Memorandum

State of Alaska
Department of Transportation & Public Facilities

To: Timothy W. Mitchell
   Coordinator,
   Experimental Features
   DOT&PF, Headquarters

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

From: Bob McHattie, P.E.
   Geotechnical Engineer
   Northern Region

DATE: December 18, 1992
FILE No.: 244N
PHONE: 451-2236

SUBJECT: Evaluation of Experimental Feature Project AK8703A

RESEARCH PROJECT NO. AK8703A, CONSTRUCTION PROJECT NO. IR-0A4-3(5),
GEOTEXTILE REINFORCEMENT OVER PERMAFROST - BONANZA CREEK SITE:

This study examined the performance of a roadway embankment section, reconstructed, after almost 20 years of poor performance, with the inclusion of several layers of geotextile. The embankment was constructed on an ice-rich permafrost foundation. The objective of the experimental design was to control longitudinal cracking in the driving lanes. To a large degree, the experimental design accomplished this objective.

I have attached, to this memorandum, a final report on the performance of the Bonanza Creek experimental feature, written by Dr. Kinney, University of Alaska, Fairbanks. The report required only slight revision from the draft version delivered to you earlier this year. There have been no major changes regarding the author's opinion as to the considerable benefits associated with this multi-layered, geotextile-reinforced embankment design. The experimental section continues to perform very well relative to its performance prior to reconstruction.

COST FOR THIS REPORTING:

Work associated with this reporting included: 1) field examination of the project site, 2) revision of the draft report and 3) writing this memo. About 9.5 hours of my time was required. To date, the expenditure on this project for FY 1993 has been $574, charged against ledger code 30744342.

RECEIVED
DEC 28 1992
ENGINEERING & OPERATIONS STANDARDS
DIRECTOR'S OFFICE
FINAL REPORT

HPR EXPERIMENTAL FEATURE PROJECT AK8703A

GEOTEXTILE REINFORCEMENT OVER PERMAFROST
BONANZA CREEK SITE

NOVEMBER 1992

BY THOMAS C. KINNEY
INSTITUTE OF NORTHERN ENGINEERING
UNIVERSITY OF ALASKA FAIRBANKS
FAIRBANKS, ALASKA 99775
EXPERIMENTAL FEATURES IN CONSTRUCTION

BONANZA CREEK SITE

Mile 330 Parks Highway

INTRODUCTION

The Bonanza Creek Experimental section on the Parks Highway was constructed in 1972 by placing 22 to 25 feet of fill over ice rich permafrost. Many inches of settlement occurred in the following years, producing very poor road performance. This section of road was notorious for dangerously wide and deep longitudinal cracks and an undulating surface requiring maintenance several times per year. Large settlements and generally poor performance, occurred despite the fact that the original construction incorporated special design features an attempt to buttress the road and thermally stabilize the permafrost.

Between the fall of 1986 and the summer of 1987 Bonanza Creek Road section was reconstructed. The embankment was rebuilt as a tension-reinforced structure, reusing soils from the existing embankment and layers of a fabric-type geotextile. The damaged pavement structure was replaced using new materials. This report presents conclusions regarding performance of the geotextile test section.

TEST SECTION

Reconstruction first required removal of the top 14 feet of fill. The embankment was then rebuilt, using the same fill materials, with a geotextile-reinforced center section and non-reinforced shoulders. A woven slit film geotextile was placed with the machine direction perpendicular to the centerline. The geotextile was placed in the center 30 feet of the roadway and the ends were wrapped up and back over the top of the two foot thick lifts. In essence, two geotextile retaining walls were constructed and tied together in the center of the embankment. Shoulder fill was placed as the construction progressed upward.

INSTRUMENTATION

Instrumentation consisted of a benchmark, PK nails placed in the road surface, slope stakes placed down the shoulders and into the valley floor, and four Slope Inclinometer casings. The PK nails were placed on 24-foot centers down the centerline and at 10 and 19 foot offsets from the centerline on each side. Four sets of vertical settlement and lateral spreading measurements and two sets of slope indicator measurements were acquired in the four year period between 1987 and 1991.
OBSERVATIONS

June 19, 1991  Obtained surface measurements and slope indicator readings. Few cracks are evident and the road does not appear to be undulating.

Oct 9, 1989  Obtained slope indicator readings.

Sept 22, 1989  Measured surface movements. Small longitudinal cracks were evident at several locations.

Oct 1, 1987  Measured surface movements.


Pre 1986  Numerous longitudinal cracks, frequent maintenance were evident. Poor driving conditions.

Slope indicator measurements indicate that the entire road embankment continued spreading laterally. There has been significant outward movement beneath the base of the reinforced portion of the embankment. The geosynthetic has apparently held the bottom of the reinforced embankment section to movements less than those occurring below. Outward movement is significantly greater in the upper 10 feet of the reinforced embankment. From the data, it appears that the embankment is spreading laterally, but is partially restrained by the geosynthetic. Some spreading was anticipated in the design, since it was known that geotextiles exert maximum restraining forces only after significant stretching has occurred. A summary of the measurements is shown below.

Lateral Spreading of Embankment
between September 1989 and June 1991
(in inches)

<table>
<thead>
<tr>
<th>Vertical Location</th>
<th>Sta. 166+75</th>
<th>Sta. 168+75</th>
</tr>
</thead>
<tbody>
<tr>
<td>At top of embankment</td>
<td>4.8</td>
<td>6.7</td>
</tr>
<tr>
<td>At the bottom of reinforcement</td>
<td>1.9</td>
<td>4.0</td>
</tr>
<tr>
<td>Below the reinforcement,</td>
<td>3.7</td>
<td>4.3</td>
</tr>
<tr>
<td>at a depth of about 20 ft.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Surface measurements over the four year study period indicate that the road surface is spreading laterally at an average rate of 2.4 inches per year. Specifically, the lateral spreading between September 1989 and June 1991 at Stations 166+75 and 168+75 were 2.6 and 6.0 inches respectively. The lateral spreading of the surface measured by the PK nails was expected to be larger than that measured by the slope indicator because the PK nails were placed 19 feet from the centerline and the slope indicators were placed 15 feet from the centerline. Further study would be necessary to explain the significance of these apparently contradictory data.

Based on the three PK nail measurements, the road surface has settled vertically at the rate of about 1.5 inches per year in the 4 years since reconstruction. Prior to the reconstruction, the embankment settled at a rate of about 1.2 inches per year for the 11 years that we have data.

**CONCLUSION**

Based on the data available, it appears that the geotextile reinforcement did not slow the rate of vertical settlement. Geotextile reinforcement of the upper 14 feet of this embankment should not effect the total vertical settlement.

However, based on the comments from individuals that have passed over the road for the past 15 years it appears that its overall performance has improved greatly. Prior to reconstruction, longitudinal cracks formed and the road was rough. After reconstruction, deformation appears to be more uniform and the road surface appears to have remained in dramatically better condition. This may be misleading, because prior to reconstruction the road embankment had been loosened and cracked to a considerable extent and any new deformation was probably magnified at the surface. After reconstruction it will take many years for the internal deformation to reach the same degree of maturity. In the interim, the embankment may be undergoing internal readjustments that are simply not "felt" at the surface yet.

Based on the slope indicator measurements it does appear that the geotextile is reducing lateral spreading in the upper part of the embankment as expected during design. There is therefore a real possibility that the geotextile reinforcement has performed its intended function.

It appears that layers of geosynthetics can be used to hold a road embankment together, in spite of a thermally degrading, ice-rich permafrost foundation condition. The total vertical settlement will probably not be changed since the general undulations caused by frost heaving or vertical thaw strain will probably not be significantly affected. However, the internal stability of the embankment can be strengthened resulting in less cracking and less abrupt differential settlements. The design procedure and the cost effectiveness are just beginning to be understood and much more work must be done before the optimum design procedure is developed and one can predict the benefit of using layers of geosynthetics to stabilize roads over permafrost terrain. Most studies indicate that
higher modulus geosynthetics than were used here may improve performance even more.

It appears that strain rates in the asphalt on the order 0.5% to 1% per year can be tolerated, under ideal conditions, with minimal asphalt cracking. Minimum cracking will probably occur if most of the total annual strain occurs during the summer when the asphalt is warm. Data from this test section is not sufficient to shed any light on this topic.

RECOMMENDATION

The concept of reinforcement with several layers of geosynthetics appears to have merit, but more research is needed to develop a reliable design procedure and to be able to predict performance. There is a considerable amount of information that can be gained from continued monitoring of this test section. This test section should be monitored and additional research should be done to develop an improved design procedure.
Memorandum

To: Timothy W. Mitchell  
   Coordinator,  
   Experimental Features  
   DOT&PF, Headquarters  

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

From: Bob McHattie, P.E.  
   Geotechnical Engineer  
   Northern Region

DATE: December 18, 1992  
FILE No.: 244N  
PHONE: 451-2236

SUBJECT: Evaluation of Experimental Feature Projects AKB703B

RESEARCH PROJECT NO. AKB703B, CONSTRUCTION PROJECT NO. F-RS-SR-071, GEOTEXTILE REINFORCEMENT OVER PERMAFROST - BIG TIMBER SITE:

This project evaluated the performance of multiple layers of geotextile used in the reconstruction of a permafrost-damaged roadway embankment. The objective was to control the differential settlements and frost heaving that occurred within the driving lanes. Since reconstruction, the road surface has continued to develop extreme deformations. There has been little or no difference in performance between the control section and either of the reinforced sections. This experimental feature is considered to be a performance failure.

DOT&PF has more recently constructed apparently successful embankments containing multiple layers of reinforcement, over very difficult foundation conditions - the Bonanza Creek experimental features section is an example. Such successes have resulted from applying the latest design techniques and geotextile materials.

I have attached, to this memorandum, a final report on the performance of the Big Timber experimental feature, written by Dr. Kinney, University of Alaska, Fairbanks. Minor revisions have been made to the draft version of the report delivered to you earlier this year. The author has not changed his opinion as to the apparent failure this embankment design. The experimental section has performed poorly since construction.

COST FOR THIS REPORTING:

Work associated with this reporting included: 1) field examination of the project site, 2) revision of the draft report and 3) writing this memo. About 10.5 hours of my time was required. To date, the expenditure on this project for FY 1993 has been $650, charged against ledger code 30744342.
FINAL REPORT

HPR EXPERIMENTAL FEATURE PROJECT AK8703B
GEOTEXTILE REINFORCEMENT OVER PERMAFROST
BIG TIMBER SITE

NOVEMBER 1992

BY THOMAS C. KINNEY
INSTITUTE OF NORTHERN ENGINEERING
UNIVERSITY OF ALASKA FAIRBANKS
FAIRBANKS, ALASKA 99775
EXPERIMENTAL FEATURES
IN CONSTRUCTION

BIG TIMBER SITE

At the Gulkana Junction
Mile 129 from Valdez on the Richardson Highway

INTRODUCTION

The road just north of the Gulkana Junction on the Richardson Highway was realigned in 1974. The road is constructed on a shallow fill on the order of a few feet thick, in an area of black spruce with a few alder. Over the years the road experienced severe distress which was primarily attributed to frost heaving and thaw settlements. The road was reconstructed in 1984 and a section from Mile 129 north was used as a test section to study the use of layers of geotextiles to stabilized roads in this environment. This is the final report on the performance of the test section.

TEST SECTION

The study area consisted of two geotextile test sections and one control section. The geotextile test sections consisted of three layers of a fairly light-weight woven slit film geotextile, Exxon GTF 300, installed at nominal depths of 20, 28, and 36 inches. The layers of geotextiles were placed with the machine direction parallel to the centerline of the road, with a total width of 42 feet and at least a 2 foot overlap between rolls. In the southern 1000-foot section, the ends of the geotextile were pulled up and wrapped back a distance of 8 inches over the 8-inch lift. In the second 1000-foot section the geotextile was brought out to the edge of the 42-foot width without wrapping. The third 1000-foot section was established as a control and contained no geotextile. Designs used at Big Timer were empirically based on suggestions from geotextile sales representatives and manufacturers. Although not based on specific stress/strain calculations. It was intended that three layers of a low strength geotextile would smooth out the surface expression of differential settlements.

INSTRUMENTATION

One deep benchmark, five 20-foot deep Slope Indicator casings and five temperature monitoring casings were installed. In addition, PK nails were installed in the road surface to measure horizontal and vertical movements.
OBSERVATIONS

Winter 1985-1986

Based on a letter by Dave Esch of DOT&PF, dated January 5, 1987, DOT&PF maintenance personnel reported 6 to 8-inch frost heaves in the test sections and suggested that the performance in the areas containing the geotextiles was worse than in the control section.

August 1986

On August 21, 1986 the site was visited by Matthew Reckard and Milt Ludington of DOT&PF. Part of a report by Dave Esch of DOT&PF dated January 5, 1987, one 35mm slide and some very curt notes are all that exist of the data. Based on this, it appears that they found the road to be fairly level with some longitudinal and thermal cracking. The surface had recently been extensively patched with full width patches from Station 2976+20 to 2976+85 and from 2967+35 to 2974+20. Other patching existed but was not full width. Horizontal and vertical surface measurements indicate that the performance of the geotextile test sections was worse than the control section. Ride meter surveys supported this conclusion. The conclusion was made that either the geotextiles negatively affected road performance or that the geotextiles were placed in areas where the conditions were the worst.

June 1987

On June 15 and 16, 1987 a team of DOT&PF Research and UAF personnel visited the site, made visual observations and excavated along the edges of the road adjacent to a thermal crack. There is reference to samples of soil and geotextile saved for laboratory testing but all of the available information from this trip is contained in a 20-minute video tape made at the site. The conclusions from the visual observations was that no part of the road appeared to be performing any better than any other part. There were undulations on the order of a few inches deep with a period on the order of tens of feet, in spite of the fact that there appeared to have been recent patching.

Test pits were excavated at each end of a large thermal crack to see if the geotextile was torn where it crossed the crack. The crack was at least two inches wide at the top and had been patched at least twice. At the edges of the road the geotextiles were not under tension and were not torn or otherwise damaged at either location.

September 1991

In the last week of September 1991, Bob McHattie of DOT&PF visited the site. There had been recent patching which covered virtually all of the road. There was no indication of any of the instrumentation visible from the surface.

All sections of the experimental feature seemed to be performing similarly. All sections
had undulating differential movement on the order of a few inches deep with periods on the order of tens of feet. No longitudinal cracking or any other abrupt differential movement was seen.

**CONCLUSION**

Based on the observations made throughout the last 6 years it appears unlikely that the geotextiles in the test sections influenced the road performance in any significant manner.

**RECOMMENDATION**

A reinforcement system consisting of three layers of light-weight geotextile does not appear to be economically justifiable, given the conditions at Big Timber. Designs involving geotextile reinforcement should be based on a full geotechnical assessment of materials properties and calculated loadings.
RESEARCH PROJECT NO. AK8703A, CONSTRUCTION PROJECT NO. IR-0A4-3(5),
GEOTEXTILE REINFORCEMENT OVER PERMAFROST - BONANZA CREEK SITE:

This research evaluates the performance of a roadway embankment section
reconstructed with the inclusion of several layers of geotextile. The objective
of the experimental design was to control longitudinal cracking in the driving
lanes. The experimental embankment section is located on permafrost foundation
soils at about mile 330 on the Parks Highway, where the highway crosses a small
valley formed by Bonanza Creek. The roadway embankment was originally built in
1977 without the aid of tensile reinforcement. Differential settlements soon
occurred that were expressed at the road surface as severe longitudinal cracking.
In spite of considerable repair efforts, the cracking process continued until the
problem embankment section was finally reconstructed in 1986.

According to the reconstruction plan, the embankment was first excavated downward
until permafrost soils were reached. The embankment section was then
reconstructed by sandwiching layers of a slit film, woven geotextile (Mirafi
600X) between layers of the original fill. The reinforced embankment section was
designed as a pair of back-to-back retaining walls. Tensile reinforcement,
provided by the layers, of geotextile has performed much as expected according
to the design method used.

Since reconstruction, the road surface has developed only minor cracking and
rutting -- pavement surface damage since reconstruction has been so slight that
the experimental section has remained unpatched. Specifically, not a single
longitudinal crack of "tire catching" width has developed to date. With respect
to the vehicle driver, performance of the embankment has been vastly improved as
a result of the reconstruction.

I have attached a draft final report (see Attachment) on the performance of the
Bonanza Creek experimental section, written by Dr. Kinney, University of Alaska,
Fairbanks. I expect the completed version of this final report to be available
for you, prior to February 1.
Cost for this Reporting:

Work associated with this reporting included: 1) accumulation of reporting documents, 2) field examination of the project site and 3) writing this memo. A total of 10 hours of my time was required. The project expenditure for 1992 has been $580 to date, charged against ledger code 30739722 (this L.C. was assigned for work on experimental features as per your memo to Paul Misterek, dated 10/14/1991).
ATTACHMENT

DRAFT FINAL REPORT

HPR EXPERIMENTAL FEATURE PROJECT AK8703A

GEOTEXTILE REINFORCEMENT OVER PERMAFROST
BONANZA CREEK SITE

OCTOBER 1991

BY THOMAS C. KINNEY
INSTITUTE OF NORTHERN ENGINEERING
UNIVERSITY OF ALASKA FAIRBANKS
FAIRBANKS, ALASKA 99775
HPR NEW PRODUCTS RESEARCH SECTION
FINAL REPORT

BONANZA CR. TEST SITE
Mile 330 Parks Highway
1986 - 1991

INTRODUCTION

The Bonanza Cr. Section or the Parks Highway was constructed in 1972 by placing 22 to 25 feet of fill over ice rich permafrost. Many inches of settlement occurred in the following years resulting in very poor road performance. This section of road was notorious for longitudinal cracking and an uneven surface requiring maintenance several times per year to keep it save. Because of the large settlements and generally poor performance, the area was used for several test sections of various types in an attempt to buttress the road or thermally stabilize the permafrost. Between the fall of 1986 and the summer of 1987 the road was reconstructed by replacing the upper portion of the road and reinforcing it with layers of geotextile. This report presents the final conclusions regarding the geotextile test section.

TEST SECTION

The test section consisted of removing the top 14 feet of fill and replacing it with a geotextile reinforced center section and sacrificial shoulders. A woven split film geotextile was placed with the machine direction perpendicular to the centerline. The geotextile was placed in the center 30 feet of the road and the ends were wrapped up and back over the top of the two foot thick lifts. In essence, two geotextile retaining walls were constructed and tied together in the center. Fill was placed on the shoulders as the construction progressed upward.

INSTRUMENTATION

Instrumentation consisted of a benchmark, PK nails placed in the road surface, slope stakes placed down the shoulder and into the valley floor, and four Slope Indicator casings. The PK nails were placed on 25-foot centers down the centerline and at 10 and 19 foot offsets from the centerline on each side. Four sets of vertical settlement and lateral
spreading measurements and were made and two sets of slope indicator measurements were made in the four year period between 1987 and 1991.

**OBSERVATIONS**

June 19, 1991 - Surface measurements made and slope indicators read. Few cracks are evident and the road does not appear to be undulating.

October 9, 1989 - Slope indicator readings made.

Sept 22, 1989 - Surface measurements made. Small longitudinal cracks evident at several locations.

October 1, 1987 - Surface measurements made.

September 1986 to September 1987 - Reconstruction

Pre 1986 - Numerous longitudinal cracks, frequent maintenance, Poor driving conditions.

The slope indicator measurements indicate that the entire road embankment is spreading laterally. There is significant outward movement around the bottom of the embankment. The geosynthetic has apparently held the bottom of the reinforced section to movements less that occur below however there is outward movement again in the upper 10 feet of the embankment. From the data it appears that the embankment is trying to spread laterally but is partially restrained by the geosynthetic. This exactly what was expected during design. A summary of the measurements is show below.

**Lateral Spreading of Embankment**
**between September 1989 and June 1991**
(in inches)

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<th></th>
<th>Sta. 166+75</th>
<th>Sta. 168+75</th>
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<td>At top</td>
<td>4.8</td>
<td>6.7</td>
</tr>
<tr>
<td>At the bottom of reinforcement</td>
<td>1.9</td>
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</tr>
<tr>
<td>Below the reinforcement at a depth of about 20 ft.</td>
<td>3.7</td>
<td>4.3</td>
</tr>
</tbody>
</table>

The surface measurements over the four year period indicate that the road surface is spreading laterally at an average rate of 2.4 inches per year. Specifically, the lateral spreading between September 1989 and June 1990 at stations 166+75 and 168+75 were 6.0 and 2.6 inches respectively. The lateral spreading of the surface measured by the PK nails would be
expected to be larger than that measured by the slope indicator because the PK nails were placed at 19 feet from the centerline and the slope indicators were placed at 15 feet from the centerline.

Based on the three PK nail measurements, the road surface has settled vertically at the rate of about 1.5 inches per year in the 4 years since reconstruction. Prior to the reconstruction, the embankment had been settling at a rate of about 1.2 inches per year for the 11 years that we have data.

**CONCLUSION**

Based on the data available it appears that the geotextile reinforcement did not slow the rate of vertical settlement. Geotextile reinforcement of the upper 14 feet of this embankment should not effect the total vertical settlement.

However, based on the comments from individuals that have passed over the road for the past 15 years it appears that the overall performance of the road has improved dramatically. Prior to reconstruction, longitudinal cracks formed and the road was rough. After reconstruction, the deformation appears to be more uniform and the road surface appears to have remained in dramatically better condition. This may be misleading, because prior to reconstruction the road embankment had been loosened and cracked to a considerable extent and any new deformation was probably magnified at the surface. After reconstruction it will take many years for the internal deformation to reach the same degree of maturity. In the interim, the embankment may be undergoing internal readjustments that are simply not felt at the surface yet.

However, based on the slope indicator measurements it appears that the geotextile is reducing the lateral spreading in the upper part of the embankment as expected during design. There is therefore a real possibility that the geotextile reinforcement has performed its intended function.

Based on the results of this test and the results of other tests performed in Alaska, it appears that layers of geosynthetics can be used to hold a road embankment together. The total vertical settlement will probably not be changed and the general undulations caused by frost heaving or thaw strain will probably not be significantly effected. However, the internal stability of the embankment can be strengthened resulting in less cracking and less abrupt differential settlement. The design procedure and the cost
effectiveness are just beginning to be understood and much more work must be done before the optimum design procedure is developed and one can predict the benefit of using layers of geosynthetics to stabilize roads over permafrost terrain. Most studies indicate that higher modulus geosynthetics than were used here may improve performance even more.

It appears that strain rates in the asphalt on the order 0.5% to 1% per year can be tolerated with minimal asphalt cracking. It may be necessary that this strain occur during the summer when the asphalt is warm and the traffic is heavy but the data from this test section is not sufficient to shed any light on this topic.

**RECOMMENDATION**

The concept of reinforcement with multi layers of geosynthetics appears to have merit but more research is needed to develop a reliable design procedure and to be able to predict performance. There is a considerable amount of information that can be gained from continued monitoring of this test section. This test section should be monitored and additional research should be done to develop a design procedure for this application.
Memorandum

To: Timothy W. Mitchell  
Coordinator,  
Experimental Features  
DOT&PF, Headquarters

Thru: Paul W. Misterek, P.E.  
Chief, Engineering Services I

From: Bob McHattie, P.E.  
Geotechnical Engineer  
Northern Region

DATE: January 14, 1992
FILE No.: 244N
PHONE: 451-2236
SUBJECT: Evaluation of Experimental Feature Projects AK8703B

RESEARCH PROJECT NO. AK8703B, CONSTRUCTION PROJECT NO. F-RS-SR-071.  
GEOTEXTILE REINFORCEMENT OVER PERMAFROST – BIG TIMBER SITE:

This project evaluates the performance of multiple layers of geotextile used in the reconstruction of a permafrost-damaged roadway embankment. The objective of the design was to control the differential settlements and frost heaving that occurred within the driving lanes. The experimental embankment section is located on permafrost foundation soils at about mile 129 on the Richardson Highway, just south of Gakona Junction (intersection with Tok Cutoff). The embankment was originally constructed in 1974 without geotextile reinforcement. Almost immediately it exhibited the bumpiness often associated with severe frost heave and/or permafrost-related differential settlements. Deterioration of the driving surface continued, finally prompting reconstruction efforts in 1984.

The embankment design experiment included two test sections which contained multiple layers of geotextile (Exxon GTF 300) and a control section with no geotextile. Both test sections were reconstructed using three layers of geotextile with placement depths at 20, 28, and 36 inches. The two test sections differed only in the way that the edges of the geotextile layers were terminated into the embankment fill. The structural capabilities of both reinforced sections should have been roughly the same however. This represented DOT&PF’s first attempt to repair a permafrost/frost heave-damaged roadway embankment using multiple layers of geotextile. The design was empirical since it was based on observations that single layers of reinforcing geotextile tended to improve the performance of embankments on ice-rich foundations. The fact that prior road performance had been particularly bad at the Big Timber test site prompted the decision to use three geotextile layers in the embankment reconstruction instead of just one.

Since reconstruction, the road surface has continued to develop extreme deformations. Observations to date indicate little or no difference in performance between the control section and either of the reinforced sections. All three sections are now considered definite performance failures. There
appears to have been no advantage gained from the specific geotextile designs used at Big Timber. (NOTE: DOT&PF has more recently constructed apparently successful embankments, containing multiple layers of reinforcement, over very difficult foundation conditions. Such successes have resulted from applying the latest design techniques and geotextile materials. The Bonanza Creek experimental section is an example that has performed very well to date.)

I have attached a draft final report (see Attachment) on the performance of the Big Timber experimental section, written by Dr. Kinney, University of Alaska, Fairbanks. I expect the completed version of this final report to be available for you, prior to February 1.

**Cost for this Reporting:**

Work associated with this reporting included: 1) accumulation of reporting documents, 2) field examination of the project sites and 3) writing this memo. A total of 9.5 hours of my time was required. The project expenditure for 1992 has been $550 to date, charged against ledger code 30739722 (this L.C. was assigned for work on experimental features as per your memo to Paul Misterek, dated 10/14/1991).
ATTACHMENT

DRAFT FINAL REPORT

HPR EXPERIMENTAL FEATURE PROJECT AK8703B
GEOTEXTILE REINFORCEMENT OVER PERMAFROST
BIG TIMBER SITE

DECEMBER 1991

BY THOMAS C. KINNEY
INSTITUTE OF NORTHERN ENGINEERING
UNIVERSITY OF ALASKA FAIRBANKS
FAIRBANKS, ALASKA 99775
HPR NEW PRODUCTS RESEARCH SECTION
FINAL REPORT

BIG TIMBER
At the Gulkana Junction
Mile 129 from Valdez on the Richardson Highway

INTRODUCTION
The road just north of the Gulkana Junction on the Richardson Highway was realigned in 1974. The road is constructed on a shallow fill on the order of a few feet thick in an area of black spruce with a few alder. Over the years the road experienced severe distress which was primarily attributed to frost heaving, thaw settlement and thermal cracking. The road was reconstructed in 1984 and a section from Mile 129 north was used as a test section to study the use of layers of geotextiles to stabilize roads in this environment. This is the final report on the performance of this test section from 1984 to 1991.

TEST SECTION
The test area consisted of two geotextile test sections and one control section. The geotextile test sections consisted of three layers of a fairly light-weight woven split film geotextile, Exxon GTF 300, installed at nominal depths of 20, 28, and 36 inches. The layers of geotextiles were placed in a longitudinal direction with a total width of 42 feet and at least a 2 foot overlap between rolls. In the southern 1000-foot section the ends of the geotextile were pulled up and wrapped back a distance of 8 inches over the 8-inch lift. In the second 1000-foot section the geotextile was brought out to the edge of the 42-foot width without wrapping. The third 1000-foot section was a control section.

INSTRUMENTATION
One deep benchmark, five 20-foot deep Slope Indicator casings and five temperature monitoring casings were installed. In addition PK nails were installed in the road surface to measure horizontal and vertical movements.
OBSERVATIONS

Winter 1985-86

Based on a letter by Dave Esch of DOT&PF dated January 5, 1987, DOT&PF maintenance personnel reported 6 to 8-inch frost heaves in the test sections and suggested that the performance in the areas containing the geotextiles was worse than in the control section.

August 1986

On August 21, 1986 the site was visited by Mat Reckard and Milt Ludington of DOT&PF. Part of a report by Dave Esch of DOT&PF dated January 5, 1987, one 35mm slide and some very curt notes are all that exist of the data. Based on this it appears that they found the road to be fairly level with some longitudinal and thermal cracking. The surface had been recently patched extensively with full width patches from station 2976+20 to 2976+85 and from 2967+35 to 2974+20. Other patching existed but was not full width. Horizontal and vertical surface measurements indicate that the performance of the geotextile test sections was worse than the control section. Ride meter surveys supported this conclusion. The conclusion was made that either the geotextiles hindered the road performance or that the geotextiles were placed in areas where the conditions were the worst.

June 1987

On June 15 and 16, 1987 a team of DOT&PF Research and UAF personnel visited the site, made visual observations and excavated along the edges of the road adjacent to a thermal crack. There is reference to samples of soil and geotextile saved for laboratory testing but all of the available information from this trip is contained in a 20-minute video tape made at the site. The conclusions from the visual observations was that no part of the road appeared to be performing any better than any other part. There were undulations on the order of a few inches deep with a period on the order of tens of feet in spite of the fact that there appeared to have been recent patching.

Test pits were excavated at each end of a large thermal crack to see if the geotextile was torn where it crossed the crack. The crack was at least two inches wide at the top and had been patched at least twice. At the edges of
the road the geotextiles were not under tension and were not torn or otherwise damaged at either location.

September 1991

In the last week of September 1991, Bob McHattie of DOT&PF visited the site. There had been recent patching which covered virtually all of the road. There was no indication of any of the instrumentation visible from the surface.

There was no indication that any portion of the road performed significantly differently than and other portion of the road. The entire section of road had undulating differential movement on the order of a few inches deep with periods on the order of tens of feet. No longitudinal cracking or any other abrupt differential movement was seen.

Note:

There is considerable reference in the files to data, but no actual data is available at present.

CONCLUSION

Based on the observations made throughout the last 6 years it appears unlikely that the geotextiles in the test sections influenced the road performance in any significant manner.

RECOMMENDATION

It does not appear economically justifiable to use this design under these conditions.
December 18, 1987

Re: New Experimental Features Projects

Mr. Charles Seslar
Structural Engineer
Federal Highway Administration
P.O. Box 21648
Juneau, Alaska 99802

Dear Chuck:

As we discussed on the telephone two days ago, I am submitting under cover of this letter initial reports for a new "Experimental Feature in Highway Construction" project and a work plan for another.

The new project is actually an ongoing HPR Research project (No. 86-7) which will now also be included in the experimental features program. It is entitled "Geotextile Reinforcement over Permafrost". The principal construction features being evaluated under this project are reinforced embankments at Milepost 330 on the Parks Highway (the "Bonanza Creek" site) and at Gakona Junction on the Richardson Highway (the "Big Timber" site). I have assigned experimental project number AK87-03A to the former and AK87-03B to the latter; an initial form 1461 report is enclosed for each. Your office should already have a copy of the approved project proposal; if not, let me know and I will send one.

The work plan is for a proposed project entitled "Wood Chips as Lightweight Fill". The recently reconstructed Parks Highway embankment at Alder Creek (about 10 miles west of Fairbanks), which incorporated up to 20 feet of wood chip fill, would be monitored under this project. Please review the proposal and let us know if it has your approval. Once approved, we will assign it a project number and submit an initial form 1461 report.

Please let me know if you need any further information.

Sincerely,

Matthew Reckard
Experimental Features Coordinator

Enclosures
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**BONANZA RECONSTRUCTION**

**SEVEN (7) PILLOW WRAPPED LAYERS**

For 8?

Completion of edge of "pillows" was somewhat of a problem—took a little more care.
PROPOSED RESEARCH STUDY

GEOTEXTILE ROADWAY REINFORCEMENT OVER PERMAFROST
PROJECT HPR 86-7

To be conducted by:

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
RESEARCH SECTION
2301 Peger Road
Fairbanks, Alaska 99701-6394

PREPARED BY:    DATE:  4/17/86
David C. Esch
Highway Research Chief

APPROVED BY:    DATE:  5/1 - 86
H. Glen Glenzer
Deputy Commissioner
Problem Statement:
Roadways constructed on thaw-unstable permafrost soils often suffer from progressive lateral spreading and cracking and from irregular thaw-related settlements. The resulting longitudinal cracks and dips reduce travel speeds, comfort, and safety, and result in excessive maintenance costs. In the past 5 years, the Department has spent hundreds of thousands of dollars constructing embankments with multiple layers of geotextiles to help reduce the impact of thaw consolidation on maintenance costs. At present, there exists no method for assessing the benefit of constructing roads in this manner and therefore no way to determine the cost effectiveness of this technique. This project seeks to remedy this, by instrumenting and monitoring several sites that have been recently reconstructed, or will be constructed in 1986.

Background and Significance:
Fabric reinforcement of embankments over soft foundation soils has developed over the past 10 years, and retained earth structures are now being constructed using engineering fabrics for the only reinforcement. The performance of such fabric structures has been documented for normal soft soil conditions. However, permafrost soils commonly have very irregular ice contents and extreme variation in settlement from point to point. This results in the need for embankments which are able to arch or bridge the resulting irregularities and cracks. In 1984, test embankments were constructed over ice-filled trenches and load tested after the ice had melted. These tests demonstrated the ability of the available fabrics to bridge trenches up to four feet in width. However, relatively large settlements were observed on the surface above the trenches, and some fabrics yielded in creep (Kinney, 85). This initial experience demonstrated the need for stronger materials with low creep properties, and in 1985 a second series of trench crossing tests were constructed with a new generation of plastic grid materials and improved fabrics. Based on these field trials, a prediction method for spanning voids with fabrics has been developed and can be tested against data from the field sites to be studied in this project.

Lateral spreading of embankments on permafrost results from deeper thawing beneath embankment slopes than beneath the travelled roadway (Esch, 1983). The installation of multiple layers of stiff, creep-resistant fabrics will provide a tensile strength to the pavement and embankment structures which is not present in normal soil embankments. By providing resistance to lateral spreading, the hazardous longitudinal cracks and ruts which develop at some roadway locations may be reduced or eliminated entirely.

Scope:
Embankments over thaw unstable permafrost which have been reinforced with three or more layers of geotextile will be the focus of this study. As these sections are typically experimental construction items, a 3-year monitoring program is planned, to give adequate time to measure annual thaw-related embankment movements. Three sites are currently considered for
inclusion in this project. The first is a combined 3-layer installation with wrapped and unwrapped edge sections 1,000 ft. in length and a similar untreated control section, constructed on the Richardson Highway at Big Timber junction in 1984. The second and third sites are a 5-layer installation constructed near Birch Lake on the Richardson in 1985, and an 8-layer reinforcement of the Bonanza Creek experimental embankment on the Parks Highway, to be rebuilt in 1986.

Method of Study

Fabrics provide a reinforcement function only when placed in tension, as fabrics cannot assume shear, compressive or flexural stresses. Soil stresses are compressive in nature until significant lateral soil movements occur. Fabric stresses can be inferred from measurements of soil movements, if the stress-strain and creep properties of the particular fabric are known. This approach will be used in this study. It will also be important to determine the seasonal nature of the embankment movements. Movements which occur while the embankment structure is frozen may cause high localized stresses in the fabric layers at the locations of all embankment creeks, as fabric to soil slippage is resisted by freeze-bonding. Frost heave and thaw settlement related stresses will both be investigated in this study.

Embayment surface movements will be observed with a grid of measurement points marked by nails placed at intervals on the road surface in fabric and adjacent control sections. Permanent non-heaving benchmarks will be installed at each site. Lateral movements will be measured between nails placed in the pavement and from slope indicators installed in shoulder areas. Subsurface movements may be observed from remote reading settlement plates or horizontal tubes placed within the embankment depths of freezing and thawing will be observed from temperature instrumentation installed in borings, and soil samples will provide date on the subsurface soil conditions.

Fabric samples will be obtained and tested to measure wide strip tensile stress-strain and creep-time properties. Soil movements and rates and fabric stress-strain properties will then be analyzed to determine the probable contributions of the fabric layers to embankment strength and deformation resistance. Crack patterns and maintenance requirements will also be analyzed to measure the overall benefits, with particular attention paid to fabric to non-fabric transition areas. Relative pavement structure strengths will also be measured both sides of transitions by use of the falling weight deflectometer (FWD) test devices, and the Mays Ride Meter will measure the ride roughness.

Products:

A final report will detail the results and conclusions from observations.
Implementation:

The costs and benefits of fabric-reinforced embankment installations on roads over thaw-unstable permafrost will be analyzed, and recommendations made for future use or non-use of such treatments.

Facilities Available & Staffing Plan:

Surveying, Inclinometer, FWD, and temperature measurement equipment of the DOT&PF will be used for this study. Borings may be done by DOT geologist and drilling crews or by contract. Fabric testing will be by University of Alaska staff and facilities. Field surveys and evaluations will be performed by DOT staff with University student assistance. Analysis and reporting will be done by DOT&PF staff, including Eric Johnson and Bob McHattie, Geotechnical Engineers, and David Esch, Highway Research Manager.

Schedule:

Initial field pavement condition and elevation surveys will be made in the spring at 1986 for the two existing sections. The Bonanza Creek site will tentatively be constructed in September and October at 1986, and will be instrumented at that time.

Field surveys will be repeated at 6-month intervals, to observe both frost heave and thaw-settlement movements, surface distress and repair manifestations, and ride roughness.

Budget: FY86

DOT-Field Surveys - 4 Crew-days @ $650 = $2,600
DOT-Field Borings - 4 Crew-days @ $1,400 = $5,600
Student - Sampling and Lab Testing of Fabrics
- Pavement Movement nail installations & measurements
- Construction Record-searches, fabric mapping, & drafting
- Laboratory sample testing
- Temperature instrumentation fabrications & observations
  Total - 3-1/2 Student-months @ $2,600 = $9,000

Misc. wire, thermistors, switches, & supplies = 480
Per Diem - 20 man - days @ $80 = 1,600
Vehicle Mileage - 2400 miles @ $.40 = 720

FY86 Total $20,000
Budget: FY87

Bonanza Creek - Field Borings by DOT
  2 crew-days @ $1,400 = $ 2,800

DOT-Field Surveys - Elevations & slope indicators
  8 crew-days @ $650 = $ 5,200

Student Work
  - Crack Mopping & Movement Measurements
  - Data processing & plotting
  - Temperature string fabrications and ?
    Total - 1-1/2 months @ $2,600 = $ 3,900

Per Diem Expenses - 12 days @ $80 = 960
Vehicle Mileage - 1800 miles @ $.40 = 720
Materials & Misc.

FY87 Total $14,000

Budget: FY88

Field Surveys - 8 crew-days @ $685 = $ 5,480
Student Assistance - Crack mopping & measurements,
  & data processing 1 month @ = 2,500
Per Diem Expenses: 6 days @ $90 = 540
Vehicle Mileage: 1200 mile @ $.40 = 480

FY88 Total = $ 9,000

Budget: FY89

Final Data Analysis & Plotting 1 - Student month @ $2,000 = $ 3,000
Report Writing DOT Research - 2 weeks @ $2,000 = 4,000
Printing & Distribution 1,000

FY89 Total = $ 8,000

Total Budget Summary:

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Project Total $51,000

Project Start 4/15/86
Project Completion 3/30/89
Duration 3 years
"Bonanza Creek" fill - Parks Highway
multi-layer geotextiles under construction
10/16/1986
October 16, 1986

Bonanza Creek fill - Parks Highway V-C - Looking West

October 16, 1986

"Bonanza Creek" fill, Parks Highway, U.C. - Looking East;
Geotextiles & culvert excavation visible
"Bonanza Creek"
Parks Highway
Culvert Replacement
Rock bedding on geotextile
10/16/1986

"Bonanza Creek"
Parks Highway
Culvert Replacement
Drag line rests on a log corduroy for support in muck
10/16/1986