H₂Ri Wicking Fabric Experimental Feature Final Report
Dalton Highway MP 197-209 Rehabilitation
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1.0 Introduction

This report presents data and construction observations from the Dalton Highway MP 197-209 Rehabilitation Project regarding the Experimental Features In Construction use of a proprietary geotextile with unique hydraulic properties. H2Ri™ (wicking fabric) was designed and produced by Tencate Mirafi® at the suggestion of DOT&PF, specifically to address drainage issues common in Alaska.

The wicking fabric includes synthetic fibers with micro-channels engineered to maximize capillary action and capable of transporting moisture to the edge of the fabric. The wicking fibers are woven into a high strength, high modulus fabric that combines high permeability under both saturated and unsaturated conditions, separation and strength with directional water movement properties. Laboratory and field testing indicated that wicking geotextile would repair soft spots in Alaskan highways caused by groundwater migration into the pavement structure.

2.0 Background/History

The Dalton Highway 197-209 Rehabilitation Project (hereafter 197-209 project) was the second phase of a two-phase parent project, Dalton Highway MP 175-209 Rehabilitation. During construction of the first phase, Dalton Highway MP 175-197 Rehabilitation, sections of the existing road were so soft that work could not be performed according to the As-Advertised Plans. A change-order added a “shot-rock” and geotextile mitigation design to repair the soft spots. This change order cost $2.168M for 7,800 linear feet of road requiring treatment, a unit cost of $278 per linear foot.

During development of the 197-209 project, 27,100 linear feet of existing road with similar soft spots were identified by DOT&PF Maintenance & Operations (M&O) personnel. The preliminary design included a “shot-rock” and geotextile treatment for these locations similar to that used in the 175-197 project. The engineer estimated a cost of $3.8M, a unit cost of $140 per linear foot.

At the same time 197-209 project was being designed, Northern Region DOT&PF, in partnership with the Alaska University Transportation Center (AUTC) and Tencate Mirafi®, was field testing the prototype wicking fabric in a test section at Milepost 110 of the Dalton Highway. Both field observations and buried instrumentation indicated that it was performing as advertised and had corrected a perennial problem for M&O. Lab testing by AUTC corroborated the moisture-moving properties of the material.

When the 197-209 project went through a Value Engineering Study, the wicking fabric was proposed as a cost-saving alternative to the proposed “shot-rock” and geotextile treatment. In addition to reducing the project cost, the use of a single layer of wicking geotextile simplified construction, as the “shot-rock” and geotextile design required subexcavation, which was problematic on the 175-197 project from a traffic control standpoint. The wicking fabric was incorporated into the project as a pay item under the Experimental Features In Construction program. See “Work Plan”.

The low bid Contractor bid a total price for the wicking fabric pay item of $1.247M. In the second year of construction, a change order for $44K was issued to re-expose the wicking fabric edges that had become covered by surface course aggregate during winter grading. This resulted in a total unit cost of $48 per lineal foot, 34% of the estimated cost of the original design and 17% of the actual cost of soft spot repairs on the 175-197 project.
3.0 Construction

Installation of the wicking fabric began on August 16, 2012. Preparation of the embankment and placement of the wicking fabric was similar to conventional geotextile installation, with a few exceptions. As the wicking fibers are oriented in the cross-machine direction, it is critical that the wicking fabric be installed parallel to centerline, with the outside edges exposed, but higher than any potential standing water. Transfer of moisture between adjacent strips relies on overlapping fabric-to-fabric contact, so it is critical that the overlaps remain clean during installation. Although Tencate Mirafi® did not require it, the Plan specifications prohibited the use of heat in the process of cutting rolls, the concern being that “cauterizing” the ends of the wicking fibers might reduce their capillary performance. As in any reinforcing geotextile installation, the fabric needs to be pulled taught and wrinkles minimized to achieve maximum performance.

First day of installation

Per the specifications, a manufacturer’s representative was required to be on site for the duration of the wicking geotextile installation. This was in addition to the DOT&PF inspectors that are on grade, but not necessarily dedicated to the geotextile installation full time. The manufacturer’s representative ensured that geotextile placement was performed according to specifications, and provided technical input when
variations from specifications were requested. The specifications for Geotextile, Wicking included the language “...in accordance with the details shown on the plans and manufacturers (sic) recommendations.”

Constructability issues are described in detail in “Post Construction Evaluation” and summarized here:

- Consider placing geotextile lower in the embankment. Shallow cover resulted in trafficability and maintenance issues.
- Geotextile roll width was not optimum for full width of geotextile placement, requiring cutting rolls.
- Limit speed of vehicles operating directly on geotextile. Speeds above 10 mph created wrinkles.
- Fabric should be continuous at culvert locations. Require culverts to be installed prior to geotextile installation. Limit additional seams.

The first issue is one of design. From both the trafficability and geotechnical perspective, placing the geotextile “deeper” would have been preferable. However, it is critical that the wicking geotextile be placed high enough that the edges cannot come into contact with standing water in the ditch and the
geometry (and wetlands footprint) had already been established when the fabric was added to the project. Therefore, the project geometry dictated the “shallower” than optimum placement.

The remaining issues are specifications related. As a practice, DOT&PF plans and specifications do not typically specify “means and methods”, such as sequence of construction or width of products. Rather, they specify performance (i.e., desired result) and the Contractor selects the methods to achieve them.

The specifications did not require 15 foot wide rolls of wicking fabric. At the time of design, H₂Ri™ was still in initial production and the project designer was unaware that different width rolls were even available. Had the Contractor purchased 17 foot wide rolls they may not have had to cut rolls to meet the design placement width. Using wider rolls might also have reduced the number of overlap seams.

The specifications prohibited operating vehicles directly on the geotextile itself; that requirement was waived by the manufacturer’s representative. Any limitation on operating speeds should have been addressed under the terms of that requirement change.

The Contractor elected to install a number of culverts after the wicking geotextile had been installed. This was an unanticipated construction sequence that resulted in many additional seams and joints in the wicking fabric installation. Although it will dictate “means and methods”, future installations should require culvert installation prior to geotextile placement.

Half-width roll/overlap seam preparation
4.0 Post-Construction Performance and Monitoring

The wicking fabric was installed in August and September of 2012. The 197-209 project was paved during the summer of 2013. M&O personnel reported good performance from the pavement between 2013 and summer 2015. Mark Sikkema, from Tencate Mirafi®, made site inspections and took the photograph below which illustrates how effectively the wicking fabric intercepts and moves groundwater out of the embankment. The sharp contrast between wet and dry surface coincides with the edge of the wicking fabric.

![Embarkment with H2Ri™ at wet/dry transition, 2013 (photo Mark Sikkema, Tencate Mirafi®)](image)

A site inspection for the purposes of the Experimental Features In Construction monitoring was performed July 28, 2015 by Jeff Currey (report author), with DOT&PF Construction and FHWA personnel in attendance. The pavement looked very good, and the ride through the project was smooth. There were no apparent dips, settlement or distress. M&O personnel confirmed that description was still accurate in December. Notable quotes include “…to this point, I believe that it has been a success.” (Bill Bunch, 12-17-15) and “I would concur…and believe it did what they said it would.” (Jeff Russell, 12-17-15).
A sample of the wicking fabric was exhumed and collected for electron microscopy, to evaluate whether the wicking fiber micro-channels were becoming “blinded” by fine materials. As illustrated below, the soil above the fabric was dry, while the soil below was moist, indicating the fabric is still effective in keeping the upper portion of the embankment dry. This has been observed whenever the edge of wicking fabric has been inspected in the field, both on the 197-209 project and at the Dalton Highway MP 110 test site.

The following photo is an electron microscopy image of a similar sample exhumed five years after installation at the original Dalton Highway MP 110 (Beaver Slide) test site, where the H2Ri™ prototype geotextile was first field tested. The Dalton 197-209 project electron microscopy results were similar, but showed less clogging. (Xiong Zhang. Pers. Comm.)
Electron Microscopy of Wicking Fabric, exhumed from Dalton Highway MP 110 Test Site 5 years after installation—Note clogging of outer fibers, but relatively unclogged inner fibers. Courtesy X. Zhang, AUTC.
A Final site inspection for the purposes of the Experimental Features In Construction monitoring was performed August 2, 2016 by Jeff Currey (report author), with DOT&PF Construction and FHWA personnel in attendance. The pavement looked good, although thermal cracking was more prevalent than in 2015 (this is not a function of wicking fabric performance) and notably more prevalent than in the adjacent MP 179-197 section, despite both projects using polymer-modified PG 52-40 grade asphalt cement. The ride through the project was smooth. There were no apparent dips, settlement or distress. M&O personnel confirmed that description was still accurate in December.

5.0 Conclusions

The H2Ri™ Wicking Fabric Experimental Features In Construction was successful. The use of wicking fabric as a substitute for the proposed “shot rock” and geotextile soft spot detail reduced the cost of the 197-209 project by $2.5 million, based on the Engineer’s Estimate. On a linear basis, the wicking fabric cost 34% of the Engineer’s Estimate cost of the “shot rock” treatment, and 17% of the actual cost for comparable “shot-rock” treatment on the adjacent 179-197 project.

Using geotextile instead of the “shot rock” design eliminated the need to subexcavate in areas with relatively thin embankment over problematic foundations. Subexcavation would have complicated traffic control, taken longer, and could have resulted in significant change orders, based on the experience of the adjacent 179-197 project. Therefore, the cost-savings may have been even greater than estimated. The performance of the wicking fabric sections is at least as good as that of the “shot rock” sections in the 179-197 project, used as control. At this point, the 197-209 project pavement profile is in better condition than the 179-197 project, but has experienced worse thermal cracking, even though it is two years younger. Both projects are in better condition for their age than many people expected, given the foundation conditions in the area.

While the emphasis of this Experimental Feature was the wicking properties of H2Ri™ geotextile, it is important to note that it is an extremely strong, high modulus geotextile irrespective of its hydraulic properties. This high strength and high modulus offers significant geotechnical benefits where the lower embankment and subgrade are marginal. The reinforcement benefits probably act in concert with the hydraulic benefits to generate the results observed at the 197-209 project.

H2Ri™ wicking fabric can be a cost-effective alternative to other designs where moisture in the embankment is a problem, but it is not a “silver bullet” solution for every application. Wicking fabric relies on a humidity gradient between the embankment moisture and the atmospheric conditions, so it may perform poorly in extremely wet environments. The fabric edge details need to be designed to ensure they maximize capillary draw out of the embankment and that there is no chance for prolonged exposure to standing water. If the outside edge of the fabric is at a higher humidity (i.e., wet) than the embankment itself, the wicking fabric will theoretically draw moisture back into the embankment.

H2Ri™ wicking fabric has been demonstrated substantially more cost effective than the other designs for the 175-197 and 197-209 projects, but it is not “cheap”. The 197-209 project Contractor’s installed bid price was nominally $9.70 per square yard, the majority of which was the purchase price of the wicking fabric itself. Future bids may be somewhat lower, as the cost of the fabric has come down with increased production and market share, but it is still significantly more expensive than similar strength geotextiles. Tencate Mirafi® manufactures a reinforcement geotextile, RS580™, with virtually identical
strength and modulus properties as the H₂Ri™ wicking fabric but with no wicking properties, at a somewhat lower cost. If neither wicking nor a very high modulus is required, there are several manufacturers that produce similar strength geotextiles at substantially lower cost than H₂Ri™.

6.0 Post-Experimental Feature Work

NR DOT&PF, AUTC and Tencate partnered to perform additional laboratory testing of H₂Ri™ wicking fabric through summer of 2016. A 73 foot-long flume was constructed in DOT&PF’s Maintenance & Operations Warm Vehicle Storage building to evaluate the performance of much wider applications of H₂Ri™ wicking fabric. The intent was determining its effectiveness on wide road sections and airport applications. The testing confirmed that H₂Ri™ could transport moisture by capillary action over 73+ foot lengths, making it viable for nominally 150’ wide installations at rural airports in which both edges are exposed. However, the data also indicated that the moisture transmission was substantially less effective at the fabric overlaps, where moisture has to transfer from one layer of fabric to the adjacent layer. This observation indicates that even more attention needs to be paid to the overlap joints, and suggests that future research on improving joint transmissivity may be warranted.

This research project tested three types of soils: clean sands, organic-rich silt and E-1 Surface Course Aggregate. The testing demonstrated that the wicking fibers became clogged when exposed directly to organic rich silts, dramatically reducing the wicking effectiveness. No appreciably clogging was observed in the sand and E-1 testing. As a result, DOT&PF now knows to specify wicking fabric placement between relatively low fines sands or aggregate and to avoid direct placement against silt, clay or organics.

During the 2016 construction season, the Milepost 196 Parks Highway Broad Pass Railroad Overcrossing project encountered difficulty working with moisture-sensitive borrow, which was exacerbated by the anomalously heavy and frequent rains that summer. H₂Ri™ wicking fabric was added to the problematic embankment sections by Change Order, utilizing specifications combining lessons learned from the Dalton 197-209 Experimental Feature and draft specification from the additional AUTC/DOT&PF research described above. Adding the H₂Ri™ wicking fabric to the project corrected the borrow workability problem and was considered an overwhelming success by the Contractor and the DOT&PF Construction team. H₂Ri™ wicking fabric is now considered a validated “tool in the toolbox” for dealing with moisture problems in NR Highway and Aviation projects, with specifications tailored to specific applications.
7.0 Comments and Recommendations

DOT&PF has learned a few things through this Experimental Feature In Construction, and through additional research performed by AUTC prior to and during the Experimental Feature process. Consider the following recommendations and observations when considering the use of wicking fabric:

- Do not specify wicking fabric without consulting personnel knowledgeable in its application and design. There are climatic and design scenarios in which it may be ineffective or even harmful.
- Incorporate wicking fabric into the design before road geometry is “locked in” if possible. The fabric needs to be high enough to ensure it stays out of any standing water, but low enough to provide hydraulic benefits to a relatively thick layer above it. A minor grade raise may substantially increase the fabric’s effectiveness and enhance constructability. Alternatively, edge drains that keep the wicking fabric edges dry may be possible for urban projects, but would need to be carefully engineered. Optimized design of wicking fabric could have environmental and/or Right-Of-Way impacts.
- Avoid placing wicking fabric in direct contact with very silty or clay-bearing soils. Continued research indicates there is potential for the micro-channels in the wicking fibers to become “choked off” by fine grains of soil over time, depending on the material in contact with the
fabric. This clogging resulted in a dramatic reduction in effectiveness in laboratory testing. Ideally, materials on both surfaces of the wicking fabric would have less than 6% passing the 200 mesh screen.

- Require the presence of the manufacturer’s representative at all times during wicking fabric installation. This ensures continuous monitoring of the installation and facilitates field adjustments by having someone knowledgeable about the product and the specific project with a vested interest in its successful application on site. Include details in the specifications on how the representative’s presence will be paid for, including meals & lodging, transportation, etc.
- Design multi-season paving projects so that if an unpaved surface has traffic for an extended period after the wicking fabric is installed, include contractual language to pay to re-expose the fabric edges. The exposed edges of wicking fabric tend to become buried by maintenance grading operations on unpaved roads. This has not prevented the fabric from continuing to function to date, but it is undesirable and is expected to reduce effectiveness.
- Prohibit operation directly on fabric and specify a minimum cover of 8” (or more) before allowing vehicles. Operating metal track-mounted equipment directly on the wicking fabric can easily damage it, and operating any equipment directly on the fabric is undesirable. Any variation from this can be addressed in the field on a case-by-case basis, under consultation with the manufacturer’s representative.
- If culverts are being installed in areas with wicking fabric, require they be installed first, so that wicking fabric can be installed in continuous sections with a minimum of joints and seams.
- Write specifications to require a minimum overlap of 2’ at longitudinal seams, and specify that both pieces of overlapping geotextile be clean, with no foreign material (including soil or aggregate) between them. During the 197-209 project, Tencate Mirafi® recommended a minimum overlap of 1’, but subsequent research by AUTC indicates that the transfer of moisture between panels of fabric through overlap is a “weak link” in the system and provides less effective hydraulic transfer than was believed at that time. Further developments in seam design may change this recommendation.
- Reducing the number of seams is desirable from both a hydraulic and a constructability perspective, so utilizing the widest rolls of wicking fabric available is preferable.
- Laboratory testing has demonstrated that wicking fabric can work up to 75’, permitting its use on embankments up to 150’ wide, if both sides of the embankment can be exposed.