TO: Gene Rehfield, P.E.
Experimental Features Coordinator
Engineering and Operations
Headquarters, DOT&PF

THRU: Paul W. Misterek, P.E.
Technical Services Engineer
Northern Region

FROM: Robert L. McHattie, P.E.
Geotechnical Engineer
Northern Region

DATE: July 18, 1996
FILE No.: XF96RPTS
PHONE: 451-2236

SUBJECT: Experimental Features, Annual Report for
AK 9103C (FINAL REPORT)

ELLIOTT HIGHWAY
MP 7 NORTH REHABILITATION
F-065-1(12)/63406
EXPERIMENTAL FEATURE - AK 9103C

Under this construction contract, three separate Experimental Features were constructed. An insulated embankment, reinforced with multiple layers of Heavy Duty Geotextile (called "pillow-wrap embankment" by project personnel), was constructed between Station 829+75 and 836+25. A 12 in.-thick, Reinforced Concrete Slab, 33 ft. wide and 250 ft. long was poured and buried beneath the roadway surface from Station 1270 to 1272+50. An open graded, Asphalt Treated Permeable Base Course was laid from Station 1460 to 1560. Stationing runs south to north throughout the project. The prime contractor for the project was Wilder Construction Company of Anchorage Alaska.

HEAVY DUTY GEOTEXTILE-REINFORCED EMBANKMENT

Introduction

This is the forth and final report in a series of reports describing the construction and field performance of a geotextile-reinforced roadway embankment section located about 25 miles north of Fairbanks, Alaska on the Elliott Highway. Prior to reconstruction, this reinforced and insulated section of the Elliott Highway experienced severe and continuous sliding and
settlement problems since completed as new alignment in 1973. Before reconstruction, the failing embankment was composed of a standard schist fill, 9 to 15 feet thick, overlain with a selected aggregate material and topped by a layer of asphalt concrete pavement. The section accumulated many additional layers of pavement as continuing sliding, spreading and subsidence required frequent releveving of the road surface.

Construction of the Heavy Duty Geotextile layered structure began on June 15, 1992. Exxon GTF 230, a woven polypropylene geotextile was supplied by the contractor to meet the required reinforcement specifications. A total of 10 geotextile layers were placed horizontally; each layer was 30 feet wide and topped with 18 inches of Type A Borrow (material containing <6% -#200). These geotextile/soil structures were called "pillows" by construction personnel. A 4 inch-thick x 46 foot-wide layer of rigid insulation was added to the reinforced structure between the 8th and 9th geotextile layers, at a depth of about 48 inches below the pavement surface. Insulfoam expanded polystyrene board insulation, rated at 35 lb/in² compression strength, was used for this purpose. The entire installation was completed June 27, 1992.

A total of 9,550 yd² of Heavy Duty Geotextile at $4.00/yd² plus 118 MBM of board insulation at $400/MBM together added about $85,400 to the price of the embankment structure between project Stations 829+75 and 836+25.

Because of the rather severe nature of the embankment failure between Stations 829+75 and 836+25 an unreinforced control section (allowing a direct comparison of performance between reinforced and unreinforced embankment) was not permitted. It was considered inappropriate, perhaps even dangerous to omit reinforcement within a portion of the most active failure area. A "thermal" control section was established immediately south of the reinforced embankment section, but only for the purpose of comparing ground temperatures in insulated versus uninsulated areas. Strings of thermistors were installed to monitor ground temperatures within the geotextile-reinforced and insulated section at Station 834+00 and also within the control section at Station 827+00.

Details concerning the configuration of the reinforced soil structure, specifications, construction methods and instrumentation were presented in an Experimental Feature construction report for this project issued December 18, 1992.
Performance After 3rd Year of Service

The Experimental Feature test site was visited on September 27, 1995, approximately three years after construction was completed. The test section was visually examined and photographed to document performance. Temperature measurements were obtained to determine the effectiveness of the polystyrene insulation layer. There has been little change in the performance of the section from last year.

Performance since reconstruction has been a qualified success. No localized and/or severe areas of failure have reappeared over the past year. Surface cracking, including minor rutting, is present, but the experimental section provides a good ride quality, and severe faulting has not recurred. Embankment spreading continues, but the reinforcement appears to prevent a concentration of stresses and strains (and therefore failure locations) within soil mass. Instead of a few individual faults creating ridges or grabens in the road surface (the situation prior to reconstruction), the embankment contains much wider zones of minor cracking. Photo #1 shows how a large number of (mostly hairline) longitudinal cracks have formed across the roadway surface.

Photos #2, #3, and #4 show longitudinal cracking that has formed along the roadway shoulder edge and on the northbound lane sideslope. The closeup view offered by Photo #3 shows exposed insulation at the outer edge of the insulation (at top of sideslope, northbound lane). Because of the placement of the reinforcement only within the central portion of the embankment, this form of cracking was expected. Design principles applied to this project included the intended decoupling of the central portion of the embankment from the sideslopes, i.e., reinforcement extended only from edge of paved shoulder to edge of paved shoulder. This design philosophy is based on the DOT&PF’s observations that, for warm permafrost areas, the potential for foundation failure is greater under shoulder and sideslope areas than directly under the central portion of the roadway embankment (winter-long snow cover causes relatively high ground-surface temperatures at these shoulder and sideslope locations). Photo #5 (taken near the north end of the reinforced section) shows the only area of the southbound lane which has thus far required patching.

It was intended that sideslope and shoulder cracks be filled, as needed, by maintenance personnel. The filling of sideslope cracks is necessary: 1. to prevent intrusion of water (a lubricant which helps promote continued sliding failure), and 2. to help prevent accidents due to the capture of the wheels of errant vehicles -- a potential liability problem.

There was an attempt to obtain ground temperature measurements to determine the thermal consequences of the presence of the insulation within the reinforced Experimental Feature, but the thermistor string beneath the insulation had been destroyed by movements of embankment and/or foundation materials underlying that section of embankment by fall of 1995. Because of the broken thermistor string, the present location of the permafrost table (location of the top of
permafrost) under the experimental section is not now known. The permafrost table under reinforced, insulated section was at about 22 feet in the fall of 1993. By the fall of 1994, the permafrost table had risen to a depth of about 6 feet -- the last time that that thermistor string was found to be functional. The permafrost table at Station 827+00 (string under insulated, reinforced section was placed at Station 834+00) was at a depth of about: 16 feet in the fall of 1993, 16 feet in the fall of 1994, and 17 feet in the fall of 1995. Based on limited data, the insulation appears to have been very effective so far.

Geotextile materials were selected with an eye to economics and the realization that some spreading and cracking of the embankment could be tolerated. As stated in the last three years of reporting, the reinforced embankment is working as expected.

mb

c: Dave McCaleb, P.E., Regional Pre-Construction Engineer
   Jim Elieff, P.E., Highway Design Group Chief
GEOTEXTILE-REINFORCED "PILOW-WRAP" EMBANKMENT
PHOTOS TAKEN 9/27/95, ELLIOTT HIGHWAY STATION 829+75 - 836+25

PHOTO #1, VIEW NORTH FROM MIDDLE OF SECTION -- SHOWS DISTRIBUTION
OF LONGITUDINAL CRACKING ACROSS ROADWAY

PHOTO #2, VIEW SOUTH FROM MIDDLE OF SECTION -- SHOWS CRACKING
ALONG EDGE OF NORTHBOUND LANE & SIDESLOPE
GEOTEXTILE-REINFORCED "PILLOW-WRAP" EMBANKMENT
PHOTOS TAKEN 9/27/95, ELLIOTT HIGHWAY STATION 829+75 - 836+25

PHOTO #3, CLOSEUP VIEW OF A SIDESLOPE CRACK SHOWN IN PHOTO #2 -- SHOWS EXPOSED INSULATION & LARGE CRACK WIDTH

PHOTO #4, VIEW SOUTH FROM SOUTH END OF SECTION (STA 829+75) ALONG EDGE OF NORTHBOUND LANE
PHOTO #5, VIEW ALONG SOUTHBOUND LANE, EDGE OF PAVEMENT, FROM NORTH END OF SECTION (STA. 836+25) -- SHOWS SHOULDER FAILURE
Memorandum

TO: Gene Rehfield
Coordinator, Experimental Features
DOT&PF, Headquarters

DATE: January 31, 1994
FILE No.: 244N
PHONE: 451-2236

THRU: Paul W. Misterek, P.E.
Technical Services Engineer

FROM: Robert L. McHattie, P.E.
Geotechnical Engineer
Northern Region

SUBJECT: Experimental Features, Annual Report for AK 9103C

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HEAVY DUTY G EO TEX T I LE- R E IN FORCED E MBANKMENT

INTRODUCTION

This is the second in a series of reports describing the construction and field performance of a geotextile-reinforced roadway embankment section located about 25 miles north of Fairbanks, Alaska on the Elliott Highway. Prior to reconstruction, this reinforced and insulated section of the Elliott Highway experienced severe and continuous sliding and settlement problems since completed as new alignment in 1973. Before reconstruction, the failing embankment was composed of a standard schist fill, 9 to 15 feet thick, overlain with a selected aggregate material and topped by a layer of asphalt concrete pavement. The section accumulated many additional layers of pavement as continuing sliding, spreading and subsidence required frequent relevelling of the road surface.

Construction of the Heavy Duty Geotextile layered structure began on June 15,
1992. Exxon GTF 230, a woven polypropylene geotextile was supplied by the contractor to meet the required reinforcement specifications. A total of 10 geotextile layers were placed horizontally; each layer was 30 feet wide and topped with 18 inches of Type A Borrow (material containing ≤6% -#200). These geotextile/soil structures were called "pillows" by construction personnel. A 4 inch-thick x 46 foot-wide layer of rigid insulation was added to the reinforced structure between the 8th and 9th geotextile layers, at a depth of about 48 inches below the pavement surface. Insulfoam expanded polystyrene board insulation, rated at 35 lb/in² compression strength, was used for this purpose. The entire installation was completed June 7, 1992.

A total of 9,550 yd² of Heavy Duty Geotextile at $4.00/yd² plus 118 MBM of board insulation at $400/MBM together added about $85,400 to the price of the embankment structure between project Stations 829+75 and 836+25.

Because of the rather severe nature of the embankment failure between Stations 829+75 and 836+25 an unreinforced control section (allowing a direct comparison of performance between reinforced and unreinforced embankment) was not permitted. It was considered inappropriate, perhaps even dangerous to omit reinforcement within a portion of the most active failure area. A "thermal" control section was established immediately south of the reinforced embankment section, but only for the purpose of comparing ground temperatures in insulated versus uninsulated areas. Strings of thermistors were installed to monitor ground temperatures within the geotextile-reinforced and insulated section at Station 834+00 and also within the control section at Station 827+00.

Details concerning the configuration of the reinforced soil structure, specifications, construction methods and instrumentation were presented in an Experimental Feature construction report for this project issued December 18, 1992.

**Performance After 1st Year of Service**

The Experimental Feature test site was visited on September 17, 1993, approximately one year after construction was completed. The test section was visually examined and photographed to document performance. Temperature measurements were obtained to determine the effectiveness of the polystyrene insulation layer.

Prior to installation of the reinforcement, embankment failure took the form of block sliding and irregular settlements due to the consolidation and lateral instabilities within the thawing foundation soils. Because of this slow, continuous failure process (regardless of repeated maintenance) the road surface was constantly spreading and subsiding. Driving conditions were greatly affected by the presence of bumps, grabens and fault ridges. Performance since reconstruction has been a qualified success. No localized and/or severe areas of failure have reappeared over the past year. Although surface cracking, including minor rutting, is certainly present, the experimental section provides a good ride quality, and severe faulting has not reoccurred. Embankment spreading does continue, but the reinforcement appears to have prevented a
concentration of stresses and strains (and therefore failure locations) within soil mass. Instead of individual faults creating ridges or grabens in the road surface, the embankment contains much wider zones of minor cracking. Some amount of cracking was expected since the geotextile must stretch before transferring strength to the soil — like a spring, the geotextile must stretch some amount before providing a resistive force. The development of shear resistance between the soil and geotextile coupled with the transfer of shear strength into the soil mass is the mechanism by which geotextile-reinforced structures work. The design objective was to select a combination of geotextile properties and layer spacing to produce a reinforced structure having a minimum but acceptable strength. Design decisions were heavily influenced by economics and the realization that some spreading and cracking of the embankment could be tolerated; the reinforced embankment is working as expected so far.

The attached photos show the condition of the road on 9/17/93. Photo No.1 provides a view looking into the south end of the reinforced section. At the right edge of pavement the block of white and yellow lines marks the beginning of the reinforced section; the short perpendicular yellow line points into the section. A concentrated zone of cracking in the right lane is seen to break up and become disseminated on entering the reinforced section. Photos No.2 and 4 give a typical impression of performance through the central part of the experimental section. Cracks seen in these photos are spread out in wide zones across the pavement. This is an indication that the geotextile is stretching and thereby being mobilized to exert restraining forces on the embankment soils. Photo No.3 looks into the experimental section from the north end. There is almost no cracking within the northern 100 feet of the section. There has probably not been enough movement in this area to even begin to mobilize the strength of the reinforcement. Photos No.5 and 6 were taken at the south end of the experimental section, looking southward toward the (thermal) control section. Photo No.6 shows how a single line of cracking enters the reinforced section and begins to bifurcate to a much wider zone of cracking. A comparison of Photo No.1 (looking into the experimental section near Sta. 829+75) and Photo No.5 (looking out of the experimental section near Sta. 829+75) demonstrates how a single severe crack (Photo No.5) becomes moderated into a wider zone (Photo No.1) as it enters the reinforced section. The highest density of surface cracking was found in the southbound lane, i.e., the lane on the downhill side of the natural ground cross-slope. A few small longitudinal cracks were found along the sideslope extending from the southbound lane; none were found on the sideslope of the uphill side of the roadway. These sideslope cracks formed outside the reinforced embankment core, and provide obvious evidence that downhill sliding continues.

Ground temperatures were measured to examine the relative protective effect of the 4 inch insulation layer. Thermistor strings in both the experimental section and the uninsulated location are 17 feet right of the centerline, near the top of the sideslope. Both of the strings penetrate through about 12 feet of embankment fill and extend roughly another 17 feet below the level of the original ground surface. These data are presented in the following table. Thawing has penetrated to a depth of about 22 feet below the road surface in the insulated section (Sta. 834+00) and about 15 feet at the uninsulated location (Sta. 827+00). Even though the insulated section exhibits deeper thawing, this may simply be evidence of different starting conditions at the two locations. Project test holes do not shed light on the initial conditions, i.e., the depth of
the permafrost table just after construction. These holes were drilled in the spring when the actual location of the permafrost table was masked by remanent seasonal frost. Data will be collected over the next several years, beginning in the fall of 1994, to help determine if thaw progression is being influenced by the insulation. Initial temperature readings on both strings were obtained by construction personnel in late 1992, but these data cannot be located at this time. If found, these data will be included with subsequent reports.

<table>
<thead>
<tr>
<th>Depth of Thermistor Below Surface (feet)</th>
<th>Experimental Section w/ 4-Inch Insulation @ Sta. 834+00 (°F)</th>
<th>Control Section w/ No Insulation @ Sta. 827+00 (°F)</th>
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<tbody>
<tr>
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<td>50.1</td>
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<tr>
<td>29.5</td>
<td>31.3</td>
<td>31.5</td>
</tr>
</tbody>
</table>

Field work for 1994 will provide another set of visual observations, photos and temperature data.

**Cost for this Reporting**

A total of about 26 hours of my time was required for report preparation. The FY 1994 expenditure is approximately $875 to date, charged against Ledger Code 30869442.

Attachments: as stated

RLM/rm
EXPERIMENTAL GEOTEXTILE-REINFORCED "PILLOW-WRAP" EMBANKMENT
PHOTOS TAKEN 9/17/93, ELLIOTT HIGHWAY STATION 829+75 - 836+25

PHOTO #1, VIEW NORTH FROM STA. 829+75 (SOUTH END OF SECTION)

PHOTO #2, VIEW NORTH FROM MIDDLE OF SECTION
EXPERIMENTAL GEOTEXTILE-REINFORCED "PILLOW-WRAP" EMBANKMENT
PHOTOS TAKEN 9/17/93, ELLIOTT HIGHWAY STATION 829+75 - 836+25

PHOTO #3, VIEW SOUTH FROM STA. 836+25 (NORTH END OF SECTION)

PHOTO #4, VIEW SOUTH FROM MIDDLE OF SECTION