ENGINEERING BULLETIN

EB124 - BENEFITS OF NONWOVEN GEOTEXTILES AS AN INTERLAYER FOR UNBONDED CONCRETE OVERLAYS

INTRODUCTION

This Engineering Bulletin is a summary of a more detailed paper prepared by The Transtec Group.1 The original paper, which contains a compilation of research and references related to the use of nonwoven geotextiles as interlayers in unbonded concrete overlays may be obtained from Propex Operating Company, LLC.

The following research was performed in order to better understand and evaluate the use of nonwoven geotextiles as interlayers between existing jointed plain concrete pavement (JPCP) and a JPCP unbonded overlay (UBOL). Three test sections were constructed and analyzed, comparing the use of a conventional hot mix asphalt (HMA) interlayer, a black nonwoven geotextile interlayer, and ReflectexTM Heat Reflective Concrete Pavement Interlayer geotextile. Each test section was instrumented with temperature sensors throughout the pavement section and displacement gauges on the joints in order to determine crack patterns, joint movement, and to monitor the temperature of the pavement. During the installation of the pavement sections the ambient temperature was anywhere between 30 and 70 degrees Fahrenheit. In order to account for all installation situations, simulations were run with hot-weather conditions using the Federal Highway Administration (FHWA) HIPERPAV software.

PROJECT INFORMATION

The JPCP UBOL was constructed on the westbound lanes of US 12, near Aberdeen, South Dakota for South Dakota Department of Transportation (DOT). The 25-30 year old existing pavement was generally in good condition with some minor faulting. Below the existing pavement was a 4" "lime-treated gravel cushion" atop a subgrade consisting of soils described by the South Dakota DOT as Sandy-Clay. The JPCP UBOL was to be 8" thick with perpendicular joints spaced at 15' with dowel bars for load transfer.

The construction consisted of placing concrete covering two lanes, 26' across, of traffic at once. Prior to concrete placement, the geotextile was laid out for several hundred feet. During construction, haul trucks would back up to the paving equipment driving directly on the geotextile (Figure 1). The concrete would be transferred from the haul truck to paving train, which included an "Iowa Special", spreader, paver, work bridge, and cure cart. The Iowa Special would transfer the concrete by conveyer belt and dump it in front of the spreader, while crews would work beneath the Iowa Special to place dowel baskets and tie bar baskets (Figure 2). The spreader would then evenly distribute the concrete across the two lanes and over the baskets. Once the concrete was distributed the paver would then slip-form and vibrate the concrete. The work bridge would then pass over the concrete around 20-30 minutes after the paver and apply a drag texture, followed by the cure cart applying 1/8" deep, longitudinal lines and white curing compound. The perpendicular joints were cut every 15' about 8-10 hours after placement. During construction, the South Dakota DOT would obtain concrete samples every 2 hours to complete quality control testing, such as slump, unit weight, air content, and concrete temperature.

Figure 1 - Haul Trucks Unloading Concrete across Reflectex

Figure 2 - Iowa Special

The focus of the research was on approximately 345 linear feet (LF) of the pavement. This section included 150 LF of black nonwoven geotextile as a bond-breaking interlayer, 41 LF of HMA as a bond-breaking interlayer, and 150 LF of Reflectex as a bond-breaking interlayer.

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INSTRUMENTATION AND DATA COLLECTION

Each of the three test sections were instrumented to monitor temperature within the new concrete, at the surface of the existing concrete or HMA, and within the existing base, and to monitor movement at the joints.

COMMAND Center sensors were utilized at two locations within each section to measure and log temperature. At each of the two locations, Command Center sensors were embedded in the existing concrete, secured at the surface of the existing concrete or HMA, and positioned at various depths within the new concrete pavement, taking temperature measurements every 5 minutes (Figure 3). Demountable Mechanical (DEMEC) strain gauges were utilized on 13 consecutive joints in order to measure joint movement (Figure 4). RocTest displacement gauges were also utilized, but because of embedment issues the results were not accurate. Data from the temperature sensors, strain gauges, and the displacement gauges were monitored and collected regularly throughout the following 6 weeks after the field work was completed.

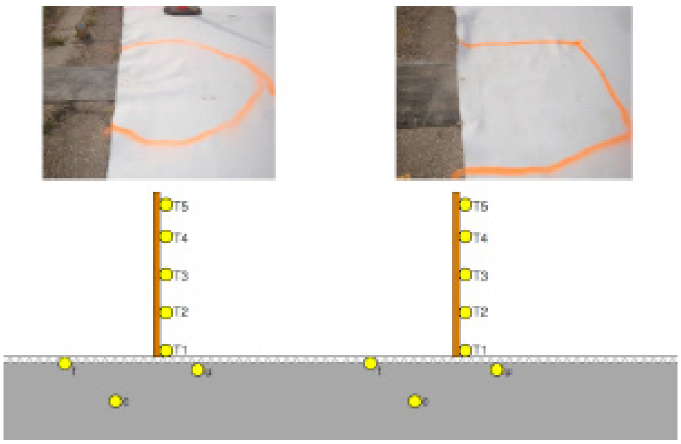

Figure 3 - Sensor Locationsv

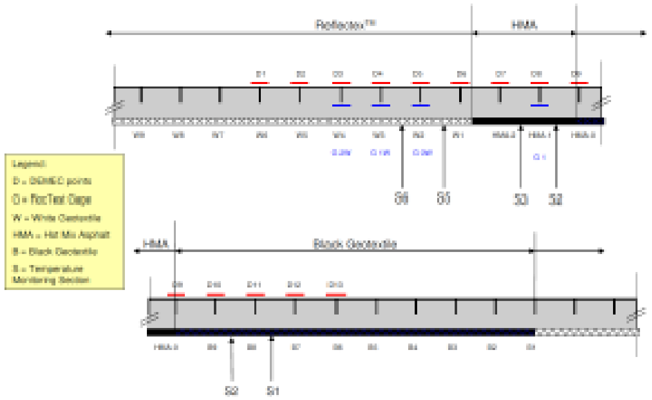

Figure 4 - Schematic of Test Section

In addition to the field monitoring, 20 concrete cylinders were cast in the field on the day before the test sections were constructed. Each cylinder was 6" in diameter and 12" long. Once cast, the cylinders remained on site for 24 hours and were then transported to the Office of Materials at the South Dakota DOT where they were stored in a lime treated water bath. Two cylinders were broken in compression after 24, 48, and 72 hours of curing as well as after 7, 14, and 28 days of curing. A total of 6 cores, two from each test section, were also taken by the South Dakota DOT from the site within 2 weeks after placement in order to observe the bond between all three layers.

ANALYSIS

Once collected, the data was then analyzed to determine crack patterns, calculate joint movement, and evaluate temperatures within the concrete pavement structure.

When looking at the first three days after placement it was seen that after the first day no cracks had occurred in the HMA section, one crack had occurred out of the nine joints in the Reflectex section, and two cracks had occurred out of the nine joints in the section with the black nonwoven geotextile. After the second day, two cracks had occurred out of the three joints in the HMA section, six cracks had occurred out of the nine joints in the section with the black nonwoven geotextile, while still only one crack had occurred out of the nine joints in the Reflectex section. After the third day, all three joints had cracked in the HMA section, seven of nine joints had cracked in the black nonwoven geotextile section, and still only one of nine joints had cracked in the Reflectex section. The cracking frequency analysis concluded that more cracks occurred under transverse contraction joints over the black nonwoven geotextile and HMA sections than over the Reflectex section.

Volumetric changes in the concrete are a result of temperature and moisture changes during early stages of the concrete curing process. When these volumetric changes occur and the concrete is restrained as a result of friction, adhesion, and/ or interlock with the interlayer, stresses occur within the concrete. When the stresses exceed that of the concrete's strength the concrete will crack. Joints act to provide a weakened plane where a crack can easily form and relieve the stress built up within the concrete. If the changes in temperature and moisture can be lessened and the occurrence of friction, adhesion, and interlock with the interlayer mitigated, then the stresses within the concrete can be minimized, reducing the possibility of cracking. It can be concluded that the minimal number of cracks under the transverse contraction joints in the Reflectex section is most likely due to the difference in temperatures provided by the reflectivity of Reflectex and the difference in restraint when compared to the black nonwoven geotextile and HMA sections.

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Joint movement was monitored by obtaining measurements from both DMEC strain gauges and RocTest displacement gauges. While multiple gauges were utilized it was determined that in order to rigorously compare any difference in movements at joints in Portland Cement Concrete (PCC) over HMA verses PCC over a nonwoven interlayer, a larger test section would be required. However, in 2007 the FHWA reported on work conducted in North Dakota on determining the restraint conditions of nonwoven geotextiles, and in 2001 Transtec reported typical restraint values for HMA. When published values are compared its shows that PCC stresses are 3.5 to 7.0 times less when placed on a nonwoven geotextile interlayer as opposed to an HMA interlayer. This is because less restraint is expected in PCC over a nonwoven geotextile interlayer than in PCC over an HMA interlayer, resulting in lower early-age stresses and a reduced risk for mid-slab cracking.

Temperature was monitored and recorded from COMMAND Center sensors at regular intervals, both within the existing pavement layer as well as within the JPCP UBOL. It was found that the temperature of the existing pavement during installation was affected by the interlayer type, showing a lower temperature under the Reflectex section than both the HMA section and the section with the black nonwoven geotextile. This lower temperature under the Reflectex section is most likely due to its high reflectivity. While the benefits of temperature need to be considered, it should be noted that the benefit of restraint conditions provided by nonwoven geotextile interlayers is crucial for JPCP UBOL.

In order to account for hot-weather conditions, simulations were run using the FHWA HIPERPAV software using the data collected from the test sections. In order to calibrate HIPERPAV the temperature data from the COMMAND Center sensors, ambient weather data collected from the airport, concrete maturity data calculated from lab cylinder compressive strengths, and other project specific design and construction information was used in order to accurately predict stress development and stress gain in the JPCP UBOL.

The first HIPERPAV analysis, using inputs representing the installation near Aberdeen, South Dakota, showed that there was no significant difference between the strength gain in the JPCP UBOL over the Reflectex section, the HMA section, or the section using black nonwoven geotextile. However, when comparing stress-to-strength ratios it was found that while there was no significant difference between the Reflectex section and the section using the black nonwoven geotextile, there was a higher critical stress in the JPCP UBOL over the HMA section. HIPERPAV predicted the maximum critical stresses in the JPCP UBOL over the HMA section to be 4.0% greater than the Reflectex section and 4.5% greater than the section using the black nonwoven geotextile (Figure 5). This shows that while both Reflectex and the black nonwoven geotextile reduce the stress in the JPCP UBOL, cool climate installations of a JPCP UBOL merits the use of a black nonwoven geotextile interlayer.

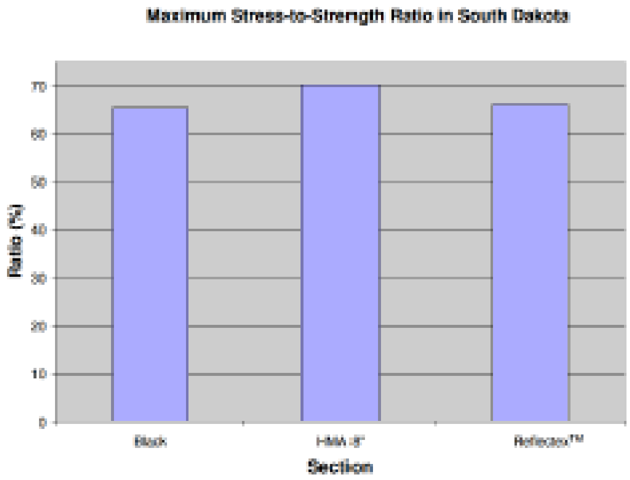

Figure 5 - Stress-to-Strength Ratios in South Dakota

The second HIPERPAV analysis, using inputs representing an installation in Texas during the summer, demonstrated similar results showing that there was no significant difference between the strength gain in the JPCP UBOL over the Reflectex section, the HMA section, or the section using black nonwoven geotextile. The performance benefit was again seen when the stress-to-strength ratios were compared. HIPERPAV predicted the maximum critical stresses in the JPCP UBOL over the HMA section to be to 10.0% greater than the Reflectex section and 7.0% greater than the section using the black nonwoven geotextile (Figure 6). This shows the benefit of Reflectex as an interlayer for a JPCP UBOL during hot climate installations.

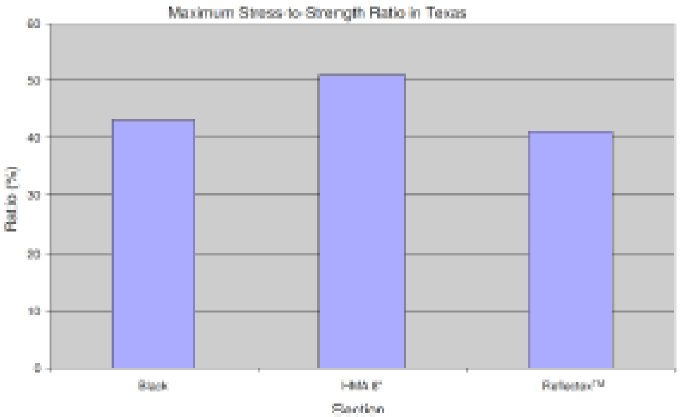

Figure 5 - Stress-to-Strength Ratios in South Dakota

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SUMMARY

The research presented showed the benefit of both Reflectex Heat Reflective Concrete Pavement Interlayer geotextile and the black nonwoven interlayer geotextile as interlayers for JPCP UBOL. Temperature sensors within the existing pavement showed that less heat was absorbed and retained by the pavement layers beneath Reflectex, and that the pavement layers beneath the black nonwoven geotextile absorbed and retained more heat than even the pavement layers beneath HMA. In addition, the use of a nonwoven geotextile as an interlayer for a JPCP UBOL reduces the restraint seen by the PCC when compared to an HMA interlayer, resulting in lower early-age stresses and a reduced risk of mid-slab cracking. With this information the FHWA HIPERPAV software showed that in cool climate installations the use of Reflectex or the black nonwoven geotextile as an interlayer in a JPCP UBOL reduce the early-age critical stress of the PCC when compared to HMA by 4.0% and 4.5% respectively. The FHWA HIPERPAV software further showed that in hot climate installations the use of Reflectex or the black nonwoven geotextile as an interlayer in a JPCP UBOL reduce the early-age critical stress of the PCC when compared to HMA by 10.0% and 7.0% respectively.

References

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