Using Geosynthetics in Overlays to Minimize Reflection Cracking

One of the more serious problems associated with the use of thin overlays is reflective cracking. This phenomenon is commonly defined as the propagation of cracks from the movement of the underlying pavement or base course into and through the new overlay as a result of load-induced and/or temperature-induced stresses.

Some of the latest techniques for reducing the severity and/or delaying the appearance of reflective cracking include incorporating geosynthetic products into the pavement structure. Geosynthetics are defined herein as grids, fabrics, or composites. This procedure is typically accomplished by attaching the geosynthetic to the existing pavement (flexible or rigid) with an asphalt tack coat and then overlaying with a specified thickness of hot mix asphalt (HMA) pavement. These materials have exhibited varying degrees of success, and their use within a particular agency has been based primarily on local experience or a willingness to try a product that appears to have merit.

Several geosynthetic products on the market claim to reduce the severity or delay the appearance of reflective cracking in HMA overlays due to stresses induced by the environment and traffic. The objective of this research was to investigate the state of the art and develop information that will aid in the evaluation of the relative effectiveness of commercially available geosynthetic materials. Specific objectives of this research include:

- Review published and unpublished information, and synthesize the findings.
- Obtain geosynthetic products representing the different categories of materials marketed for reducing reflection cracking in HMA overlays.
- Fabricate HMA beams reinforced with geosynthetic materials, and measure their relative resistance to thermally induced stresses.
- Identify and utilize the best available model to analyze the laboratory data, and...
different geosynthetic products
incorporate geosynthetics for
design process. The program
check with the FPS-19 pavement
computer program as a design
products on HMA cracking.
researchers used fracture mechanics to study
the best mathematical model and
program. Researchers identified
specimens, was used in this testing
accommodates 3x6x20-inch beam
(TTI) overlay tester, which
these products were
and one polypropylene nonwoven
fabric. These products were
synthesized.

What We Did...
An extensive review of
publications was conducted, and
pertinent information regarding
geosynthetic selection, application,
performance, and costs was
synthesized.

Researchers selected six
different geosynthetic products
including two fiberglass grid
composites, two polyester grid
composites, one fiberglass grid,
and one polypropylene nonwoven
fabric. These products were
incorporated into HMA beam
specimens and evaluated in the
laboratory by measuring relative
resistance to thermal cracking.
The Texas Transportation Institute (TTI)
overlay tester, which
accommodates 3x6x20-inch beam
specimens, was used in this testing
program. Researchers identified
the best mathematical model and
used fracture mechanics to study
the effects of various geosynthetic
products on HMA cracking.

Researchers developed a
computer program as a design
check with the FPS-19 pavement
design process. The program
permits evaluation of additional
alternative overlay scenarios that
incorporate geosynthetics for
addressing reflective cracking.

Researchers identified test
directional joints in a
length to minimize construction
and service.

Film thickness around aggregate
particles and decreases the
durability of the mixture. The
mixture for this investigation
was sampled at a production
plant and stored in metal
containers. Re-heating of the
mixture for beam fabrication
was necessary, which of course
caused further oxidation of these
thin films. These findings are
considered the major causes for
the relatively low number of
cycles to failure recorded
during this investigation.

The remainder of the quality
assurance tests were within
acceptable ranges of the JMF.

Control beams were fabricated
with and without an asphalt tack
coat (0.05 gal/yard²) between the
overlay and level-up course.
Laboratory results indicate that
a thin tack coat significantly
increased the number of load
cycles to failure. Therefore, in
typical overlay construction, the
simple addition of a thin asphalt
cement tack coat appears to
increase the cracking resistance of
the overlay.

Plots of measured load versus
pseudo displacements were produced
to determine the rate of
change of dissipated pseudo
strain energy (or pseudo work)
per unit area of crack growth,
defined as the pseudo J-Integral.

By considering the effects of
the geosynthetic products
on the loading and unloading
paths of the HMA specimens, a
new geosynthetic rating factor,
termed reinforcing factor, was
developed.

Limited laboratory testing
indicated that the use of
emulsified asphalt as a tack coat
for geosynthetics produced a
plane of weak shear, which could
promote slippage during overlay
design and construction.

The Researchers Recommend...
The following recommendations are
based on the information
obtained from this investigation:

• Guidelines for selection and
use of geosynthetics with HMA
overlays on flexible, rigid, and
composite pavements to reduce
reflection cracking have been
prepared as part of this research
project. Researchers recommend
that these guidelines be printed
as a separate document for
use by pavement designers,
inspectors, and contractor
personnel.

• A computer program was
developed as a design check for
FPS-19. This design
check should be used with
alternative overlay scenarios
when geosynthetics are being
considered for addressing
reflection cracking.

• Emulsified asphalt should not
normally be used as tack
for geosynthetics installed to address
reflection cracking in HMA
overlays. If emulsion is used,
sufficient time should be allotted
for breaking before application
of geosynthetics and curing
before application of the new
overlay.

• When placing a self-adhesive
fiberglass grid to address
reflective cracking in an HMA
overlay, a tack coat should be
applied on top of the grid (i.e.,
after grid application). The
appropriate quantity of tack is
that normally used without a
grid. Type of tack should be
hot applied asphalt cement (not
emulsion) of the same grade
as that determined in the HMA
overlay.

• When ordering geosynthetics,
the contractor should specify
the desired roller width and
length to minimize construction
joints and maximize efficiency.
Longitudinal joints in a
wheelpath should be avoided.
The contractor should also
consider the maximum roll
weight that his application
equipment can handle.

• Placing a ¾-inch to 1-inch
level-up course on the existing
cracking on flexible, rigid, and
composite pavements to reduce
reflection cracking can significantly add to the
performance of geosynthetics in
delaying reflection cracking.

• Regarding DMS-6220, Fabric
For Underseals, asphalt
retention should be at least 0.2
to 0.3 gallons/yard²; retention 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/yard². It
is recommended that TxDOT
follow AASHTO M 288 and
specify a paving fabric with a
101-pound tensile strength
and 4.1-ounce/yard² minimum
unit weight. The small cost
differential will probably not
affect the bid price for installed
paving fabric.

• Specific recommendations are
given regarding Item 356, Fabric
Underseal; Item 3203, Geogrid-
Fabric Composite for Pavements;
Item 3126, Reinforcement Mesh
for Joint Repair; and Item 3031,
Fabric Joint Underseal. These
recommendations address:
(1) requiring a geosynthetic
manufacturer’s representative
on site during the first three
days of construction, (2) filling
cracks exceeding 1/8 inch in
width, (3) repairing faulted
joints/cracks, (4) proper storage
of geosynthetic rolls, (5) suitable
construction joint overlaps
in geosynthetic products,
(6) appropriate temperature of
asphalt tack material, (7) ideal
blotting material in the event of
excessive bleeding of asphalt
tack through the geosynthetic,
(8) controlling traffic on
geosynthetic products, and
(9) treatment of damaged areas
of geosynthetics.

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determine the material properties that have the greatest effect on overlay performance.

- Plan and construct test pavements to evaluate relative resistance to reflective cracking of various geosynthetics.
- Determine the relative effectiveness of each category of geosynthetic products in reducing reflective cracking.

What We Did...

An extensive review of publications was conducted, and pertinent information regarding geosynthetic selection, application, performance, and costs was synthesized.

Researchers selected six different geosynthetic products including two fiberglass grid composites, two polyester grid composites, one fiberglass grid, and one polypropylene nonwoven fabric. These products were incorporated into HMA beam specimens and evaluated in the laboratory by measuring relative resistance to thermal cracking. The Texas Transportation Institute (TTI) overlay tester, which accommodates 3x6x20-inch beam specimens, was used in this testing program. Researchers identified the best mathematical model and used fracture mechanics to study the effects of various geosynthetic products on HMA cracking.

Researchers developed a computer program as a design check with the FPS-19 pavement design process. The program permits evaluation of additional alternative overlay scenarios that incorporate geosynthetics for addressing reflective cracking. Researchers identified test pavement locations in Pharr, Waco, and Amarillo Districts for evaluation of geosynthetic products. Due to unavoidable construction delays, only the Pharr District test pavements were constructed during the initial phase of the study. All three of the test pavements will be constructed, and relative performance, particularly related to reflective cracking, will be evaluated for several years.

Researchers prepared field guidelines for selection and use of geosynthetics with HMA overlays on flexible, rigid, and composite pavements to reduce reflection cracking. The Texas Department of Transportation’s (TxDOT) geosynthetic-related specifications were studied, and modifications were recommended to improve them.

What We Found...

Based on the findings of this study, the following conclusions appear warranted:

- Performance of geosynthetics in addressing reflection cracking in HMA overlays has ranged from great successes to disastrous failures. Generally, the cost-effectiveness of geosynthetics in reducing reflection cracking is marginal.
- The geosynthetics tested in the laboratory consistently increased the number of cycles to failure in the overlay tester.
- Quality assurance tests were performed on selected beams and compared to the TxDOT job-formula (JMF).

Extraction revealed asphalt contents between 4.1 percent and 4.6 percent as compared to the optimum asphalt content of 5 percent. Insufficient asphalt cement produces inadequate film thickness around aggregate particles and decreases the durability of the mixture. The mixture for this investigation was sampled at a production plant and stored in metal containers. Re-heating of the mixture for beam fabrication was necessary, which of course caused further oxidation of these thin films. These findings are considered the major causes for the relatively low number of cycles to failure recorded during this investigation. The remainder of the quality assurance tests were within acceptable ranges of the JMF.
- Control beams were fabricated with and without an asphalt tack coat (0.05 gal/yd²) between the overlay and level-up course. Laboratory results indicate that a thin tack coat significantly increased the number of load cycles to failure. Therefore, in typical overlay construction, the simple addition of a thin asphalt cement tack coat appears to increase the cracking resistance of the overlay.
- Plots of measured load versus pseudo displacements were produced to determine the rate of change of dissipated pseudo strain energy (or pseudo work) per unit area of crack growth, defined as the pseudo J-Integral. By considering the effects of the geosynthetic products on the loading and unloading paths of the HMA specimens, a new geosynthetic rating factor, termed reinforcing factor, was developed.
- Limited laboratory testing indicated that the use of emulsified asphalt as a tack coat for geosynthetics produced a plane of weak shear, which could promote slippage during overlay construction and service.

The Researchers Recommend...

The following recommendations are based on the information gained from this investigation:
- Guidelines for selection and use of geosynthetics with HMA overlays on flexible, rigid, and composite pavements to reduce reflection cracking have been prepared as part of this research project. Researchers recommend that these guidelines be printed as a separate document for use by pavement designers, inspectors, and contractor personnel.
- A computer program was developed as a design check for FPS-19. This design check should be used with alternative overlay scenarios when geosynthetics are being considered for addressing reflection cracking.
- Emulsified asphalt should not normally be used as tack for geosynthetics installed to address cracking in HMA overlays. If emulsion is used, sufficient time should be allotted for breaking before application of geosynthetics and curing before application of the new overlay.
- When placing a self-adhesive fiberglass grid to address reflective cracking in an HMA overlay, a tack coat should be applied on top of the grid (i.e., after grid application). The appropriate quantity of tack is that normally used without a grid. Type of tack should be hot applied asphalt cement (not emulsion) of the same grade as that determined in the HMA overlay.
- When ordering geosynthetics, the contractor should specify the desired roll width and length to minimize construction joints and maximize efficiency. Longitudinal joints in a wheelpath should be avoided. The contractor should also consider the maximum roll weight that his application equipment can handle.
- Placing a ¾-inch to 1-inch level-up course on the existing pavement surface before the installation of the geosynthetic material will provide optimum reduction in reflection cracking. Both theory and practice indicate that a leveling course can significantly add to the performance of geosynthetics in delaying reflection cracking.
- Regarding DMS-6220, Fabric for Underseals, asphalt retention should be at least 0.2 to 0.3 gallons/yd²; retention 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/yd². It is recommended that TxDOT follow AASHTO M 288 and specify a paving fabric with a 101-pound tensile strength and 4.1-ounce/yd² minimum unit weight. The small cost differential will probably not affect the bid price for installed paving fabric.
- Specific recommendations are given regarding Item 356, Fabric Underseal; Item 3203, Geogrid-Fabric Composite for Pavements; Item 3126, Reinforcement Mesh for Joint Repair; and Item 3031, Fabric Joint Underseal. These recommendations address: (1) requiring a geosynthetic manufacturer’s representative on site during the first three days of construction, (2) filling cracks exceeding 1/8 inch in width, (3) repairing faulted joints/cracks, (4) proper storage of geosynthetic rolls, (5) suitable construction joint overlaps in geosynthetic products, (6) appropriate temperature of asphalt tack material, (7) ideal blotting material in the event of excessive bleeding of asphalt tack through the geosynthetic, (8) controlling traffic on geosynthetic products, and (9) treatment of damaged areas of geosynthetics.
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