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16. Abstract

This report presents the results of the investigation of twenty projects exemplifying the use of geotextiles by the Alaska Department of Transportation and Public Facilities. These projects fall into three categories: subdrainage and riprap liners, embankment separation and reinforcement, and paving overlays. The report is introduced with a status of geotextile manufacture and design followed by a description of geotextile properties. Each section begins with a discussion of the principles for the use of geotextiles which is followed by the case histories. Based on the experience gained in the case histories and existing literature, recommendations for the use of geotextiles are presented along with recommended specifications. The report concludes in saying that the use of geotextiles in Alaskan engineering will continue to grow as designers become more familiar with existing design techniques and as research learns about the functions of geotextiles.

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APPLICATION OF GEOTEXTILES IN ALASKA

Final Report

by

Eric G. Johnson, P.E.

August 1983

State of Alaska
Department of Transportation and Public Facilities
Division of Standards and Technical Services

for

Division of Planning and Programming
Research Section
2301 Peger Road
Fairbanks, Alaska 99701

in cooperation with
U.S. Department of Transportation
Federal Highway Administration

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ABSTRACT

This report presents the results of the investigation of twenty projects exemplifying the use of geotextiles by the Alaska Department of Transportation and Public Facilities. These projects fall into three categories: subdrainage and riprap liners, embankment separation and reinforcement, and paving overlays. The report is introduced with a status of geotextile manufacture and design followed by a description of geotextile properties. Each section begins with a discussion of the principles for the use of geotextiles which is followed by the case histories. Based on the experience gained in the case histories and existing literature, recommendations for the use of geotextiles are presented along with recommended specifications. The report concludes in saying that the use of geotextiles in Alaskan engineering will continue to grow as designers become more familiar with existing design techniques and as research learns about the functions of geotextiles.

CHAPTER I

INTRODUCTION

Geotextiles were first used behind a concrete block revetment in Florida in 1958. During the 1960's many projects were constructed using geotextiles for drainage and erosion control. In the 1970's the use became widespread, including subgrade reinforcement and separation. At that time one geotextile was usually sold for all applications. By the late seventies geotextiles were beginning to be produced for specific applications. Today large varieties of geotextiles of various types and strengths are being manufactured. To the general engineer inexperienced in geotextiles, this presents a bewildering problem. This report seeks to remedy this, by presenting a general overview and case histories of Alaska projects to familiarize him or her with geotextiles.

Geotextiles are a marriage of two fields: the textile industry and civil engineering. This presents several problems. Many tests used to evaluate geotextiles were initially developed for testing other textiles such as for garments or carpets. Other tests are used for manufacturing quality control. Because of this, some tests do not simulate field performance. The American Society of Testing and Materials is currently trying to develop standard tests. The tests being used today may be replaced or improved in the future.

Since the use of geotextiles is relatively new when compared to other engineering materials, much of the theory of design is still being developed. Much laboratory research has been done on the performance of geotextiles, but many of the results have not been verified in the field because of their complex behavior. As a result, while some areas of geotextile design lend themselves to rigorous analysis, other designs must be based on matching the best geotextile to the situation.

The Alaska Department of Transportation and Public Facilities has been using geotextiles since 1974. This report presents selected case histories of Alaska projects exemplifying the use of geotextiles. The projects are reviewed and where possible analyzed, but most are evaluated in terms of specifications and field performance. The uses investigated include sub-surface drainage filters, riprap liner, embankment layer separation, embankment reinforcement, and pavement water proofing and reinforcement. At the end of each chapter recommended specifications are presented for each use. These specifications are based on the latest research and may change in the future as new information becomes available. It is emphasized that this is not intended to be a design manual. It is meant to provide the transportation designer with a method for selecting geotextiles for most general cases. If a rigorous design is required for a special case it is recommended that a geotechnical engineer be consulted.

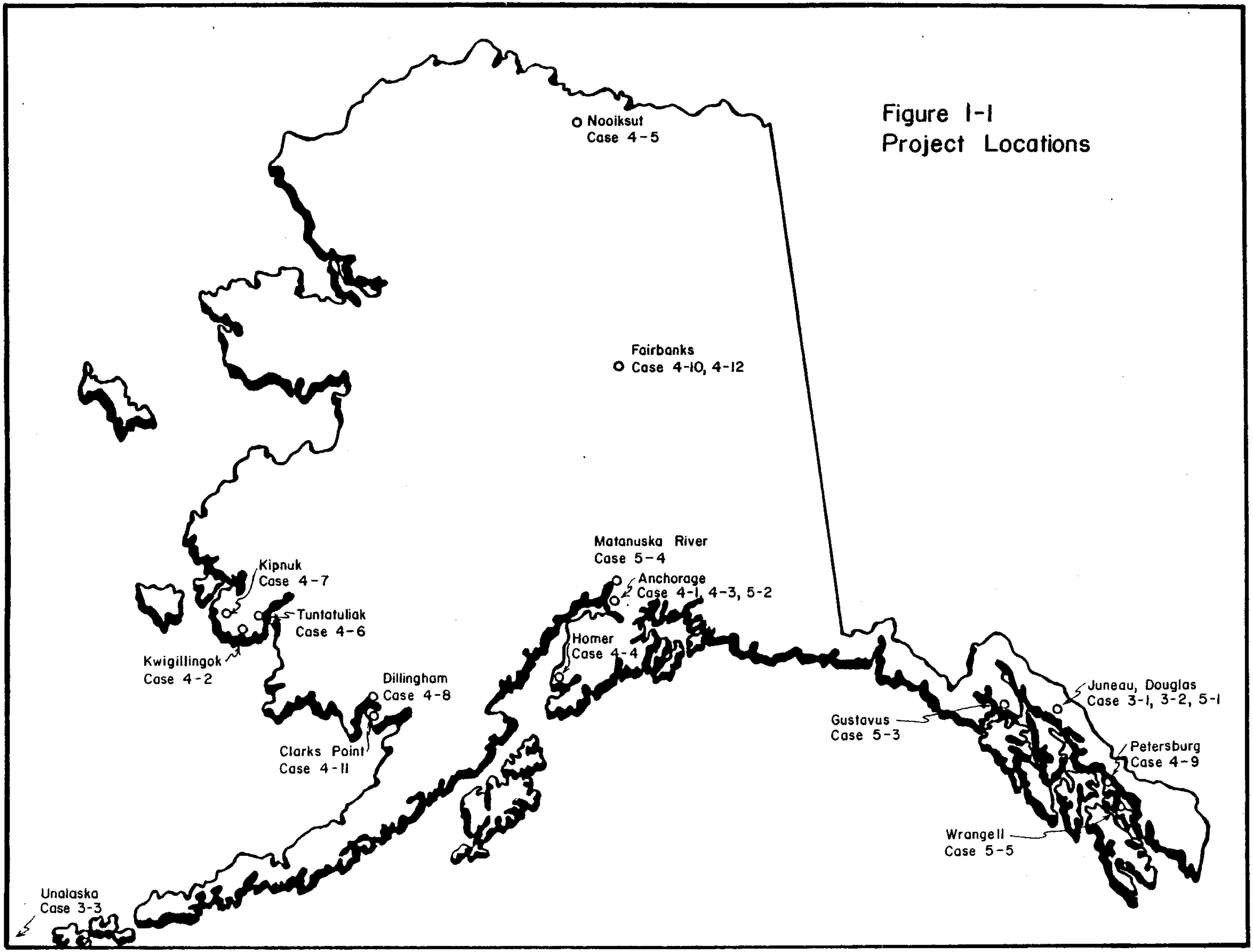

Figure 1-1
Project Locations

TABLE 1-1

PROJECTS INVESTIGATED

(For locations see Figure 1-1)

		Geotextile Function	Geotextile Name & Type	Quantity Sq.Yd.	In Place Cost-$
3-1	Brotherhood Bridge to Auke Bay	Subdrain	Mirafi 140 Nonwoven	10,000	--
3-2	Cordova Street to Douglas	Subdrain	Mirafi 140 Nonwoven	10,000	--
3-3	Unalaska Bridge	Riprap Liner	Typar 3401 Nonwoven	3,000	--
4-1	Minnesota Extension Phase I	Separation and Reinforcement	Mirafi 500X Woven	18,700	1.10
4-2	Kwigillingok Airport	Reinforcement	NA	--	--
4-3	Anchorage International Airport, North-South Runway	Separation	Mirafi 500X Woven	77,000	--
4-4	Homer Bypass	Separation	Mirafi 500X Woven	4,500	1.55
4-5	Nooiksut Streets	Separation	Typar 3401 Nonwoven	--	2.50
4-6	Tuntatuliak Airport	Separation and Reinforcement	Typar 3401 Nonwoven	30,000	--
4-7	Kipnuk Airport	Separation and Reinforcement	Mirafi 140	30,000	--

		Geotextile Function	Geotextile Name & Type	Quantity Sq.Yd.	In Place Cost-$
4-8	Dillingham Materials Site Access	Separation and Reinforcement	Mirafi 140 Nonwoven	300	--
4-9	Tongass National Forest (Petersburg)	Separation and Reinforcement	Fibertex Needle-Punched	500	--
4-10	Phillips Field Road	Separation	Typar 3401 Nonwoven	13,000	1.50
4-11	Clarks Point Road	Separation and Reinforcement	Mirafi 500X Woven	4,700	1.28
4-12	Chena Hot Springs Road	Reinforcement	Typar 3401 Nonwoven	13,000	1.48
5-1	North Douglas Highway	Paving Overlay	Petromat Nonwoven	8,600	2.50
5-2	Elmendorf Air Force Base	Paving Overlay	Petromat Nonwoven	6,000	1.88
5-3	Gustavus Airport	Paving Overlay	Bidim Nonwoven	52700	--
5-4	Matanuska River Bridges	Bridge Membrane	Petromat Nonwoven	2,000	--
5-5	Wrangell Airport	Paving Overlay	Amopave Nonwoven	105,800	0.65

General References

1-1 Koerner, R. M. and J. P. Welch, Construction and Geotechnical Engineering Using Synthetic Fabrics, John Wiley & Sons, New York, 1980.

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1-3 Haliburton, T. A., J. D. Lawmaster, and V. C. McGuffey, "Use of Engineering Fabrics in Transportation-Related Applications." for FHWA Office of Development, October 1981.

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CHAPTER II

GEOTEXTILE DESCRIPTION AND PROPERTIES

Description: Geotextiles are permeable, synthetic fiber fabrics used in the construction of civil engineering projects. There are many other names for geotextiles. Some of these are: engineering fabrics, geofabrics, plastic filter clothe, filter fabric, and synthetic fabric. The international term for these materials is geotextiles, which comes from the latin "geo", meaning soil, and "textilis", meaning woven fabric. Geotextiles are manufactured from various synthetic materials. The most popular of these are polyethylene, polyester, and nylon.

Geotextiles fall into three broad categories based on the method of manufacture: nonwoven, woven, and composite. Nonwoven geotextiles include spunbonded and needlepunched. Spunbonded geotextiles are constructed by randomly extruding a continuous filament over a belt and then bonding it by heat or resin. With the needlepunch process, the fibers are mechanically entangled by punching needles through the geotextile. Woven geotextiles are generally constructed of a monofilament, multifilament or slit film strands crossing each other at right angles. Because of the strength of the filaments used in the manufacturing process, woven geotextiles are generally stronger than nonwovens of the same weight. Very strong geotextiles are manufactured with steel strands woven into the synthetic filaments. Composite geotextiles are contructed of woven and nonwoven geotextiles sewn together. A more complete description of the manufacture of geotextiles can be found in reference 2-1.

Properties: The following is a general description of the physical properties of geotextiles shown in manufacturers' literature and used for construction project specifications. For a complete description of all physical properties, laboratory tests, and their significance, see the references listed in the Bibliography.

Grab Tensile Strength: The strength of the geotextile of a specific width (usually 4 inches) gripped in 1 inch jaws.

Elongation at Failure: The percentage increase in length at failure expressed as the ratio of the length at failure to original length.

Mullen Burst Strength: An inflated rubber membrane is used to distort the geotextile out of its plane until it bursts.

Permeability: An adaption of the normal soil permeability test. Measures the rate of diffusion of water under pressure through the geotextile. Because geotextiles are relatively thin a better measure of this ability is the water flow rate.

Water Flow Rate: The volume of water that will pass through the geotextile at a given head for a given period of time.

Equivalent Opening Size: The size of the openings in a geotextile expressed as an equivalent U.S. Standard Sieve No.

Trapezoidal Tear Strength: The force required to continue a tear in the geotextile.

Puncture Strength: The resistance of a geotextile to penetration by a blunt object.

Ultraviolet Stability: The ability of a geotextile to resist degradation due to exposure to ultraviolet light.

Thermal Shrinkage: The amount of shrinkage of a geotextile at a specified temperature expressed as a percentage of the original length.

Most of these tests for these properties were developed for the textile industry and were not meant to measure properties for engineering applications. They represent a marriage between the textile industry and civil engineering. The tests may change in the future to provide a better measure of engineering performance.

Geotextile Desciption and Properties

References

2-1 Koerner, R. M., and J. P. Welch, Construction and Geotechnical Engineering Using Synthetic Fabrics, John Wiley & Sons, New York, 1980.

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2-4 Haliburton, T. A., J. D. Lawmaster, and J. G. McGuffey, "Use of Engineering Fabrics in Transportation-Related Applications," for FHWA Office of Development, October 1981.

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CHAPTER III

SUBSURFACE DRAINAGE AND RIPRAP LINER

In this function the geotextile acts as a soil restrainer rather than a true filter. The intent is to prevent the soil particles from moving out of their position and through the geotextile thereby clogging it or being blocked behind the geotextile blinding it. The openings must be large enough to allow the passage of water and small enough to retain the soil. Two criteria are required: permeability and retention.

Subdrains:

It has been long recognized that geotextile encapsulated drains have many advantages over drains with graded granular filters: a geotextile is cheaper than the equivalent granular material; costs less to install; and has a higher percentage of success. The state of Alaska has installed several geotextile encapsulated drains. This report will discuss two drains installed in the Juneau area. (See Location Map, Figure 1-1.)

Case 3-1 Brotherhood Bridge to Auke Bay

This project consisted of reconstructing and widening a two lane road in a side hill cut into a 20^{o} cross slope. A fabric encapsulated drain 2 feet wide by 5 feet deep was constructed in the uphill ditch as shown in Figure 3-1. The drains were constructed 300 feet long with a 42 foot length of 8" perforated pipe at the outfall. The drain was backfilled with coarse concrete aggregate. The fabric selected for this project was Mirafi 140S; a nonwoven, polypropylene fabric.

In the spring of 1982, 8 of the 10 drains investigated were flowing. Two drains were selected for further investigation: one flowing and one with no flow. Figure 3-1 shows a profile of the soils encountered in a backhoe trench dug directly behind each drain. The flowing drain was found to be buried in approximately 3 to 4 feet of fine fibrous organics underlain by 6 inches of gravelly sand overlying a dense clayey silt till. All water was found to be flowing in the sand layer which intercepted the drain 2.5 to 3 feet from the surface. The fabric in the side of the trench had a thin layer (< 1 mm) of organics and fines against and inbedded in the fabric from the top of the sand layer down to the bottom of the trench. Above the sand layer the fabric was essentially clean. The drain with no flow was found to be buried in the dense clayey silt till. No water was flowing in the till so that no water was reaching the drain.

To evaluate the performance of the fabric in the working drain, a falling head permeability test was performed on a sample of fabric taken from where the sand layer intercepted the drain. The permeability of the fabric with embedded soil was found to be 0.001 cm/sec. The Darcy permeability of sand, as determined from gradation, was calculated to be .04 cm/sec. The reported initial fabric permeability was 0.1 cm/sec. It appears that during operation of the drain, fines moved into and adjacent to the faric, reducing its permeability from 0.1 to 0.001 cm/sec. The final permeability substantially conforms with Giroud's (Reference 3-1) permeability criteria:

$$k_{fabric} > 0.1\ k_{soil}$$

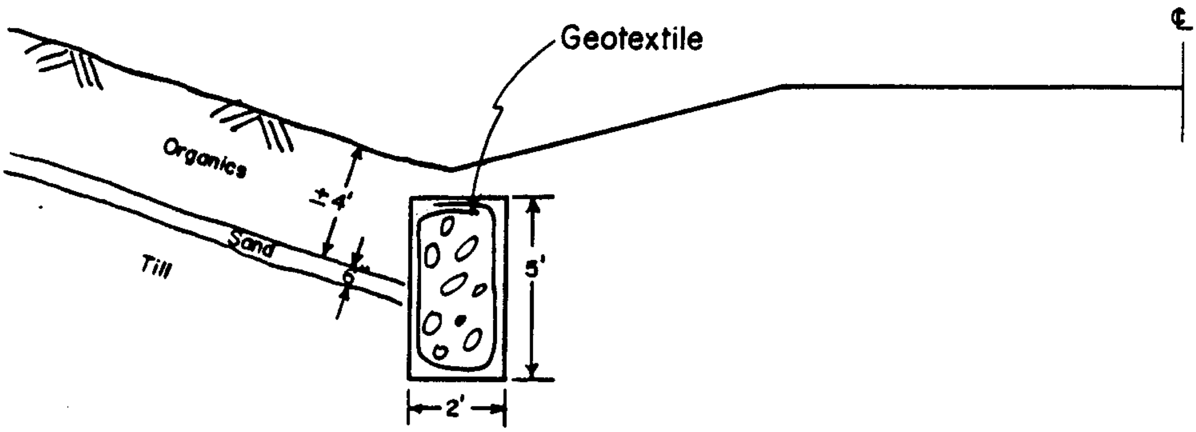
It appears that the classical filter permeability criteria of $k_{filter} > 10 \times k_{soil}$ may be overly conservative with respect to geotextile permeability and that the fabric reaches the lower permeability by trapping fines.

To further evaluate the successful drain, the maximum inflow and outflow were calculated. Since only the 6 inch sand layer was carrying the water its maximum capacity was checked. With a 20% slope, 0.04 cm/sec permeability and 300 foot drain length the maximum in-flow would be 22.0 gallons per minute. The calculated permeability of the coarse concrete aggregate drain backfill is 7 cm/sec. The trench was 2 feet by 5 feet with a slope of 3 percent. This yields a potential outflow capacity of 34.0 gallons per minute. the drain capacity is adequate for the conditions on this project. It can be seen that if the sand layer had been much thicker than 6 inches a perforated pipe would have been required in the drain to increase its capacity.

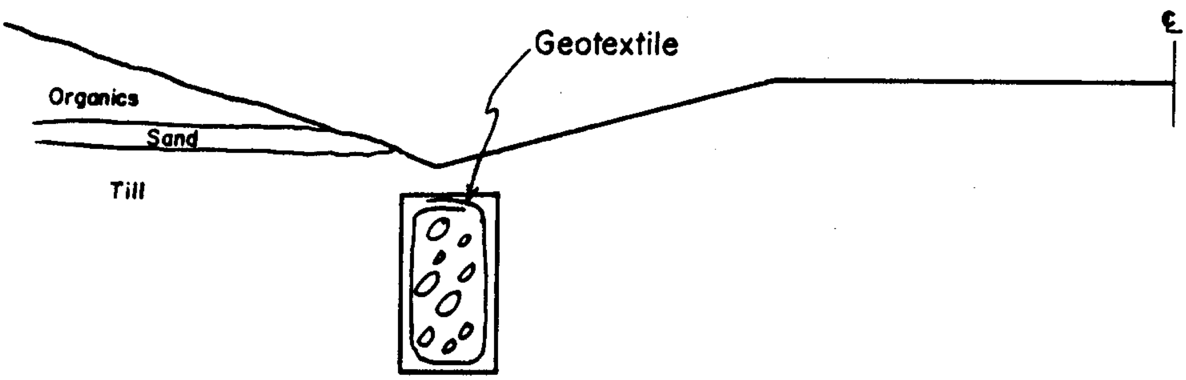
During the course of construction, surface water was allowed to flow into some of the drains. Fines in the water clogged the geotextile. This should be prevented as much as possible. This illustrates the fact that for the geotextile to work it must be designed to restrain the soil from movement rather than act as a filter.

Case 3-2 Cordova Street to Douglas

This project is located on Douglas Island across the Gastineau Channel from Juneau. The roadway section consisted of a sidehill cut-fill with the fill retained by a soldier pile retaining wall. Geotextile encapsulated



a Successful Drain, Drainage Layer Intercepts the Drain



b Unsuccessful Drain, Drainage Layer Does Not Intercept the Drain

Figure 3-1, Brotherhood Bridge to Auke Bay subdrains similar to those used on the Brotherhood Bridge to Auk Bay Project (Case 3-1) were constructed with Mirafi 140S. All drains worked well except for one. Here a 2 inch pipe drain from around a house was discharged directly into the side of the drain through a hole in the geotextile. The drain backed up and the owner of the house disconnected the drain and let it flow on the surface. The outflow capacity of the geotextile drain is 30 gallons per minute with no perforated pipe, using methods shown in Case 3-1. The 2 inch pipe at a 10 percent slope has a capacity of approximately 70 gallons per minute. It can be seen that the drain from the house probably saturated the geotextile drain. These calculations also show that pipes should not be discharged in geotextile encapsulated drains.

Subdrain Recommendations

1. A backhoe trench should be dug at proposed subdrain locations during the materials investigation. This will determine if the drain will intercept the ground water and determine soil gradations to estimate permeability.

2. The in-flow and out-flow for each drain should be calculated to properly size the capacity of the drain.

3. Filter criteria and specifications for geotextiles should be adopted as presented in Table 3-1.

Riprap Liner:

Case 3-3 Unalaska Bridge

A geotextile was installed in June of 1979, as a filter between the riprap and 1 1/2:1 embankment slope on the bridge approach fills. (See Figure 3-20). The original design did not include the geotextile. The embankments were to be constructed of shot rock, but the rock broke down during handling creating a large amount of fines. All riprap installations in the area showed that the fines had leached through the riprap causing the riprap to drop into the water and expose the embankments to erosion. To prevent this, Typar 3401 was placed on the embankment from the toe of the fill (underwater) up to elevation 12. The fabric was first installed by hanging the rolls from a crane with steel pipe. The free end of each roll was placed at the toe with the help of a diver. Later, because of the high winds, the spools were placed on saw horses at the top of the embankment and the free end of the fabric was pulleddown the embankment and underwater by the diver. A six inch gravel blanket was placed over the fabric and Class III riprap was placed on top of this. Class III riprap has 10 percent stone greater than 7 tons and 50 percent greater than 3.5 tons. The layer of gravel protected the geotextile from puncture by the riprap and kept the geotextile in place and kept the geotextile in intimate contact with the protected soil, thereby preventing movement of the soil particles which could blind or clog the geotextile.

Investigation: In June of 1982 the installation was inspected. It was found that all the gravel above the fabric had washed out through the

Photo 3-1, Geotextile failure due to ultraviolet light exposure, Unalaska Bridge Riprap Liner, Case 3-3.

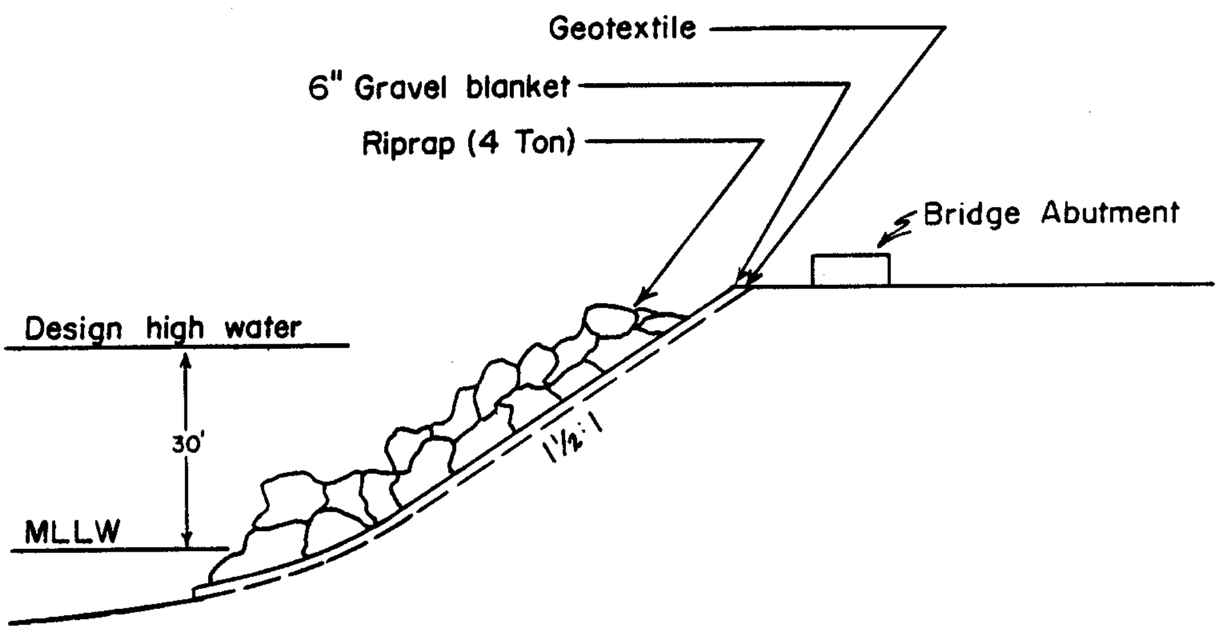


Figure 3-2 Unalaska Bridge Abutment

riprap voids exposing the fabric to sunlight. On the south embankment all riprap was in place. The fabric was wrinkled. On the north abutment fill, the riprap in the line of direct wave attack was absent, exposing large areas of fabric. The exposed fabric had degraded badly due to ultraviolet light. The fabric could be torn like paper. In this area the embankment was composed of a large amount of fines. At one point the material had flowed down behind the fabric indicating that excess water had been trapped behind the fabric.

Analysis: Experience has shown that in critical installations a geotextile with a minimum of 4 percent open area is required (Reference 3-2). If the percent open area is below this, geotextiles installed in high hydraulic gradients will clog. To obtain this percentage open area a woven geotextile is required.

Recommendations:

1. A minimum of 4 percent open area should be required for riprap liner and other critical installations such as behind a retaining wall, where clogging of the geotextile will cause failure of the installation.

2. Geotextiles used for these installations should be woven and stabilized against ultraviolet light.

3. Filter criteria and specifications for geotextiles should be adopted as presented in Table 3-1.

4. A minimum thickness of 6 inches of gravel bedding material should be placed over the geotextile prior to placement of the riprap. (Reference 3-3). The gradation for this layer should be designed using standard criteria for graded filters.

TABLE 3-1

RECOMMENDED SPECIFICATIONS

SUBSURFACE DRAINAGE AND RIPRAP LINER

General Description: The geotextile shall be a woven or nonwoven fabric consisting only of long chain polymeric filaments or yarns such as polypropylene, polyethylene, polyester, polyamide, or polyvinylidene-chloride formed into a stable network such that the filaments or yarns retain their relative position to each other. The geotextile shall be inert to commonly encountered chemicals and conform to the properties in the following table.

		Geotextile Requirements[1]		
		Subsurface	Riprap Liner	
Geotextile Property	Test Method	Drainage	Unprotected	Protected
Grab Tensile Strength, lbs, min	ASTM-D-1682	90	200	100
Grab Tensile Elongation, %	ASTM-D-1682	15-100[2]	15-70[2]	15-70[2]
Burst Strength, psi, min	ASTM-D-751	125	500	250
Trapezoid Shear, lbs, min	ASTM-D-2263	25	50	50
Equivalent Opening Size, U.S. Standard Sieve	CW 002215	See Below[3]	See Below[3]	See Below[3]
Water Permeability, k, cm/sec., min	AASHTO M288	k(soil)	10 x k(soil)	10 x k(soil)
Water Flow Rate, gal/min/ft^2, min	AASHTO M2882	40	40	40
Percent Open Area, min	COE Method	N/A	4	4
Ultra violet Radiation % Strength, Stability Retention, min.		N/A	90	90
Mildew, Rot Resistance % Strength Retention, min	AATCC-395	95	95	95

1. 95% confidence of exceeding this figure in both directions
2. Between this range
3. A. Soils with 50% or less particles by weight passing No. 200 sieve: EOS No. (fabric) $\geq$30 sieve
   B. Soils with more than 50% particles by weight passing U.S. No. 200 sieve: EOS No. (fabric) $\geq$50 sieve

Subsurface Drainage and Riprap Liner

References

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3-7 Wood, P.D., C. Hayes, and T.A. Haliburton, "Comparative Hydraulic Performance Evaluation of Geotechnical Fabrics," Research Report to Carthage Mills Erosion Control Company, by Haliburton Associates, Stillwater, Oklahoma, December, 1980.

CHAPTER IV

EMBANKMENT SEPARATION AND REINFORCEMENT

This application of geotextiles is a complex combination of several related functions. The first is separation. Here the geotextile prevents intrusion of the granular embankment material into a soft subgrade and prevents pumping of the fines up into the granular material. The second function is lateral reinforcement. This function provides restraint against horizontal movement of the soil. The third function is to provide subgrade restraint whereby local shear failures are prevented. This effectively increases the bearing capacity and reduces the required granular overlay thickness. Finally the geotextile provides membrane support of wheel loads. This is provided where the granular overlay is thin and the roadway is allowed to deflect. Another benefit that has been demonstrated in the laboratory, but not confirmed in the field, is that of capillary cutoff (Reference 4-1). This may reduce spring time deflections by reducing the amount of moisture in the base or subbase.

Alaska's soft soils generally consist of peats and cohesionless silts. While these soils can initially be very weak, once confined and the excess moisture squeezed out, they become quite strong. For embankments greater than about 3.5 feet thick, geotextiles are not required for the long term condition. The critical time is during construction. A second critical time exists for low volume roads with thin granular overlays during the spring when the underlying silts are in a thaw-weakened condition.

The design and selection of geotextiles for embankment separation and reinforcement falls into two categories: embankments thicker than 3.5 feet and embankments thinner than 3.5 feet. For most embankments this will result in a use specification rather than a true design. The following paragraphs explain the reasons for the specifications. If a situation arises that requires stronger fabrics a Geotechnical Engineer should be consulted.

For embankments greater than 3.5 feet thick, the geotextile acts mainly as a separator, providing strength only for the initial lift. For embankments or initial lifts thinner than 3.5 feet, the geotextile begins to be affected by the wheel loads. The geotextile acts to prevent local shear, only allowing general shear to occur. This represents an effective increase in the initial bearing capacity of approximately 80 percent. The initial lift thickness over the geotextile is then governed by the contractor's choice of equipment, over which the designer has little control, as well as the subgrade strength. For most Alaska soils, this benefit is effective only just after initial construction. Once the subgrade has consolidated and gained strength and reached a CBR value of 3 or greater, the geotextile acts only as separator. Research has shown that geotextile strength or type does not affect the function of this design (Reference 4-20). Therefore minimum strength requirements are needed. These specifications are presented at the end of the chapter. Over muskeg a woven geotextile is recommended.

A method for design using geotextiles as reinforcement for roadway embankments over voids caused by thawing permafrost ice wedges, has been developed (Reference 4-21). A field trial of this method is presently being conducted to evaluate its conclusions. For this application a geotextile that is very stiff and has a high tensile strength is required. If the use of geotextiles is contemplated over permafrost this method of design is recommended.

This chapter presents selected case histories from the Alaska Department of Transportation and Public Facilities projects since 1974. Many more were investigated. Those presented here were chosen to provide examples of uses and highlight some problems and successes. It is hoped that they will provide the design engineer with an appreciation for the use of geotextiles for embankment separation and reinforcement.

Case 4-1 Minnesota Extension Phase I

This project includes construction over two miles of peat by stage construction and surcharge, and insulation of silty clay in a cut to prevent differential frost heave. A geotextile was used in three different applications.

The first application was separation of peat and granular embankment in a transition from full peat excavation to no peat excavation. (See Figure 4-1.) The 50 foot zones were designed to provide smooth transitions from peat excavation to overlay, thereby reducing the effects of any long differential settlement. The fabric was used to prevent mixing of the embankment material with peat disturbed during partial excavation. Mirafi 500X, a woven split tape polypropylene geotextile, was used though a weaker non-woven fabric would have probably worked as well in this application.

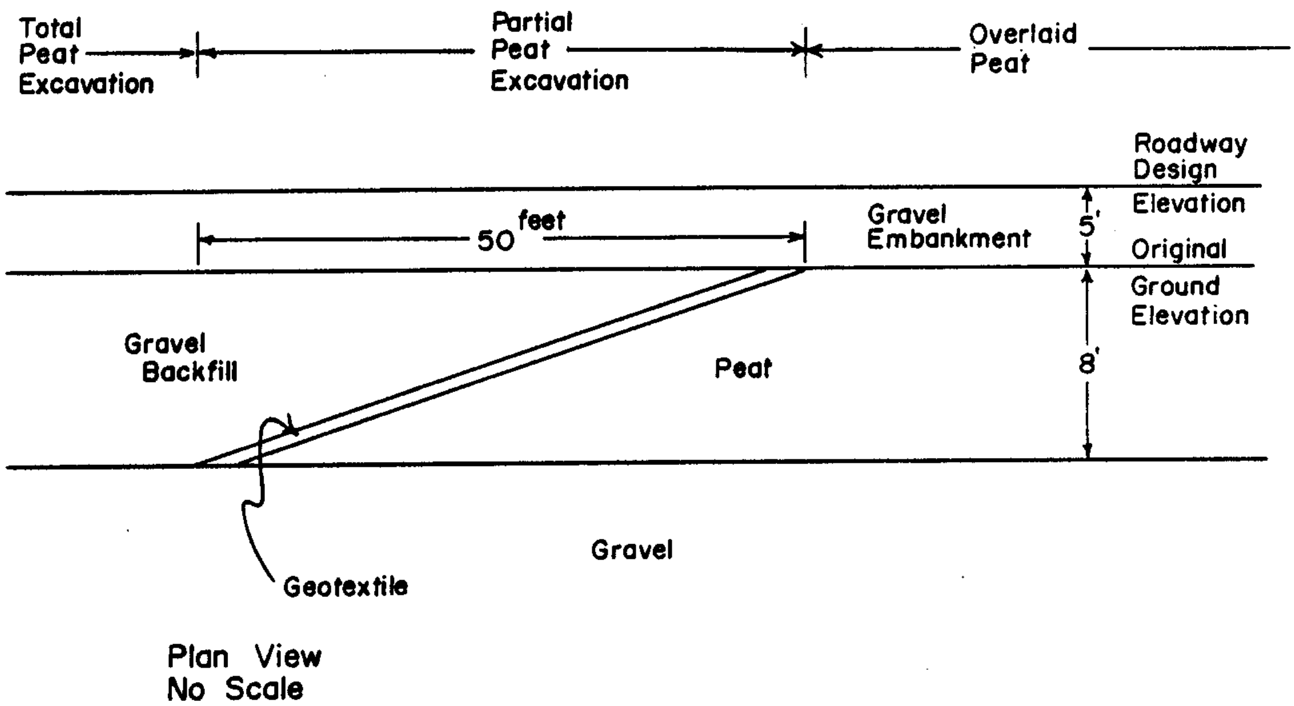

Figure 4-1 Minnesota Extension
Peat Excavation Transition

The fabric was placed transverse to centerline with 1.5 feet of overlap. No problems were encountered during installation.

Mirafi 500X was also used as a separator on the same project under a insulation installation. A 1200 feet long excavation in silty clay and silt was allowed to freeze during the winter. Substantial differential frost heaving occurred because of varying soil types and water conditions. The designed 4 foot embankment would distort badly during the winter making this high speed structure unsafe. To prevent this problem a 4 inch layer of insulation board (high density beadboard, "Geofoam") was included in the embankment. (See Figure 4-2.) The fabric was placed on the silt and silty clay. A 6 inch layer of sand was then placed as bedding for the insulation. No strengths of the silt were taken but pickup trucks were able to drive on the sand covered geotextile. This allowed the insulation to be installed easily and prevented the sand from mixing with the silt and silty-clay.

During construction of the embankment above the insulation, rock dumps loaded with peat were allowed to run over the embankment. At this time there was 2.5 feet of cover over the silt. As the trucks moved over this section it was possible to see the roadway visibly deflect. This continued for several days until the silt set up. Once the excess moisture was squeezed out of the silt the deflections were not visible. The fabric kept the silt and embankment separate while the silt was in this initial weak condition.

In June of 1982 the embankment was excavated to view the performance of the fabric. The sand above the geotextile was sampled to determine if any

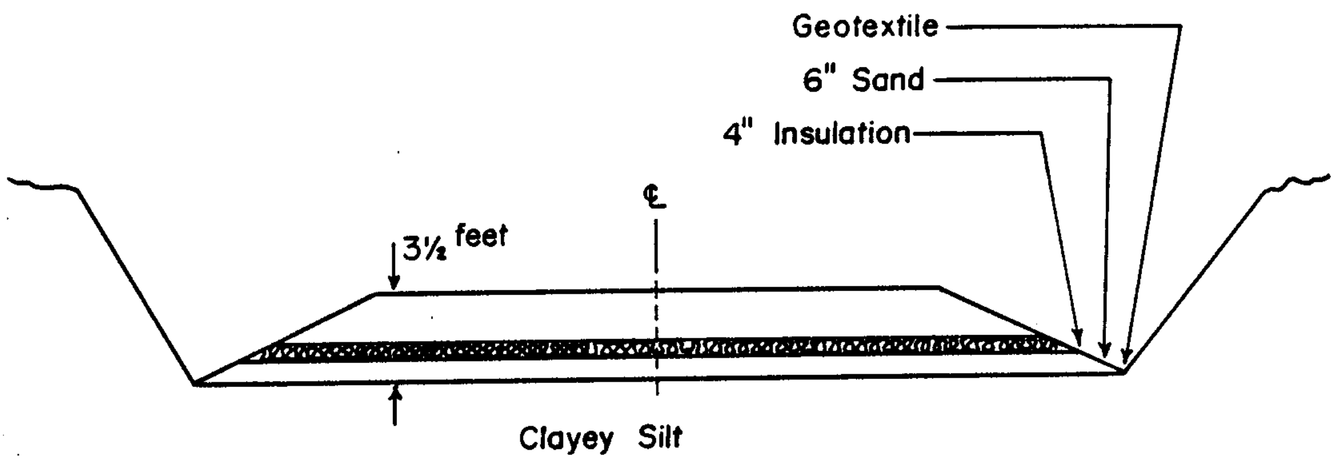

Figure 4-2, Minnesota Extension Insulated Section fines had pumped through the fabric. The fines content (minus No. 200 sieve) was found to be 8%, which was the average fines content of the sand at the time of its placement. It appears that no significant fines were pumped through the fabric. The clayey-silt was sampled and found to have a moisture content of 17.5% which is fairly dry for this material. It is hard to draw conclusions from this since the initial moisture content of the clayey silts is unknown, but the clay-silts in the ditch adjacent to the site, 20 feet from the point sampled, are saturated and water is flowing in the ditch.

In a third application, Mirafi 500X was used to reinforce and separate the embankment from weak amorphous peat in an old drainage path. The upper 2 to 3 feet of peat had a minimum shear strength of 54 pounds per square foot and an average strength of 94 pounds per square foot. At a depth of 5 feet the peat increased in strength to a minimum of 370 psf and an average of 394 pounds per square foot. The intent of the design was to hold the embankment together while displacing the upper 2 to 3 feet of peat. The embankment was to rest on the firmer peat at depth. The fabric was laid perpendicular to centerline with 3 feet of overlap. The initial lift of 5 feet of gravel was end dumped and dozed out over the geotextile. A peat wave was pushed up ahead of the embankment. Approximately half way across the drainage channel the peat wave had to be excavated with a backhoe. This was done again when the end of the peat deposit was reached.

The embankment was constructed to grade and then surcharged to remove the long term peat settlements. A piezometer located in the center of this section showed that consolidation of the amorphous peat was taking much

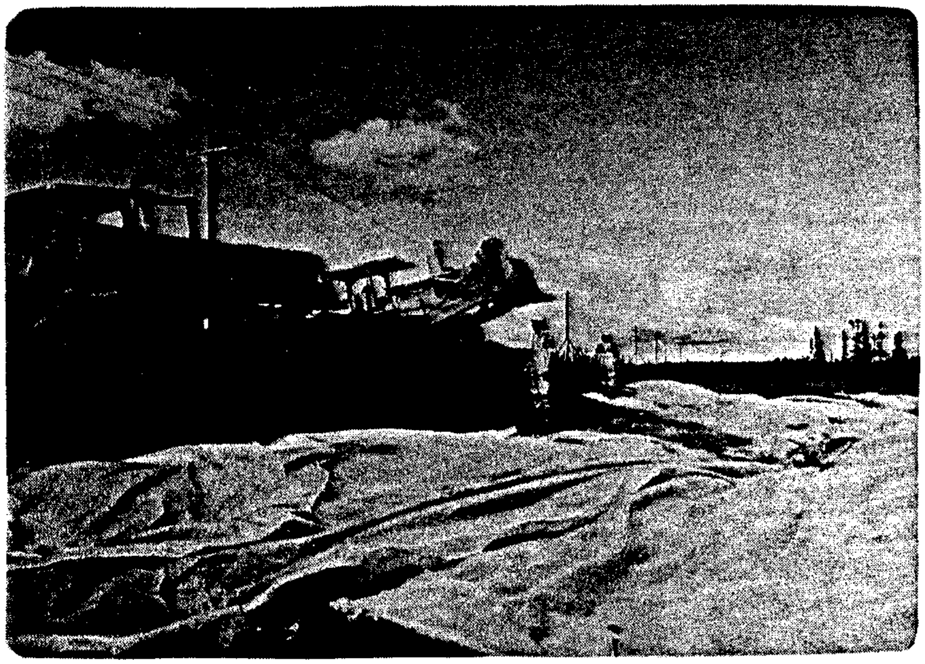

Photo 4-1, Geotextile used for separation and reinforcement, Minnesota Extension Displacement Area, Case 4-1.

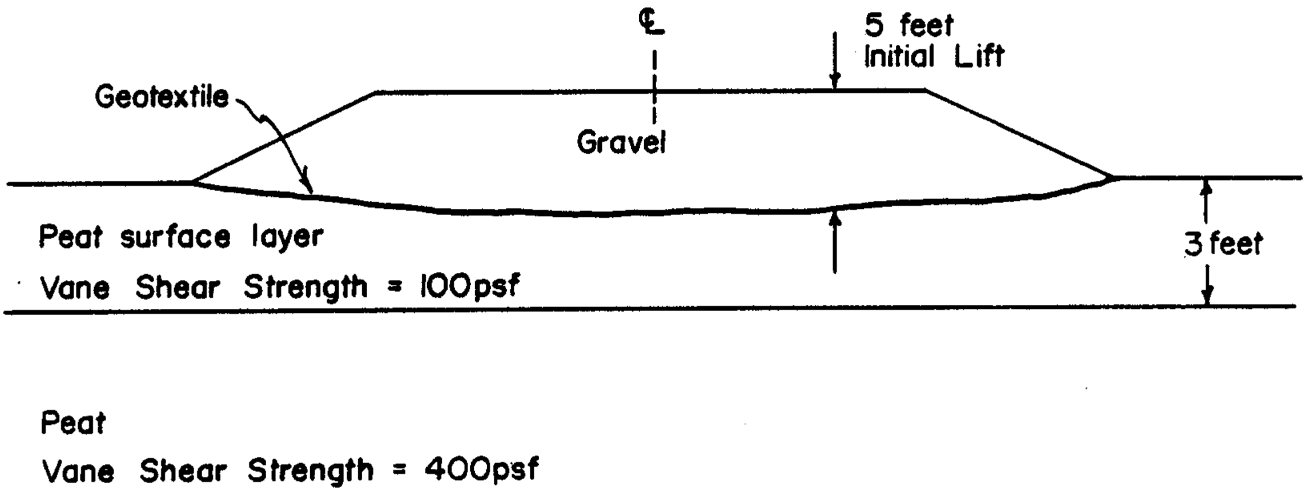

Figure 4-3 Minnesota Extension Displacement Section

longer than the adjacent fibrous peat section. This had not been anticipated. The amorphous peat had not been sampled because it was too weak and the consolidation time for the fibrous peat was used to design the surcharge time. To complete the project as scheduled required an additional two feet of gravel surcharge to be placed over this area.

The question arose as to the possibility of the increased settlement time being due to the presence of the geotextile. To answer this it was postulated that three possible reasons could cause the increased settlement time: 1) the fabric permeability, 2) blinding or clogging of the fabric, and 3) the amorphous peat permeability.

To check the first possible reason, the portion of the excess pore pressure in the peat that was caused by the permeability of the fabric was calculated. It was found that the pore pressure contribution by the fabric was 7.0×10^{-4} psi (Reference 4-4). The insignificance of this number shows that the fabric is so thin that its permeability did not increase the settlement time unless blinding occurred. This is also the conclusion of Vinson (Reference 4-5) and Giroud (Reference 3-1).

The second possibility was addressed by testing the permeability of the geotextile after construction in both the amorphous and the fibrous peat. Falling head permeability tests were run on samples cut from the fabric exposed during the excavation of a utility trench through the embankment. The tested permeability of the fabric over the fibrous peat was only 7.5×10^{-4} cm/sec, while that over the amorphous peat was 2.8×10^{-3} cm/sec.

This indicates that the fabric over the peat with the faster settlement time was clogged more than the fabric over the amorphous peat. Therefore clogging or blinding was probably not the cause of the increased settlement time. It appears then that the increase in settlement time was due to the lower permeability of the amorphous peat as compared to the fibrous peat.

Case 4-2 Kwigillingok Airport

Kwigillingok is located on the Kuskokwim River Delta where there are no local aggregate sources. Aggregates are barged in from a source 90 miles away. The local materials are silts and sandy silts. Construction with these materials is complicated by the fact that they are generally permanently frozen. The usual technique for handling these materials is to construct embankments with frozen silts and sandy silts in the winter. The embankments are then allowed to thaw and consolidate for several years before an aggregate surface is applied.

The design for this airport included a layer of impermeable polyethylene membrane "visqueen" placed on the permafrost. The intent was to allow the 3 feet thick embankment over the membrane to both freeze dry and dry by evapotranspiration of any natural vegetation. The membrane would also prevent additional water from being wicked-up into the upper 3 feet. It was hoped that the membrane would also help bridge the thawing permafrost.

The project was constructed in the spring of 1973. In the fall of 1974 the embankment was probed with a peat sampler to evaluate the possibility of aggregate surfacing. It was found that the upper 3 feet above the membrane was wet. Free water was found just above the membrane. The thawed permafrost below the membrane was saturated. It was determined that the embankment would not support construction equipment. The following summer the visqueen was ripped to allow the embankment to drain.

While this project is not an example of the use of geotextiles, it was included in this study to point out the necessity of fabric permeability. The impermeable membrane blocked drainage of water through the embankment keeping the material above the membrane saturated and unstable. The thawing permafrost was not allowed to consolidate because drainage was blocked upwards. It too, remained unstable due to trapped excess moisture.

Case 4-3 Anchorage International Airport North-South Runway

The design of this runway included a 15 feet deep subcut in silty clay and clayey silt. The pavement design required that the upper 10 feet of the backfill be nonfrost susceptible. The first 5 feet of the sandy gravel backfill was end dumped into place. When fully loaded scrapers started to complete the backfill, they began to pump the silt up through the non-frost susceptible sandy gravel. When the subcut was backfilled, silt could be seen boiling out of the surface of the originally nonfrost susceptible gravel.

To prevent this, Mirafi 500X was placed on the silt at the bottom of subsequent subcuts. Approximately five feet of non-frost susceptible gravel was end dumped over the fabric. With the geotextile in place the pumping did not occur.

Case 4-4 Homer Bypass

The design for this project included up to 6 feet of subcut in a side hill to prevent differential frost heaving of the underlying silt. In the process of making the subcut, water draining from uphill mixed with the silt reducing its strength. When the sandy gravel (up to 12% passing the 200 sieve) backfill was end dumped into the subcut it could not be compacted. The backfill would not drain and construction vehicles had difficulty trafficking it even after several days. No pumping was observed.

When Mirafi 500X was placed in the bottom of the subcut, compaction was achieved and construction traffic had no problem trafficking the backfill material.

Case 4-5 Nooiksut Streets

Nooiksut is located on the North Slope 90 miles west of Prudhoe Bay. The streets were designed with a 5 feet high embankment to protect the permafrost from thaw. Construction was in November of 1980 after the active layer had frozen. The ground was cleared of snow, taking care to disturb the surface mat as little as possible. Typar 3401 was rolled out parallel to centerline with 3 feet of overlap. Frozen gravel was then embanked with scrapers operating directly on the geotextile. No damage to the fabric was noted. There were some problems with wrinkling until the equipment operators got used to driving on the geotextile.

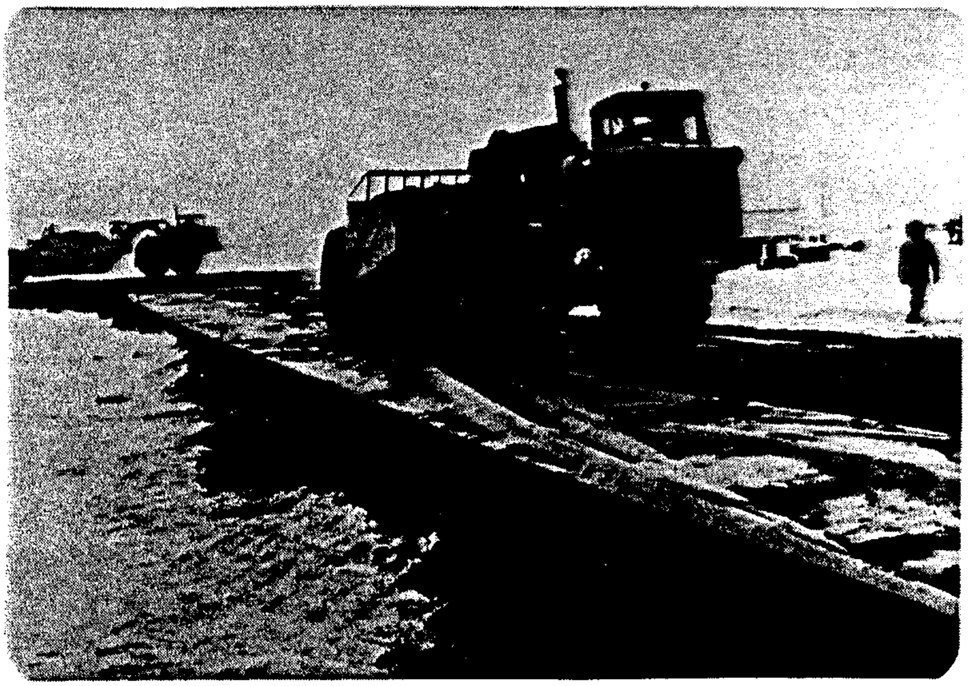

Photo 4-2, Scraper running directly on geotextile, Nooiksut Streets, Case 4-5.

The intent of the geotextile was to separate the embankment material from the thawing permafrost under the side slopes. Permafrost will thaw because of the reduced gravel thicknesses under side slopes. Ordinarily the 5 feet of embankment would protect the permafrost under the roadbed but if thaw reached through the embankment because of unseasonably warm weather or water intrusion, the geotextile would act to keep the gravel from settling into the permafrost. If the gravel was to be re-used at another location more gravel would be retrieved with the fabric in-place. This is a consideration on the North Slope where gravel is expensive and hard to come by.

Case 4-6 Tuntatuliak Airport

Tuntatuliak is located on the lower Kuskokwim River where gravel is scarce, and aggregates have been barged from as far away as Seattle, Washington. The runway embankment was constructed initially of sandy silt and silt. In 1977 the project was overlaid with 1 to 2 feet of gravel. A geotextile was designed to separate the silt from the expensive gravel and provide some additional strength.

Construction began in early spring when the silt was at its weakest strength due to thawing. The contractor selected Typar 3401. To haul the gravel a special vehicle dubbed a "Tundra Truck" was used over the fabric. This was a vehicle originally used to haul fertilizer in rice paddies. It consisted of a tricycle frame with three 4 feet diameter tires pressured to 10 to 12 psi. The truck bed has a capacity of 5 cubic yards. During the construction both the geotextile and underlying silt were pumped up through the gravel. The project was stopped until the silt had drained and gained strength later that summer. The project was then constructed with no problems.

Giroud's method for geotextile reinforcement (Reference 4-6), was used to backfigure the strength of the silt. Using 1 foot of gravel cover and the no rut condition, the strength was found to be approximately 100 pounds per square foot. The calculations also showed that 20 inches of gravel would equal the 12 inches of gravel cover and geotextile. Failure would also have occurred with only 20 inches of cover, and the underlying silt would have been pumped into the gravel. The geotextile prevented this contamination thereby saving the cost of additional gravel, even though a bearing capacity failure did occur.

Case 4-7 Kipnuk Airport

Kipnuk is also located on the Lower Kuskokwim River. The embankment is constructed of sandy silt and was designed with Mirafi 140 and a 6 inch overlay. The project was constructed in the winter when the runway was covered with ice. It was so slippery that a light airplane was blown off the runway. The geotextile was placed on the ice with 6 inches of frozen gravel placed over it. As the gravel was spread over the geotextile, it began to slide over the ice. This caused the fabric to tear. The geotextile was deleted from the project and it was constructed without it. Since then the gravel has disappeared into the silt. A possible solution may have been to freeze-bond the geotextile in place prior to adding the gravel overlay.

Research into the cold temperature geotextile behavior indicates that the mechanical properties do not change significantly at temperatures below freezing (Reference 4-6). Winter construction has been successfully completed with geotextiles on many other projects (See Case 4-5), so that the tearing of the Mirafi was probably caused by a combination of the presence of the ice and the thin lift of frozen gravel.

Case 4-8 Dillingham Materials Site Access

In the summer of 1975, the Alaska Department of Highways in conjunction with the Celanese Corporation constructed a test road with Mirafi 140. The purpose was "to evaluate the savings in gravel depth that can be realized when Mirafi 140 Ground Stabilization and Drainage Fabric is used in the construction of gravel roads over soft organic soils," (Reference 4-7). A 65 feet long test section was constructed with geotextile over peat and compared to an adjacent 50 feet long control section without fabric. The sections were compared after 80 passes of a 40,000 pound front-end loader.

The test section was constructed over a peat deposit averaging 30 inches deep with an average shear strength of 550 pounds per square foot. The average gravel thickness over the geotextile was 18 inches with a minimum of 14 inches. The control section averaged 24 inches with a range of 21 to 26 inches.

The road was evaluated visually after passes with the front-end loader two thirds full. This resulted in a total weight of 40,000 pounds distributed over the 4 single tires. After 10 passes both sections "looked the same."

After 40 passes the section without the geotextile developed a "severe" rut with the presence of water in the rut. With 80 passes the test was terminated and the following subjective conclusions were made:

1. A test section constructed with 14 inches of borrow fill gravel over Mirafi 140 gave slightly superior performance compared to a control test section constructed with 26 inches of borrow fill gravel without the geotextile.

2. A test section constructed with 26 inches of borrow fill gravel over Mirafi 140 gave an order of magnitude superior performance compared to a control test section constructed with 26 inches of borrow fill gravel without fabric.

The report concluded that "this test indicated that a savings of 12 inches (of gravel) can be realized by using Mirafi 140 fabric in gravel road construction over saturated organic soils." While this report was not a rigorous analysis of the fabric performance and the numbers are specific to this test, it does show the advantage of using geotextiles on low volume roads.

Case 4-9 Tongass National Forest

In 1977 the Forest Service constructed a test section approximately 20 miles south of Petersburg over 700 feet of fine fibrous peat (Reference 4-8). The deposit averaged 10 feet deep with a range of 9 to 11 feet. The average moisture content was 960 percent. The peat shear strengths ranged from 50 to 350 psf with an average of 250 psf. These were measured with a 2 inch diameter vane shear device. The geotextile used was Fibretex, a non-woven needle-punched spunbonded polypropylene weighing 12 oz/yd^2. The tensile strength was 800 to 900 lb/ft at 100 to 200 percent elongation. The test section was divided into three sections: 1) single layer of geotextile, 2) double layer of geotextile, 3) no geotextile. The rock size used in the fill was highly variable ranging from 4 feet down to sand. The purpose of the test section was to demonstrate the differences in rock thicknesses required to reach a stable roadway.

Thickness measurements showed that with no geotextile 5 to 7.5 feet of rock was required. With single and double fabric layers the required thickness of rock ranged from 3.5 to 5.5 feet. The savings in rock was reported as about 28 percent. This was attributed to the presence of the fabric preventing local shear failure. Further analysis of the data by use of finite element methods showed that the "main function of the fabric is to prevent local bearing failures" and "when shear failures do not occur, the embankment settlement is essentially the same with or without fabric and independent of fabric type."

Case 4-10 Phillips Field Road

In 1977 this unpaved road in Fairbanks was upgraded with 12 to 18 inches of sandy gravel over the existing sandy gravel fill. The existing 1 to 2 feet thick fill was constructed over an alluvial silt. In the spring soft spots developed because of the lack of adequate cover over the silt. During construction Typar 3401 was placed below the select material in two sections, to separate the silt and gravel. This resulted in three typical sections: 1) 18" of select material with no fabric, 2) 18" of select material with geotextile and, 3) 12" of select material with geotextile. The geotextile was placed with the joints parallel to centerline with 2 feet of overlap. The roadway was sealed with a bituminous surface treatment. No problems developed during construction indicating that the geotextile did perform the function of separation. No difference in performance has been noted between the different sections to date.

It is hard to evaluate the long term performance of this kind of application. Because of its flexibility the geotextile provides no strength vertically. For it to develop strength it must deflect. The gravel overlay and surfacing is designed for low deflections so the fabric cannot deflect and gain strength. Calculations show that for a 0.050 inch deflection (relatively high for a surfaced roadway) the tension in the geotextile will be approximately 10^{-7} pounds. Even though the geotextile provides no strength, the presence of a geotextile in a pavement structure may increase its resilient modulus, thereby increasing the surface life. (Reference 4-1).

Case 4-11 Clarks Point Road

This road is a low volume local service road. The original design included a geotextile placed on muskeg with 2 feet of granular cover. As is typical of most low traffic volume designs no soil strengths were obtained during design due to budget constraints. The intent was to get as much money into actual construction as possible.

During construction in the summer of 1981 a major cut on the project was found to contain silt with a moisture content close to its liquid limit. The material had been planned for use in a large embankment adjacent to the cut. The silt was essentially unuseable in the state encountered so construction was stopped until it drained enough to allow embankment construction. Torvane tests showed the saturated strength to range from 150 to 200 psf. It was decided to place Mirafi 500X over the silt with 1 to 1.5 feet of gravel cover. The embankment was then allowed to drain until it would support a fully loaded 10 yard truck. From Mirafi's design charts the silt had to increase in strength to between 400 to 600 psf to support a 10 yard truck.

In June of 1982, the project was visited to evaluate the performance of the geotextile installations. A portion of the geotextile was exposed by excavation on the silt embankment. The silt just below the geotextile was tested with a torvane and was found to have a strength of between 1000 and 1100 psf. This demonstrates the increase in strength of the silt due to draining and compaction. A sample of the fabric was tested for permeability and was found to have a permeability of 7.7×10^{-4} cm/sec.

Vane shear tests of the peat adjacent to the embankment were taken using a 2 1/2" vane. The minimum vane shear strength was estimated to be 160 psf. This strength has been estimated by reducing field vane strengths by 40% due to the fact that vane shear testing in peat has been found to be dependent on the size of the vane. (Reference 4-9). The 2 1/2 feet thick embankment was excavated and a vane shear test was attempted under the geotextile. The strength was found to be greater than 900 psf, the limit of the test. This increase of strength was due to consolidation of the peat. This demonstrates that the critical time for the geotextile is during construction.

Case 4-12 Chena Hot Springs Road, Fairbanks

This project consisted of reconstructing 350 feet of an existing embankment between two small lakes. The embankment was built over an unfrozen silt and had experienced large settlements and lateral spreading. To allow construction without stabilizing berms and to help make the settlements more uniform, a geotextile reinforced embankment was designed. The design is basically a double geotextile reinforced wall within the embankment with 1 1/2 horizontal to 1 vertical side slopes covering the wall. As shown in Figure 4-4, five layers of fabric were used with 9 inch lifts of Subbase Grading "E" embankment material between, except for one 12 inch lift. The geotextile was placed with geotextile joint parallel to centerline with a 3 foot overlap. The geotextile was placed under the driving lanes, providing a 32 feet wide installation. The outside edge of the fabric was brought up to the geotextile layer above it to form a wall face and then lapped down 4 1/2 inches in 4 feet (Figure 4). This prevented a geotextile to geotextile interface at the face of the wall. The ends of the treated section also formed a wall. A 100 feet transition from no excavation to full excavation was also constructed at both ends.

The project was constructed the summer of 1979 using Typar 3401. The installation has performed well to date. There have been some minor settlements but they are uniform and do not affect the ride. A minor crack

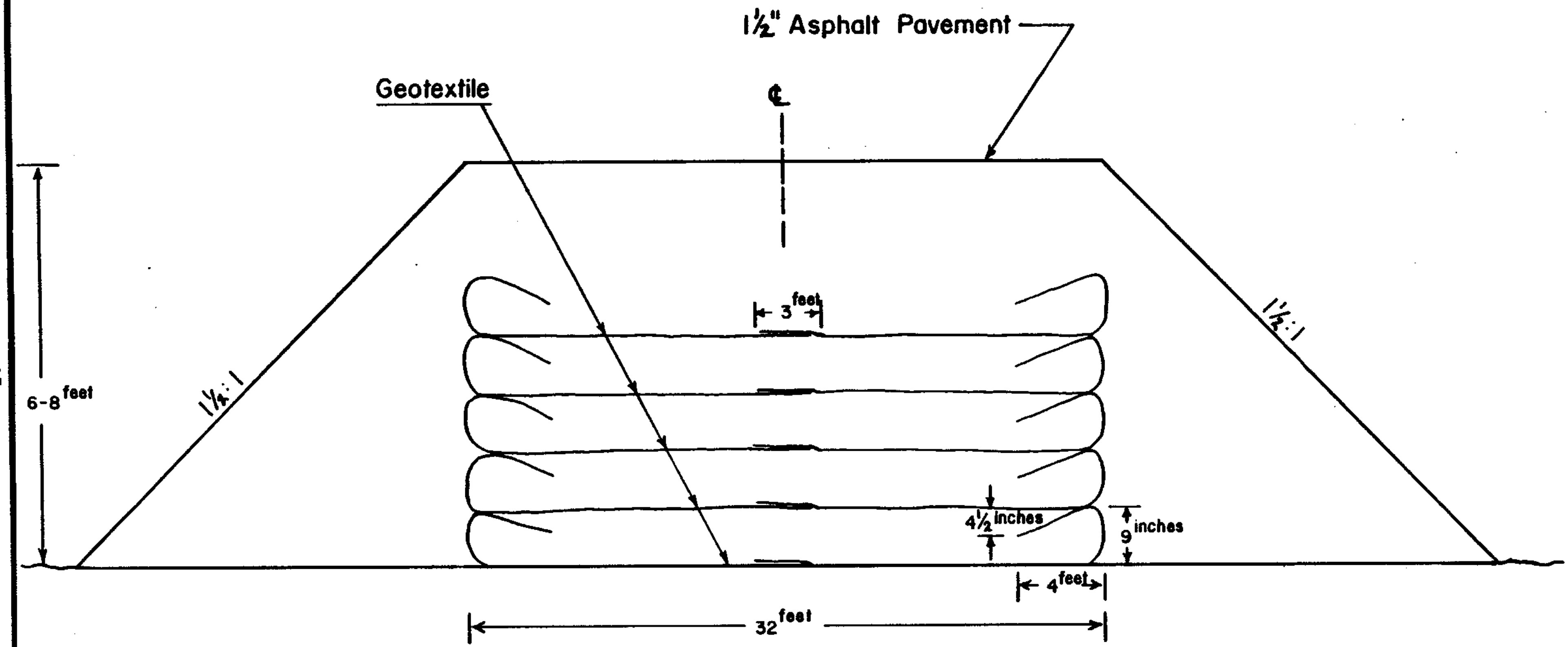

Figure 4-4 – Chena Hot Springs Road Reinforced Embankment has formed at each end of the section. There are no cracks in driving lanes except on the east end where a longitudinal crack comes into the reinforced section for 15 feet and ends. One crack has opened up at the edge of the driving lane for about one hundred feet indicating the shoulder is moving out laterally while the geotextile reinforced embankment core is stable.

This application will not prevent vertical settlements of the underlying foundation because of the flexibility of geotextiles. A geotextile reinforced embankment may work in high embankments over permafrost. Because of thaw at the toe of the embankments and resulting instability cracks and grabens eventually open up in the roadway surface requiring frequent maintenance as well as causing safety problems. This application should act to hold the core of the embankment together thereby preventing the cracks from reaching the riding surface. The geotextile reinforcing should be designed as a free standing wall using the most recent design methods. For an example method, see Reference 4-20.

Recommendations:

1. Specifications shown in Table 4-1 be adopted for embankment separation and reinforcement.

2. Geotextiles should be used at the bottom of silt subcuts between the silt and backfill when the silt is saturated and pumping is expected. The use of a contingency item in a contract for geotextiles should be established where this may be a problem.

3. Shallow embankments over initially weak silts may require a stronger geotextile than recommended in Table 4-1. For this situation consult a geotechnical engineer.

4. Over muskeg, the use of geotextiles will depend on the condition of the surface mat and the subsurface strengths of the peat. It is recommended that woven geotextiles be used where test data is not available.

5. A minimum of 3 feet of overlap should be used. When placed on firm ground this may be reduced to 1.5 feet. Where embankment settlements are expected the seams should be sewn.

6. When the embankment is to be constructed from shot rock a minimum of 1 foot of 6 inch minus material should be placed directly over the geotextile. Experience has indicated that even with "strong" geotextiles puncturing by large rock can be expected.

7. In areas of very weak soil a geotechnical engineer should be consulted for special construction techniques and geotextile specifications.

8. Analysis and design of reinforced embankments over thermokarst should use methods presented in "Use of Geotextiles to Bridge Thermokarsts" by Dr. Thomas C. Kinney (Reference 4-21).

TABLE 4-1

RECOMMENDED SPECIFICATIONS

EMBANKMENT SEPARATION AND REINFORCEMENT

General Description: The Geotextile shall be a woven or nonwoven fabric consisting only of long chain polymeric filaments or yarns such as polypropylene, polyethylene, polyester, polyamide, or polyvinylidene-chloride formed into a stable network such that the filaments or yarns retain their relative position to each other. The geotextile shall be inert to commonly encountered chemicals and conform to the properties in the following table:

Geotextile Property	Test Method	Geotextile Requirements[1] Nonwoven	Woven
Grab Tensile Strength, lbs, min	ASTM-D-1682	90	200
Grab Tensile Elongation, %, max	ASTM-D-1682	110	30
Burst Strength, psi, min	ASTM-D-751 (Diaphragm Method)	170	375
Trapezoid Shear Strength, lbs, min	ASTM-D-2263	25	75
Puncture Strength, lbs, min	ASTM-D-3787-80	40	75
Water Flow Rate, gal/min/ft^2, min	AASHTO M288-82	20	20
Mildew, Rot Resistance, %, min	AATCC-30	95	95

[1] 95% confidence level of exceeding in both directions

Embankment Separation and Reinforcement

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CHAPTER V

PAVING GEOTEXTILES

Paving geotextiles are used in combination with an asphalt overlay to seal the pavement from infiltration of water and retard reflective cracking. The geotextiles are usually non-woven polyester or polyethylene. The geotextile is installed after first cleaning the existing pavement and filling any cracks over 1/8" wide. In some instances a leveling course of hot asphalt pavement is installed before the geotextile. Next, an asphalt tack coat of either asphaltic cement or emulsion is sprayed over the pavement. The application rate is generally 0.2 to 0.3 gal. per square yard. The geotextile is then placed on the tack by hand or mechanical equipment and broomed to provide a good bond. Large wrinkles should be cut and laid open. Joints should be overlapped 3 inches or more. The hot asphalt concrete overlay is placed on the geotextile at not more than 325°F. The heat and pressure forces the tack coat up into the geotextile.

When the structural design life of a pavement is reached, fatigue cracking has prorated from the bottom of the asphalt layer and appears on the surface. Once this has started, water infiltrates the pavement structure, which, in turn, accelerates the fatigue cracking. Ridgeway (Reference 5-2) performed crack permeability tests and found that a crack with a 2 inch head, can pass 2.4 gallons per day per lineal foot of crack. While this may be higher than would actually be expected, it shows the magnitude of the problem.

Caltrans has found that once 5% cracking has occurred, the deterioration of the pavement begins to accelerate (Reference 5-3). In an average of two years, 30% fatigue cracking has occurred, and in two more years, 100% cracking has occurred. The Alaska Department of Transportation and Public Facilities research indicates that the acceleration of the deterioration may be even faster. This is probably the combination of the infiltration problem with the effects of frost. By preventing the water from entering the pavement structure, the geotextile may decrease the amount of acceleration of the fatigue cracking. Installations with paving geotextiles have not been in place long enough to verify this.

When geotextile fabrics were first used in asphalt overlays, it was thought that they might prevent reflective cracking. But because of the large stresses due to traffic loading and thermal contraction, the original cracks reflect through the new overlay. Most geotextiles have too much stretch, relative to the asphalt stiffness to prevent reflective cracking. Studies have shown that in warmer climates the thermal reflective cracking is reduced, but in northern climates, where the thermal stresses are too great, most of the cracks reflect through in the first year (Reference 5-1). The use of geotextiles does retard the development of fatigue crack reflection. But, while the new overlay may be structurally sound, it will develop a crack pattern similar to the original pavement well before reaching its design life.

The major benefit claimed for a paving geotextile is its waterproofing of pavement structure. Even though a crack will reflect through to the surface, the asphalt in the geotextile prevents water from getting to the base. The geotextile itself does not break because it is flexible. Conversely, others claim that upward drainage of water from frost heaving may be impeded by an impermeable surface, and that cracks provide pressure relief and drain adjacent uncracked areas.

Since the cracks reflect through, they will still require sealing to fill the crack above the geotextile. This should reduce the amount of sealant and the time spent crack sealing. Another possible benefit is that once the fatigue or aligator cracking has reflected through the asphalt overlay, the asphalt in the geotextile will help prevent the pieces of pavement from popping out due to traffic.

From the above, it can be seen that the paving geotextile may or may not act to extend the life of a pavement that has reached the end of its design life. In cases of cracking due to structure problems, such as a weak base, the geotextile does not cure the problem, it just puts off the correction. In these cases the use of paving geotextiles should be considered temporary and experimental and should be used with overlays, to extend the time until a permanent solution can be constructed. For low volume roads, the increase in the time for the reflection of fatigue cracking to occur may be significant due to the low number of traffic loadings.

Case 5-1 North Douglas Highway

In 1975 this road was programmed for an overlay. Various sections of the original 1 1/2 inch asphalt pavement were fatigue cracked. A research study was initiated to investigate the benefits of using a paving geotextile (Reference 5-4). Three test sections were selected. Each section was divided into a treated area and an untreated area for a comparison.

Petromat, a nonwoven polyproplene was selected. All cracks were sprayed with emulsified asphalt and sand was broadcast over the cracked areas in an attempt to fill the cracks. Two application rates for AC-5 tack were tried initially: 0.21 gal/sq.yd. and 0.37 gal/sq.yd. It was found that 0.37 gal/sq.yd. resulted in bleeding so the lower rate was selected. The Petromat was overlain with a nominal 1/2 inch leveling course of asphalt pavement followed by 1 1/2 inches of asphalt pavement and 3/4 inch of open graded Asphalt Friction Course.

To date no fatigue cracks have reflected through any of the test sections, so a comparison cannot be made. The traffic on this road is very light.

Case 5-2: Elmendorf Air Force Base

In 1978 the Corp of Engineers constructed two test sections using Petromat and Bituthene Tape. The purpose of the test sections was to investigate the use of the geotextiles to reduce the reflective cracking in an asphalt overlay on the East-West Runway at Elmendorf Air Force Base north of Anchorage (Reference 5-5). The site was selected to investigate the geotextiles' effectiveness in cold climates. The two test sections were located adjacent to the keel strip where the greater number of reflective cracks were expected. Each of the sections was approximately 1000 feet by 55 feet.

The original 6 inch Portland Cement Concrete pavement was overlayed with a gravel sandwich of 4 inches of granular material with 2.5 inches of Hot Asphalt Cement from 1953 to 1957. All the PCC slab joints reflected through the overlay. The overlay placed in 1978 with the fabric was 1.5 inches of Hot Asphalt Cement.

The Bituthene tape is a composite membrane of polyproplylene woven mesh laminated to layer of adhesive rubberized asphalt. It comes in 18 inch wide rolls and weighs 3.96 pounds per square yard. The tape was applied to swept dry pavement. Cracks greater than 0.5 inches were filled with a mixture of RC-250 asphalt and fine sand and covered with a double layer of tape. Smaller cracks were covered with only one layer of tape.

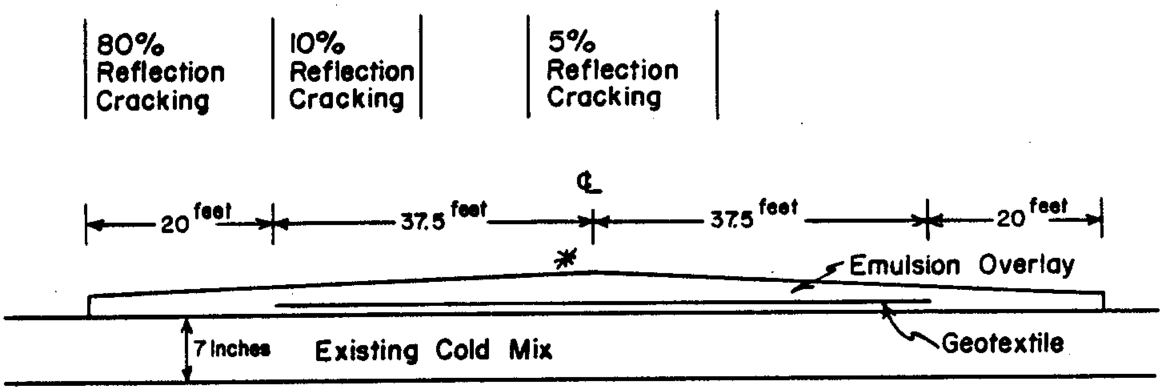
The Petromat described in Case 5-1, was placed on a tack of 0.25 gallons per square yard of AC 2.5 asphaltic cement. An application rate of 0.30 gal/yd^2 was originally specified but it was found to be excessive. Four rolls 12 feet wide and one 8 feet wide were used to obtain a total width of 54 feet. A 6 inch overlap was used between rolls. The first roll was hand laid. This did not provide as smooth a surface as the rolls installed with a contracter fabricated applicator mounted on a wheeled tractor. The cracks were not specially treated because they had been filled with RC-800 prior to the project. Major wrinkles were removed by cutting or hand brooming. Some bleed through was noticed in the wheelpath of the tractor.

One year after installation of the geotextile 100 percent of the primary cracks (Portland Cement Concrete joints) had reflected through the overlay and 60 percent of the secondary cracks had reflected through. After two years 90 percent of the secondary cracks had reflected through and after the third year 95 percent of the secondary cracks had reflected through. Cores of the cracks up to 0.2 inches wide were taken and permeability tests were performed. It was found that the asphalt impregnated geotextile formed an impermeable seal even though the crack reached the surface of the overlay. The cracks were found to be shifted a few inches laterally when they reflected through the fabric. While there was practically no reduction in reflective cracking, the major benefit of the geotextile was considered to be the waterproofing of the pavement.

Case 5-3 Gustavus Airport

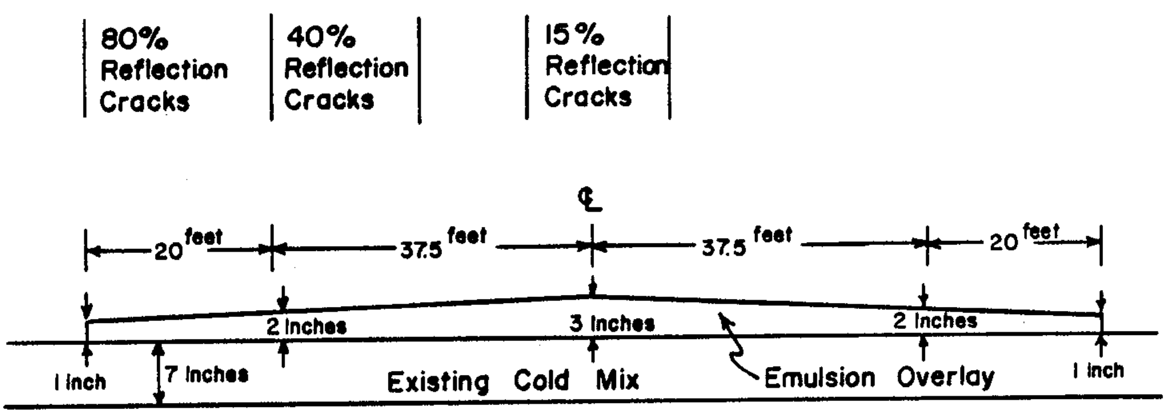
Gustavus is located approximately 60 miles west of Juneau in southeast Alaska. The original runway was paved with 7 inches of cold mix during World War II. The pavement still performs quite well structurally but is extensively thermal cracked. In 1978 the runway was overlaid with an emulsion cold mix. The typical section shown in Figure 5-1 consisted of 3 inches of overlay at centerline sloping to 2 inches at 37.5 feet either side of centerline. From here the overlay sloped to 1 inch in the next 20 feet either side of centerline. The original runway was 300 feet wide so that only the center position was overlaid. Bidim, a non-woven polyester geotextile was used under half the length of the runway. No records exist of the tack coat application rate.

The reflective cracking was visually inspected in June of 1982. Because the original runway was not completely overlaid, it was possible to compare



Geotextile Section

*Same overlay dimensions as below



No Geotextile Section

Figure 5-1 Gustavus Airport Emulsion Overlay the reflective cracking through the overlay to the amount of cracking shown in the original pavement. Figure 5-1 shows the results of the visual estimates of cracking for the different thicknesses of overlay for both the sections with and without the geotextile. For both sections the 1 inch overlay exhibited 80 percent of the original cracks, because the geotextile did not extend out this far. The 2 inch overlay with no geotextile exhibited 40% of the original cracks while the section with the geotextile showed only 10% of the cracks. At the centerline, with 3 inches of overlay, the section without the geotextile showed 15 percent cracking. The cracks were in a block pattern 20 to 30 feet on a side. The geotextile section showed less than 5 percent cracking. These cracks were single transverse cracks. In summary, the section with 2 inches of overlay and the geotextile performed a little better than the three inch overlay with no geotextile. This airport is serviced with one Boeing 727-200B jet a day. The cracking shown is probably thermal rather than deflection related.

Case 5-4 Matanuska River Bridges

These bridges are located on the Glenn Highway approximately 30 miles north of Anchorage. Due to corrosion of the bridge deck reinforcing steel caused by salt used in winter sanding, the concrete decks were spalling. To prevent the salt from getting to the deck, the Maintenance Section installed Petromat in conjunction with a 2 inch asphalt concrete overlay during the summer of 1982. As stated previously, Petromat is a non-woven polypropylene paving geotextile. A tack coat of 0.25 gallons per square yard of AC-5 was applied to the cleaned deck prior to placement of the Petromat and the 2 inch overlay. This installation has not been in place long enough to note its performance, but the asphalt impregnated geotextile should seal the deck from further salt infiltration. Corrosion of the steel will probably continue due to existing salt in the concrete.

Case 5-5 Wrangell Airport

This case does not show an example of the use of paving geotextiles even though a paving geotextile is programmed for this project. This case is presented to show the influence of surface water intrusion through cracks on the performance of the pavement, where the base is frost susceptible. The amount of material passing the No. 200 sieve in the base averages 11% with a maximum of 15%. This project was originally constructed in 1975 with a three inch pavement. One half the runway was paved in a single lift with continuous construction joints through the pavement. Within two years of construction fatigue cracks developed across the keel strip between the construction joints. On the other half of the runway, the pavement was constructed in two lifts with the joints overlapped, so that there was no continuous joint through the pavement. Seven years after construction fatigue cracks were just beginning to occur at the joints. The area between the joints still shows no fatigue cracks. This clearly shows the effect of water allowed into base. If a paving geotextile does seal the cracks, the effect of the water on the frost suseptible base should be reduced considerably. Note that on a non-frost susceptible base the effect of water may be small.

TABLE 5-1

RECOMMENDED SPECIFICATIONS

PAVING GEOTEXTILES

General Description: The geotextile shall be a nonwoven fabric consisting only of long chain polymeric filaments or yarns such as polypropylene, polyethylene, polyester, polyamide, or polyvinylidene-chloride formed into a stable network such that the filaments or yarns retain their relative position to each other. The geotextile shall be inert to commonly encountered chemicals and conform to the properties in the following table.

Geotextile Property	Test Method	Requirements[1]
Grab Tensile Strength, lbs	ASTM-D-1682	90
Grab Tensile Elongation, %	ASTM-D-1682	150 max
Asphalt Retention, gal/sq.yd., minimum	Texas DOT 3099	0.2
Shrinkage from Asphalt, %	Texas DOT 3099	15.0[2]

[1] 95% confidence level of exceeding in both directions

[2] 95% confidence of being less than

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

The State of Alaska Department of Transportation and Public Facilities has used geotextiles since 1974. Since then the availability of geotextiles and design techniques to the designer has progressed tremendously. Still, the field of geotextiles is in a state of flux, making it exciting and challenging. There are definite monetary benefits to using geotextiles. While this report is not a design manual, it is hoped that the examples presented here will stimulate the designer to consider geotextiles in the course of roadway and airport design, and be aware of the pitfalls that can occur.

The recommended geotextile property specifications presented here will do away with the need to write specifications calling out specific geotextiles. These specifications should also save time certifying geotextiles for construction projects. There is still the problem of testing geotextiles, which has not been addressed in this report. The presented recommended specifications are based on 95% confidence level. It is recommended that either the Department or independent laboratories test geotextiles for general certification to these specifications. Then geotextiles should be tested for randomly selected projects to assure manufacturing consistency.

In conclusion, it is recommended that the designer be alert to the possible use of geotextiles on all projects. As stated in the introduction, this report is not a design manual. There are many new complex design techniques for using strong geotextiles. it is also recommended that in unusual situations with weak soils, a geotechnical engineer be consulted for complex design techniques not presented in this report.

Chapter VII

IMPLEMENTATION

Engineering fabrics usage in Alaska, encouraged by low unit fabric costs and by strong sales promotions, has progressed rapidly in the past five years. The conclusion can be reached, therefore, that fabrics are already commonly "implemented", as demonstrated by the many case histories reported herein. The field of engineering fabrics is changing rapidly, as new products are continually introduced and older ones are modified. To be competent in this field, the designer must seek the best technical advice available and actively follow the current literature. The chapter recommendations contained herein provide some guidance to the designer and were developed in consultation with fabric representatives and researchers in other states. These recommendations should be used unless superceded by more recent research information. In particular, the past practice of specifying fabrics by trade name "or equal" should be eliminated in favor of specification by properties. Many fabric installations are made as soil reinforcement to restrict surface and subsurface movements. The need for fabrics in these cases, as well as their proper performance, will depend on the strength properties of the soils and fabrics involved. Soil strength analysis is an engineering specialty called Geotechnical Engineering, and requires specialized field and laboratory investigations and mathematical analysis. For this reason, fabric designs which attempt to reinforce embankments must be developed with the assistance of a geotechnical engineer. The use of specialized consultants for this work is particularly encouraged.

The final area of work to be performed to fully implement engineering fabrics involves the research, analysis, and development of new fabric design methods and the documentation of the economic and performance benefits of current fabric installations. Designers are encouraged to work closely with researchers to provide comparison sections for field monitoring. The major question remains that of identifying the economic benefits of installing fabric versus applying normal construction techniques.

Paving Geotextiles

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