equipment (typically a specially equipped small tractor) can handle. Excessive roll weight may cause the roll core to sag during placement thus producing wrinkles.

Fabrics

Nonwoven paving fabrics typically exhibit relatively low moduli and thus can mobilize only limited stress at low strain levels. Fabrics have demonstrated mixed results in reducing reflective cracking by acting as a stress-absorbing interlayer. There is evidence that an asphalt-impregnated fabric will resist intrusion of surface water into the base even after reflective cracks appear at the pavement surface. Some Department engineers believe this reduction of water in the base/subgrade reduces localized swell and thus helps maintain pavement smoothness.

In theory, using a thicker fabric should result in lower stresses at the tip of a crack than using a thinner one. Therefore, the thicker layer should be more effective in delaying reflection cracking. The full thickness of the nonwoven fabric must be saturated with asphalt. Clearly, asphalt retention rate is an important property. Asphalt retention should be at least 0.2 gallons/yd^2; it is directly related to the fabric weight and thickness. When used as a stress-relieving interlayer, the fabric should generally have a minimum weight of 4.1 ounces/yd^2 (AASHTO M 288-06 [AASHTO, 2006]). Both theory and limited evidence indicate that a thicker fabric with greater asphalt retention may delay cracking longer than a thinner fabric. Additionally, heavier fabric will reduce bleed through during construction and reduce the effect of any damage by construction traffic. The maximum practical weight for a paving fabric is about 6 oz/yd^2 to allow proper asphalt saturation in the field. (Button and Epps, 1982).

Full-width fabrics should be limited to use on flexible pavements where there is extensive random cracking and waterproofing of the pavement is needed and justified. Widespread alligator cracking often indicates structural failure, which must be addressed by major rehabilitation efforts. A fabric/seal coat or fabric/overlay to address structural problems should be considered only a short-term solution. If widespread alligator cracking is due to surface aging of asphalt and not structural failure, full-width fabric may be an inappropriate treatment; rejuvenation or surface recycling may be more appropriate. Strip fabrics are recommended for use on widely spaced cracks and joints where a prolonged waterproofing interface is desired. Waterproofing may limit base and subgrade movement due to freeze-thaw action or expansive soils. Fabrics have not demonstrated good success in reducing reflection of thermal (transverse) cracks in flexible pavements and joints in concrete pavements.

Grids

Grids typically exhibit much higher moduli than fabrics and logically should take on more stress at low strain levels. Grid systems serve primarily as a reinforcing interlayer. To act as overlay reinforcement, a grid must be tightly stretched, or slightly pretensioned, and it must have sufficient stiffness. Typical grids used as overlay reinforcement exhibit stiffnesses varying from 80 to >1000 lb/inch. However, only the stiffest grids (>1000 lb/inch) can act as overlay reinforcement (Barksdale, 1991).

Some grids contain a thin, continuous sheet, designed to assist in installation (i.e., adhere to the tack coat) that melts when the hot overlay is applied. Other grids have thin, permanent fiber strands partially filling the openings that adhere the grid to the tack coat. Neither of these products forms a waterproof barrier. These products should be considered as grids and not composites.

Composites

Composites may offer benefits of both fabrics (stress-relieving interlayer) and grids (reinforcement). Composites are recommended for use on pavements where both reinforcement and waterproofing are desired.

Membranes

Heavy-duty membranes should serve as both a waterproofing membrane and a stress-relieving interlayer. The mastic membrane should provide both reduced permeability and be sufficiently soft and thick to act as a stress-relieving interlayer. Membranes are relatively expensive and are normally placed in strips over joints or cracks.

COST CONSIDERATIONS

The in-place costs of geosynthetics and other methods to address reflection cracking are influenced by: (a) the specific product used, (b) the quantity to be placed, (c) local experience with its installation, (d) local labor costs, and (e) the general condition of the market place. The in-place cost of fabrics has fallen significantly since the early 1980s, apparently due to stiff competition and, perhaps, improved contractor experience and acceptance of geosynthetics. In 1991, NCHRP Synthesis 171 offered the following rule of thumb: The in-place cost of a full-width paving fabric is roughly equivalent to the cost of about 0.5 to 0.6 inch of asphalt concrete (Barksdale, 1991).

Under favorable conditions (many of which are described herein), some geosynthetic products can delay reflection cracking in an asphalt overlay about two to four years longer than a similar overlay without a geosynthetic. Reflection cracks are usually sealed through a maintenance program. Such maintenance costs and any delays by a geosynthetic are reasonably easy to quantify, and should be considered when the cost of different design alternatives are analyzed. An estimate of the probability of success should be included in all economic analyses. NCHRP Synthesis 171 indicated that, under favorable conditions, the probability of success of a paving fabric will be about 60 to 65 percent. The use of geosynthetics and other techniques should, at a minimum, be compared with the cost of using an overlay of similar thickness with a crack-sealing program. (Barksdale, 1991).

A simple approach is to determine or estimate the performance equivalency between two alternatives and directly compare their costs. California DOT indicated a paving fabric interlayer may be equivalent to about 1.2 inches of HMA in retarding reflective cracking. Using typical in-place costs, a fabric interlayer is about 50 percent of the cost of 1.2 inches of HMA (Holtz et al., 1998), and this assumes a 100 percent success rate. Considering a 65 percent probability of success, the economic advantage of using paving fabrics appears to be somewhat less unless the potential benefits of reduced water infiltration and resultant improved ride quality are considered. One should obtain realistic cost data for the particular situation and estimate a reasonable probability of success.

Determination of cost effectiveness of products in pavements typically requires several years. As a result, information on cost effectiveness of the newer grids and composites is not currently available in the literature.

Heater scarification is an alternative for addressing reflective cracking. The decision to use a geosynthetic or heater scarification for controlling reflective cracking may come down to economic conditions for the particular project. The two procedures are not equivalent. Heater scarification may be used in conjunction with a geotextile to provide, for practical purposes, a 1-inch leveling course. In this case, heater scarification must compete with a new leveling course in order to be the most cost-effective alternative. If a pavement exhibits large spaces between thermal cracks (e.g., greater than about 15 to 20 feet, depending on the temperature regime), crack movement due to thermal variations and traffic is expected to exceed the capability of a fabric to effectively control reflective cracking. In this case, it seems reasonable to heater scarify the old pavement rather than or in addition to installing a geosynthetic. Again, heater scarification is competing with new overlay material. If heater scarification reduces the overlay thickness and/or maintains the required grade, it may be cost effective.

PAVEMENT DESIGN CONSIDERATIONS

Overlay Thickness

Overlay thickness for both flexible and rigid pavements should be determined as if the geosynthetic interlayer is not present. Generally, overlay thickness should not be reduced from that determined by standard methods when using a geosynthetic. When overlay thickness is reduced based on contributions of the geosynthetic, it should not be reduced to less than four times the size of the largest aggregate in the HMA overlay mixture nor less than 1.5 inches.

Avoid the use of thin (< 2 inches) or inadequately compacted overlays with fabric, particularly on high traffic volume facilities. Stage construction is not recommended. That is, a thin overlay should not be constructed with plans for placing another thin overlay in a few years. Data and experience suggest that a minimum overlay thickness of 2 inches should be used with or without paving fabrics (Barksdale, 1991).

A poorly compacted overlay may exhibit high permeability and allow water to become trapped on top of a fabric interlayer. Trapped water can lead to stripping and/or freeze-thaw damage in the overlay.

Overlay Type

Normally, only dense-graded, well-compacted, low permeability HMA mixtures should be used as overlays over fabrics or composites. Beneath permeable HMA mixtures (e.g., PFC or OGFC), a waterproof fabric must he placed at a drainable grade so that surface water drains out of the overlay. For milled inlays, proper drainage must be provided. Permeable overlays, such as poorly compacted mixtures with interconnected voids, should not be permitted. A poorly compacted overlay over a waterproof membrane (asphalt-impregnated fabric) can trap and hold water. Retained water can cause rapid failure of the overlay due to freezing and/or stripping of the asphalt.

Flexible Pavements

The recommended steps (Barksdale, 1991) in developing an overlay design for flexible pavements where a paving fabric is a potential candidate are given below.

Pavement Condition Evaluation

A general pavement condition survey is valuable in establishing the type, severity, and extent of pavement distress. Such information is needed to develop required repair strategies and the overlay design strategy. Candidate pavements should be divided into segments. Non-destructive surveys, including visual distress, ground penetrating radar (GPR), deflection (FWD), or seismic (SPA), are possible tools to establish where these divisions should be made. For each segment, determine extent and severity of cracking (longitudinal, transverse, alligator, block, random), rutting, patching, potholes, flushing, raveling, etc. Crack widths should be measured. An excellent guide is "Distress Identification Manual for the Long-Term Pavement Performance Studies" (SHRP/LTPP/FR-90-001) (SHRP, 1990).

A tentative conclusion should then be drawn as to whether a geosynthetic is a suitable candidate in the rehabilitation scheme. If a formal pavement condition survey is not performed, at a minimum, the type, extent, and level of cracking should be established.

Structural Strength

Overall structural strength of the pavement should be evaluated, along its length, using the falling weight deflectometer (FWD). The pavement should have a remaining life of greater than 5 years, as computed by standard methods.

Base/Subgrade Failure

Areas that have experienced base or subgrade failures should be identified. There should be no evidence of severe load associated distress (e.g., alligator cracking < 5 percent of area, no deep ruts or failures). When nondestructive testing devices are not available, proof loading of the pavement with a loaded truck has also been used to identify structurally weak areas. Reflection cracking will not be significantly delayed by geosynthetics in areas that have base/subgrade failures.

Remedial Pavement Treatment

The results of the pavement condition survey and deflection measurements should be used to develop a pavement repair strategy for each segment.

Overlay Design

A realistic overlay thickness must be selected to ensure a reasonable overlay life. Using geosynthetics with thin, under-designed overlays, which lead to significant reflection cracking in three to five years, or less, will not justify the use of a geosynthetic.

Performance Monitoring

To develop a data bank of performance histories with geosynthetics, performance monitoring during construction and service of the overlay is highly desirable. Constructing a control section without the geosynthetic, with all other items equal, will provide valuable comparative data for future decisions. Without a control section, the so-called test has no value.

Rigid Pavements

The process (Barksdale, 1991) for determining candidate rigid pavements for rehabilitation with overlays having a geosynthetic is generally similar to that previously described for flexible pavements. Vertical joint deflection surveys should be performed to determine if grout injection or joint repairs are necessary. Joint deflections can be conducted using FWD, Rolling Dynamic Deflectometer, or proof rolling with a loaded truck. Geosynthetics should not be used when vertical joint deflections exceed 0.008 inches unless corrective measures are taken to reduce joint movements.

Horizontal thermal joint movement should be less than about 0.05 inch. Because horizontal joint movement is approximately proportional to slab length, thermal joint movements will increase as joint spacing increases. Careful attention must be given to performing the required remedial measures, including joint cleaning and resealing, patching, grouting, joint repair, slab replacement, etc. (Barksdale, 1991).

Overlay thickness should not be reduced when a geosynthetic interlayer is employed.

OVERLAY CONSTRUCTION WITH A GEOSYNTHETIC

Geosynthetic Storage

During storage, geosynthetics should be protected from precipitation, extended exposure to sunlight, temperatures exceeding 160°F, sparks/flame, and chemicals. Geosynthetics containing any polymer will degrade upon prolonged exposure to sunlight. They should be protected from direct sunlight even if the geosynthetic is marked UV stabilized. Water-soaked materials are cumbersome and may not readily adhere to an asphalt tack. If rolls have taken on water, the core may not be strong enough to support the geosynthetic during placement. Geosynthetics should be stored in such a manner to avoid misshapen rolls.

Surface Preparation

Before application of a geosynthetic, the existing pavement should be thoroughly cleaned using a broom and/or compressed air and should be dry. Fill cracks exceeding 1/8 inch wide with appropriate crack sealant. Fill cracks exceeding 1 inch wide with a fine-grained bituminous mixture. Faulted cracks or joints with vertical deformation greater than ½ inch should be leveled using fine-grained bituminous mixture or other suitable material. These recommendations are designed to ensure that the geosynthetic or leveling course will have continuous firm support, which will assist in proper compaction of the overlay and allow continuous tack coat application to uniformly saturate the geosynthetic product. Potholes should be properly repaired even with the existing pavement surface. Crack filler and patching materials should be allowed to cure prior to placement of the geosynthetic.

Importance of a Leveling Course

Apply a leveling course to uneven, rutted, or extremely rough surfaces (e.g., milled, new seal coat). For best results, place a leveling course (0.75 to 1 inch thick), whenever possible, before placing the geosynthetic. Theory (Pickett and Lytton, 1983) and practice

(Brewer, 1997) have shown prolonged appearance of reflection cracking from placing a leveling course before placing the geosynthetic. A leveling course does several important things to promote success of the overlay including providing a smooth surface on which to place a geosynthetic and a fresh, unoxidized surface to which the geosynthetic or new overlay can bond. A leveling course can also reestablish a drainable grade.

Because the movement at cracks and joints in jointed concrete pavements is relatively large, a leveling course is highly recommended.

Tack Coat Selection and Application

Selection of proper tack material and application rate is one of the most important aspects in construction and performance of geosynthetic interlayers. One should consult the particular geosynthetic manufacturer’s installation manual. Hot asphalt cement (AC) is usually recommended as tack for geosynthetics. Tack coat should be applied uniformly at the specified rate using a calibrated asphalt distributor truck. The tack coat should be sprayed approximately 4 inches wider than the geosynthetic. Common field problems with tack coat applications include proper temperature control, clogged or leaking spray bars or nozzles, application of too much or too little material, and nonuniform distribution.

Tack application temperatures are generally about 290°F to a maximum of 325°F. Temperature of the tack when the geosynthetic is placed can be critical. Polypropylene may be damaged or shrink at temperatures above about 300°F (Button et al., 1983). Optimum temperature for embedment of fabric is 180°F to 250°F. One must install fabric while asphalt is still tacky. However, if fabric is embedded in asphalt that is much hotter than 180°F (particularly in hot weather), the fabric may become prematurely saturated and cause construction problems (e.g., fabric pick-up, slippage). A noncontact thermometer is useful in determining binder temperature.

Tack rate should not normally be reduced to solve construction problems. Such reductions can cause subsequent system failure. Insufficient tack rate is the leading cause of poor fabric interlayer performance and failure (AIA, 1999). Insufficient tack will result in unsaturated fabric, which will disallow interlayer bonding, which in turn, can lead to overlay slippage and/or debonding and will not provide waterproofing.

Weight tickets and tank gauges may not be sufficiently accurate for checking tack rate. Tack rate should be verified using preweighed, thin pans placed directly in the path of the distributor truck. The pans can be recovered after passage of the distributor truck and weighed to compute the tack application rate. If measured tack rate is different from specified rate, it should be appropriately adjusted before further use. Application spot checks should be conducted periodically and be used to verify weight tickets and calibrated stick measurements.

Emulsified asphalt is not normally recommended as tack for geosynthetics. Although emulsified asphalts have been successfully used as tack, they develop bond strength more slowly than asphalt cement, and debonding on windy days has been reported. If emulsified asphalt is used, it should be allowed to break and set before the geosynthetic is placed. Placement should be followed immediately by pneumatic rolling to minimize disruption by wind or traffic. A larger quantity of emulsion is required as compared to AC (to yield the proper amount of residue) and the viscosity of emulsion is lower than AC (and stays lower longer). This may cause problems with runoff, particularly on sloped or undulating pavements. If emulsified asphalt is used as tack, it should not be diluted with water. The inspector should ensure the emulsion has not been diluted. When calculating tack coat shot rate, recall that emulsion is only about 65 percent asphalt, therefore, tack rate must be adjusted upward by dividing it by the asphalt content (percentage) of the emulsion: (e.g., emulsion shot rate = desired asphalt tack rate/0.65).

Cutback asphalts should never be used as tack for polymeric geosynthetics, because the solvent can remain for extended periods and weaken the polymer.

For general cost estimating, a 4 oz/yd^2 fabric will require approximately 0.25 gal/yd^2 of residual asphalt for tack, similar weight composites will require about the same or less tack, grids will normally require much less tack.

Fabrics

The design tack coat application rate for a particular fabric is normally provided by the manufacturer/supplier. Type of tack should be hot applied asphalt cement (not emulsion) of the same grade as that determined for the HMA overlay.

Tack coats for fabric application are relatively heavy and should be applied uniformly with a calibrated distributor truck. Insufficient or excessive asphalt tack applied for fabric adhesion can result in overlay failures due to slippage at the fabric interface, especially in areas of high shear forces during periods of hot weather. Excessive tack can cause slippage of the paving machine or subsequently migrate to the pavement surface and appear as flushing in the wheelpaths. Low-viscosity asphalts are more susceptible to this bleeding than higher viscosity materials.

Tack coat should be applied using relatively long shot lengths. Start-stop operations less than a few hundred feet yield highly variable asphalt application rates. Shot lengths equal to fabric roll lengths (about 300 feet) are convenient for some operations. Greater lengths are encouraged provided the freshly sprayed asphalt does not become contaminated with dust or other foreign material. Starting and stopping on paper will reduce the buildup of asphalt at the overlapping sites.

Grids

Grids or mesh products often do not have enough continuous surface area to adhere tenaciously to an asphalt tack coat. Some grids are fastened to the existing pavement by methods other than asphalt tack (e.g., self adhesive or nailing). Therefore, tack may or may not be necessary to fasten a grid to the existing pavement. Generally, one should follow the manufacturer's recommendations for tacking grids. However, keep in mind that the interface between the existing pavement and the new overlay often needs tack to prevent delamination and/or slippage due to vertical and horizontal traffic loads, respectively.

When placing a self-adhesive grid product for use with an overlay on an old pavement surface (i.e., not a new leveling course), a tack coat should be applied on top of the grid (i.e., after grid application) to ensure adequate adhesion at the interface. The appropriate quantity of tack is that normally used without a grid or slightly more. Type of tack should be hot applied asphalt cement (not emulsion) of the same grade as that determined for the HMA overlay. If the grid is placed on a new leveling course, the tack coat may not be necessary.

Composites

Typically, the tack coat selection and application guidelines for fabrics apply to composites.

Membranes
Self-adhesive membranes may or may not require tack coat. If a tack is required, it may be a proprietary product.

Placement of Geosynthetics

An experienced crew using a small tractor rigged for handling geosynthetic rolls should be specified for geosynthetic placement. Such a crew can move much faster than the paving train. To avoid placing traffic on geosynthetic, no more geosynthetic should be placed than can be overlaid the same day. Manual placement should be disallowed except in small areas where equipment may have difficulty maneuvering.

As the geosynthetic is spread onto the asphalt tack coat, it must be aligned and smoothed to remove wrinkles and folds. Some wrinkling of geosynthetics during installation is unavoidable due to curves and undulations in the pavement surface. Folds that result in a triple thickness must be slit with a knife and overlapped in a double thickness. Wrinkles can be a source of premature cracking in the overlay due to compaction without firm support or possibly due to shrinkage (polypropylene products) (Button et al., 1983).

A 4-inch to 6-inch overlap is suggested at all longitudinal and transverse joints. Overlaps should be in the direction of paving to avoid fabric pick-up by sticky tires. It is necessary to apply additional asphalt tack at these locations to ensure proper saturation and bonding. For this purpose, emulsified asphalt can be applied using a hand sprayer, brush, or mop.

Traffic will damage geosynthetics and may cause delamination from the pavement surface prior to overlay placement. Geosynthetics significantly reduce pavement surface friction and can present skidding hazard, particularly during wet weather. Significant traffic should never be allowed on geosynthetics. If trafficking is necessary, speed should be strictly controlled to 25 mph. If significant trafficking is necessary, an alternative to geosynthetics should be considered.

To avoid displacement or damage to geosynthetics while turning construction equipment, turning should be gradual and kept to a minimum. Parking of construction equipment on a completed geosynthetic/asphalt tack interlayer, even for short periods, should be avoided.

Geosynthetics should not be placed during rainfall or when rain is expected. Rainfall before, during, and after placement can result in severe debonding and even loss of the geosynthetic. Geosynthetics can be successfully employed on highly textured surfaces such as freshly milled pavement. Milled surfaces may require additional tack coat; this can be accomplished by pretacking any milled surfaces (e.g., next to curbs). In urban areas subject to high shear forces (e.g., at intersections), a highly textured surface may help decrease the probability of slippage. However, on highly textured surfaces, geosynthetics are more subject to damage by rainfall and traffic.

Fabrics
The bonded or glazed side of a fabric is better to drive on than the fuzzy side (i.e., less damage). The fuzzy side should be placed next to the tack coat. This practice will provide the highest bond strength and best slippage resistance.

When fabric is applied on hot days (>90°F), pavement surface temperatures near 160°F may prevail. These temperatures can be sufficiently high to keep the viscosity of asphalt tack low enough to partially saturate the fabric during placement and fully saturate the fabric in the wheelpaths of construction vehicles. Tires of HMA haul trucks can become coated with asphalt and will often pick up the fabric. The amount of asphalt tack coat should not be reduced to solve this problem. The following corrective measures should be considered:

1. First, allow the tack to cool longer before placing fabric.
2. Alternatively, hand spread a small amount of HMA mix on top of the fabric in the wheelpath of the haul vehicles.
3. Application of sand is the least desirable choice, as sand will absorb some of the asphalt and defeat its purpose. If sand is used, the quantity should be minimized and the grading should be coarse.
4. Change to a "heavier" grade of asphalt cement for the tack coat material.
5. Shorten the distance between fabric placement and the paving machine.
6. Minimize the number of vehicles on the fabric.

Cool weather construction may require the use of a lightweight rubber tired roller to properly attach the fabric to the tack coat. Rolling is preferred over a short shot length to solve the cool weather fabric adhesion problem. Excessive rolling should be avoided.

High winds can be problematic during application of fabrics particularly on a highly textured milled surface. Limited pneumatic rolling of a fabric immediately after application will maximize adhesive strength and minimize its disruption by wind and construction traffic. Pneumatic rolling on a steep grade or cross slope can result in slippage at the pavement fabric interface if the asphalt tack is still hot.

Construction joints in geosynthetics should generally follow the manufacturer's instructions. Additional tack hand-applied on transverse fabric overlaps or applied by distributor on longitudinal overlaps can reduce disruption by wind and construction traffic. Emulsified asphalt is suitable for securing fabric overlaps at construction joints.

Grids and Composites

Placement of grids and composites are generally similar to placement of fabrics. They should be tensioned during placement using a specially equipped tractor or laid flat to maximize their reinforcement effects.

Membranes

Membranes are thicker and heavier than fabrics and grids and are usually placed by hand in strips along pavement joints or cracks.

Placement of HMA Overlay

An HMA overlay can be placed immediately after placement of a geosynthetic using conventional equipment and techniques. No cure time is necessary. The HMA mixture should be no less than 250°F nor greater than 325°F as it exits the paving machine. The minimum temperature is required to obtain adequate density of the overlay and pull the binder up through the fabric. The maximum temperature is required to avoid damage to geosynthetics containing polypropylene. If in-place density specifications are met, typically, heat and rolling will have occurred to achieve fabric saturation.

On hot days, premature saturation of the fabric may occur. Therefore, it may be necessary to broadcast a thin layer of HMA mix in front of the paving machine in the wheelpaths of haul trucks and the paving machine to prevent fabric "pick-up."

If the installed geosynthetic should get wet due to rainfall, the overlay should not be placed until all free water is removed. The fabric surface may be slightly damp but one should not be able to squeegee any free water out of the geosynthetic. If an overlay is placed over excess moisture, the resultant steam will not permit adequate bond of the interlayer system and could lead to overlay problems. (Marienfeld and Baker, 2001)

A minimum compacted overlay thickness of 1.5 inches is desirable as the first lift over a geosynthetic. If the thickness of the overlay is tapered toward the edges, at the thinnest point, it should not be less than 1.5 inches. Thinner overlays will not generate enough heat to draw the asphalt up into the paving fabric to produce a well-bonded interlayer. (Marienfeld and Baker, 2001)

Project Inspection

Table 1 contains a suggested generalized checklist for geosynthetic/overlay placement.

The following items are recommended for comprehensive inspection of geosynthetic interlayers:

- noncontact thermometer,
- geosynthetic knife,
- scale capable of 0.01- to 0.02-gram increments,
- calculator,
- tack coat calculator reference chart,
- test units (for measuring binder rates), and

POTENTIAL CONSTRUCTION PROBLEMS

In hot weather (pavement temperatures >120°F), asphalt tack may bleed through fabrics. Vehicles can splash asphalt onto their painted surfaces. Construction traffic can become sticky and pick up fabric, in severe cases wrapping the fabric around the tires or axles. Bleeding can be exacerbated by excessive pressure applied by the brush on the fabric application tractor.

Incomplete fabric saturation can occur due to insufficient tack application rate, overlay temperature, and/or overlay compaction.

If wet fabric is applied or if fabric is applied on damp pavement, blistering can occur due to vaporization of moisture underneath the asphalt-impregnated fabric. Pavement that has recently received rainfall but has a dry surface can retain enough moisture to cause blistering. If blisters appear, workers should eliminate them by using a lightweight rubber-tired roller before overlaying.

Wrinkles in geosynthetics can occur due to uneven pavement surface, improper alignment during placement, damaged rolls, and/or curves in the roadway.

TABLE 1. Inspection Checklist for Geosynthetic Product Placement.
(Modified after CalTrans, 1981)

Primary Work
1. Sample geosynthetic for quality testing.
2. Store geosynthetic in area protected from sun and water.
3. Determine grade of asphalt to be used for tack coat and obtain a sample.
4. Determine the rate of application of tack coat.

Preparation of Old Pavement
1. Sweep surface clean.
2. Seal cracks larger than 1/8 inch or place leveling course.
3. Fill cracks larger than ½ inch with fine graded asphalt mixture.
4. Repair rough, uneven, or unstable areas, large spalls, and potholes.
5. Place leveling course.

Application of Asphalt Binder
1. Check application rate and temperature of asphalt and obtain a sample.
2. Watch for poor asphalt spread practices such as:
   a) frequent stops and starts
   b) spread overlaps
   c) nonuniform spread
3. Test binder application rate on roadway using preweighed, thin pans.

Geosynthetic Placement
1. Ensure minimal wrinkles or folds in geosynthetic (or bubbles in fabrics).
2. Avoid excessive overlaps in geosynthetic; follow specifications or manufacturer's recommendations.
3. Insure that geosynthetic follows proper alignment.
6. Geosynthetics have different characteristics on each side. Ensure it is placed with the proper side downward.
5. If bleeding of tack coat occurs, broadcast small amount of asphalt concrete (not sand) on geosynthetic in wheelpaths to prevent construction vehicle tires from sticking.

Overlay Placement
1. Discourage lengthy windrows of asphalt concrete.
2. Ensure proper temperature of asphalt concrete behind paving machine.
3. After compaction, displace HMA and expose some geosynthetic to confirm adequate saturation by tack coat (if appropriate).
3. Encourage expeditious, thorough rolling of asphalt concrete overlay.
4. Ensure specified density of overlay.

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