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Review and Update of Geosynthetic Specifications in the State of Alaska

FINAL REPORT

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16. Abstract Alaska Department of Transportation and Public Facilities (AKDOT&PF) routinely uses geosynthetics for soil stabilization, soil reinforcement, separation, mechanically stabilized earthen structures, embankments, drainage, erosion control, pavement, and silt fences. AKDOT&PF desires geosynthetic specifications and construction guidelines that are relevant, accurate and well organized so that these products can be efficiently and effectively utilized in appropriate transportation construction projects. The department's specifications and design practices have not been updated since 2004 and, therefore, do not account for new design practices or geosynthetics. The main objective of this project was to update Alaska's geosynthetic design guidelines and construction specifications to provide for the most economical geosynthetic selection while minimizing conflicts and promoting competition between manufacturers.			
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Executive Summary

With hundreds of geosynthetic products and a wide variety of applications where these materials are suitable, determining the most suitable product for a given situation can be challenging. The process of comparing multiple products and selecting the most cost effective solution is not easy. Geosynthetics are typically defined by their primary function, and specific functions can be applied to multiple applications. The six primary functions of geosynthetics are filtration, drainage, separation, reinforcement, fluid barrier and protection. For geosynthetics used in transportation projects, applications may include: layer separation in roads, base reinforcement, stabilization of weak soils, embankment reinforcement, retaining walls, drains, silt fence, foundation support, soil encapsulation, liners, erosion control, asphalt overlays, and much more.

While general properties of the material are helpful in describing the composition, size and basic characteristics of geosynthetics, specific design properties are needed for each specific application. These design properties are typically index or performance properties. Index properties are generally used by manufacturers for quality control purposes and are generally not appropriate for design. Nevertheless, index properties are often used to compare and select the proper geosynthetic for a given application. Index properties are generally used to characterize the mechanical, endurance or hydraulic properties of the geosynthetic, and include parameters such as tensile strength, junction strength, creep, friction, puncture resistance, flexibility, abrasion resistance, chemical, biological and ultraviolet resistance, temperature stability, opening characteristics, permeability, and in-plane flow – just to mention a few. Performance tests can be used to characterize the geosynthetic in its anticipated environment, and can be a great way to determine how well a geosynthetic will work in a particular application; however, they tend to be expensive and time consuming to run. Despite the fact that there are dozens of tests that can be used to describe a geosynthetic, generally only a few are used for any particular application.

Alaska Department of Transportation and Public Facilities (AKDOT&PF) routinely uses geosynthetics for a variety of applications such as soil stabilization, soil reinforcement, separation, mechanically stabilized earthen structures, embankments, drainage, erosion control, pavement, and silt fences. To ensure geosynthetics are used and selected properly, AKDOT&PF desires geosynthetic specifications and construction guidelines that are relevant, accurate and well organized. The main objective of this project was to update Alaska's geosynthetic design guidelines and construction specifications to provide for the most economical geosynthetic selection while minimizing conflicts and promoting competition between manufacturers. Work toward this objective began with a thorough review and synthesis of current geosynthetic design and construction practices in Alaska, a review of historic and planned uses of geosynthetics within the state, and a review of design and construction practices used in other state and federal agencies.

There are various classifications of specifications: generic, performance, approved list, and approved supplier, or some combination thereof. Generic specifications are the most common and perhaps the most preferred since they are based on the geosynthetic material properties needed to provide a stable and safe design. Performance specifications are expensive and time consuming and are therefore most often used for critical projects. Approved list specifications, such as the National Transportation Product Evaluation Program (NTPEP), are advantageous because the testing is done on all applicable products beforehand for standard applications, which reduces time, error, and last-minute substitutions. Approved supplier specifications are most useful for proprietary systems.

Alaska geosynthetic specifications were thoroughly reviewed, and modifications to their existing specifications were suggested based on information from multiple sources accumulated from decades of research and experience from manufacturers, designers, researchers and practitioners. Changes were suggested to update the specification to:

1) improve clarity and flow, make formatting and layout consistent with other Alaska specifications, and maintain active voice,
2) update content to make it more consistent with standard practice, design, recent developments in materials and design, and existing state and federal specifications, and
3) make it consistent with the unique Alaska conditions or standard practices.

These changes were presented to and discussed with AKDOT&PF staff on several occasions during the project and finally presented during a one-day workshop held in Anchorage at the end of the project. The purpose of the workshop was to update AKDOT&PF staff on the proper use of geosynthetics for transportation applications common in Alaska and to discuss and finalize changes to the specifications.

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Introduction

Alaska Department of Transportation and Public Facilities (AKDOT&PF) routinely uses geosynthetics for soil stabilization, soil reinforcement, separation, mechanically stabilized earthen structures, embankments, drainage, erosion control, pavement, and silt fences. AKDOT&PF desires geosynthetic specifications and construction guidelines that are relevant, accurate and well organized so that these products can be efficiently and effectively utilized in appropriate transportation construction projects. The department's specifications and design practices have not been updated since 2004 and, therefore, do not account for new design practices or geosynthetics. The main objective of this project was to update Alaska's geosynthetic design guidelines and construction specifications to provide for the most economical geosynthetic selection while minimizing conflicts and promoting competition between manufacturers. Work toward this objective began with a thorough review and synthesis of current geosynthetic design and construction practices in Alaska, a review of historic and planned uses of geosynthetics within the state, and a review of design and construction practices used in other state and federal agencies. Using the information from these resources, modifications were suggested to the existing material and construction geosynthetic specifications listed in Table 1.

Table 1: Alaska Construction Specifications Using Geosynthetics

Specification	Title
Section 729	Geosynthetics
Section 511	Mechanically Stabilized Earth (MSE) Walls
Section 630	Geotextile for Embankment Separation and Stabilization
Section 631	Geotextile for Subsurface Drainage and Erosion Control
Section 632	Paving Fabric
Section 633	Silt Fence
Section 634	Geogrid Soil Reinforcement

Geosynthetic Use

The use of geosynthetics in transportation construction projects generally follows these four steps: 1) establishing the scope of the project; 2) design, which includes determining material properties and identifying the types of geosynthetic(s) to meet performance requirements, construction considerations and design life; 3) geosynthetic material selection; and 4) installation and inspection. Geosynthetics can provide benefits to many different types of transportation construction projects, so determining where geosynthetics are most appropriate and beneficial is the first step. Geotextiles and geogrids are the most commonly used geosynthetics in transportation applications and are the primary focus of this effort, although geocomposites, geocells, geomembranes and geonets are also used. Geotextiles can be used as filters, separators, drainage layers, fluid barriers, protection, reinforcement, while geogrids are primarily used as reinforcement or structural elements. There are various brands, manufacturing processes, strengths, etc. of these two types of materials, so understanding which material or combination of materials is most appropriate in a specific application is important. Common geosynthetic applications for transportation construction projects in the state of Alaska are provided in Table 2.

Table 2: Common Geosynthetic Applications in Alaska

Application	Geosynthetic
Mechanically stabilized earth (MSE) walls	geogrid / geotextile
Slope stabilization	geogrid / geotextile
Soil reinforcement	geogrid / geotextile
Embankment separation	geotextile
Embankment stabilization	geogrid / geotextile
Subsurface drainage	geotextile
Erosion control	geotextile
Paving fabric	geotextile
Silt fences	geotextile

A publication from the Federal Highway Administration (FHWA) entitled "Geosynthetic Design and Construction Guidelines" (Holtz et al., 2008) is an invaluable resource for the proper use of geosynthetics in transportation related projects. This document provides a good starting point once it has been determined that geosynthetics are an appropriate component of the design. All of the applications listed in Table 2, and more, are included in this manual. This publication was the predominant resource consulted during the review of Alaska's geosynthetic specifications because it covers the broad spectrum of geosynthetic use in transportation, is the culmination of decades of geosynthetic practice and research, including design examples and suggested specifications, and was put together with the mutual endorsement of designers, researchers, manufacturers, and practitioners.

Geosynthetic Applications

The purpose of this section is to provide background information for the applications listed in Table 2. The background material includes a brief description of the application, an overview of design details, and a discussion of how Alaska's specifications currently treat the application. Recommendations are given regarding how Alaska's specifications should be changed.

To understand which types of geosynthetics are most applicable in a given situation, one must understand the primary functions of the various types of geosynthetics. Geosynthetics have six primary functions: 1) filtration, 2) drainage, 3) separation, 4) reinforcement, 5) fluid barrier, and 6) protection (Holtz et al., 2008). A brief outline of how each of these primary functions is defined is provided in Table 3.

Table 3: Definition of Geosynthetic Functions

Filtration	• Prevent soils from migrating into drainage aggregate or pipes, while maintaining water flow through the system • Used below riprap or other armor materials to prevent soil erosion while preventing hydrostatic build up in the protected slope
Drainage	• Allow water to pass from or through low-permeability soils; lateral transmission of water • Dissipation of pore pressure
Separation	• Prevent intermixing of dissimilar materials which would otherwise compromise their strength
Reinforcement	• Add tensile strength to soil to provide improved structural support • Lateral restraint of soil (e.g., the base and subbase) by increased friction and/or interaction improving its strength/modulus characteristics • Improved bearing capacity by redirection of failure surfaces into higher strength material • Membrane support from tensile restraint under higher deformations or rut
Fluid barrier	• Prevention of water flow from one location to another
Protection	• Provide stress relief or cushion to prevent damage and/or erosion to underlying soil • Provide stress relief to reduce reflection cracking

Mechanically Stabilized Earth (MSE) Walls (Section 511)

A variety of mechanically stabilized earth (MSE) wall systems are available as cost efficient alternatives to conventional retaining walls and earthen embankments. Using modern materials and design procedures, MSE walls can be constructed to accommodate almost any low to moderate-height situations that require a certain degree of soil retention. Due to the unique flexibility specific to MSE wall systems, they have been found to perform well in areas with poor foundation soils and/or high seismic activity; however, the relatively large footprint of MSE walls can make their application in tall cut situations uneconomical.

Although MSE wall is a term used to describe a wide range of soil reinforced structures, MSE walls that use geogrids or geotextiles as the reinforcing elements (i.e., geosynthetic reinforced soil (GRS) walls) was the primary focus for the purposes of this project. Today most transportation related applications of geosynthetic reinforced MSE walls take advantage of the proprietary prepackaged systems that oftentimes use geogrid reinforcing components. Often the aesthetic demands of earth retaining structures are met with different facing options that are customizable or available as part of a packaged system. Examples of currently available geosynthetic MSE wall facings include: modular block wall units (also called concrete masonry units or concrete modular blocks), wrap-around facings, welded-wire facing, segmental precast concrete panels, full-height concrete panels, cast-in-place concrete and timber (Holtz et al., 2008).

While different MSE wall design techniques exist, it is recommended by Federal Highway Administration's (FHWA) Geosynthetic Design and Construction Manual that the simplified coherent gravity method be used for transportation related designs as currently included in Berg et al., 2009 and AASHTO, 2013. Both internal and external modes of failure should be considered regardless of the design procedure chosen. A retaining structure's stability includes the consideration of external forms of failure and requires checks on the structures resistance to sliding, overturning (which can be overlooked if earth pressure's resultant force is located in the middle third of the foundation), deep-seated instability, seismic activity, and the surrounding soil's bearing and settlement issues. Internal failure modes vary with respect to the type of reinforcement used. For geosynthetic reinforced MSE walls the internal failure modes include: reinforcement rupture, reinforcement pullout, reinforcement creep, and reinforcement and facing connection failure (Holtz et al., 2008). Chapter 4 of the Federal Highway Administration's Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design & Construction Guidelines (FHWA NHI-10-024, Volume I) outlines and details design procedures, and gives specific examples of designing geosynthetic reinforced MSE walls. Tensile strength, soil-reinforcement interaction, creep resistance and connection tensile strength and pullout, respectively, can be used to ensure adequate stability of the structure.

Other components that should be considered during MSE wall design that indirectly influences their stability is surficial and subsurface water, and seismic activity. The designer must be fully aware of the negative effects that water may have on both the strength of soil and loads experienced by the wall. These effects should be mitigated by providing design details for proper water drainage. Extra drainage details can often be avoided if free draining reinforcement fill is used consisting of less than 3 to 5 percent non plastic fines (Elias et al., 2001 and Berg et al., 2009).

Holtz et al. (2008) include specification requirements and Berg et al. (2009) contain example specifications that were consulted to update Alaska's specifications for this application. The following modifications were suggested as part of this review based on these materials.

- Include a material category for Modular Concrete Block Units and create a new Subsection (704-2.04) to specify these materials. The FHWA-HRT-12-051 Sample Guide Specifications for Construction of Geosynthetic Reinforced Soil-Integrated Bridge System (GRS-IBS) (FHWA, 2012) gives CMU facing element requirements and would be a good starting point for a new subsection 704-2.04 on Modular Concrete Block Units. Include references to modular concrete blocks throughout the specification.
- Include a material category for Structural Fill, and create a new Subsection (704-2.13) to specify these materials. Draft specifications are suggested, as recommended by AKDOT&PF. Replace reference to Select Materials Type A with a new reference to the Structural Fill material.
- Change sodium sulfate soundness loss specification to 15% maximum loss in five cycles.
- Include provision to limit backfill materials to pH between 3 and 9, as recommended by FHWA NHI-10-024 (Berg et al., 2009) and FHWA-NHI-07-092 (Holtz et al., 2008). AASHTO LRFD Bridge Design recommends a lower limit of 4.5 be used for permanent applications.
- Consider changing electrochemical requirements for steel reinforcement to make backfill chloride content dependent upon the resistivity value of the soil.
- Include provision to limit the thickness of the manufactured concrete wall panels to 5.5 inches, as required by AASHTO LRFD Bridge Design Specifications 2013.
- Include provision to specify the thickness of the cover concrete on manufactured concrete wall panels to at least 1.5 inches over reinforcing steel, as required by AASHTO LRFD Bridge Design Specifications 2013.
- Clarify that the geogrid requirements for reinforcement are listed in Subsection 729-2.04 or as specified in the Plans.
- Include requirements for plans and elevations sheets including dimensions, details and cross-sections necessary to construct the wall in the Working Drawings subsection.
- Include requirements for details of the facing elements and connections between the facing elements and soil reinforcement in the Working Drawings subsection.

- Include provision to prohibit the use of studded (i.e., sheep's foot, pad foot) rollers for compacting the backfill material atop the soil reinforcement in the Excavation and Backfill subsection within the Construction section.
- Clarify that the geotextile requirements for weep holes are listed in Subsection 729-2.01 for Subsurface Drainage and as specified in the Working Drawings.
- Specify that geocomposite material should follow specifications in the Working Drawings.
- Include provision to specify the use of light compaction equipment near the wall face in Retaining Wall Construction subsection.
- Include provision to slope backfill away from the wall face to prevent ponding of water behind the wall during construction.
- Many of the other state specifications give vertical and horizontal tolerances that are governed by the facing structure's stiffness. Along with the obvious structural stability these tolerances invite, they often provide pleasing aesthetics to the structure. In addition to vertical and horizontal tolerances, many states require horizontal joint offsets and differential settlement limits to oppose unsightly wall distortions.
- It appears that Alaska DOT&PF does not have a document outlining preapproved MSE wall systems and manufactures, and may consider adding this as a Subsection to Alaska's Standard Specifications for Highway Construction.
- Leveling pads are often required as part of the foundation preparation and consist of a 1 foot wide by 6 inch thick unreinforced concrete strip footing between the wall facing elements and the foundation backfill material. Consideration should be given to add standard language to the specification to specify the materials, tolerances, and construction guidance associated with the leveling pads.
- No mention of timber is made within Section 511: Mechanically Stabilized Earth (MSE) Walls of Alaska's current Standard Specifications for Highway Construction although it is considered a facing commonly used on geosynthetic reinforced MSE walls (Holtz et al., 2008). Both geotextiles and geogrids can be used in conjunction with timber facings to construct low to moderate-height structures. This specific type of MSE wall often is used in applications requiring temporary retaining walls in remote locations and is worth considering for inclusion within Alaska's Specifications.

Separation and Stabilization (Section 630)

Separation and stabilization is an application that is generally associated with the construction of a working platform for a roadway (paved or unpaved) structure or embankment on soft ground.

Geosynthetics help separate the underlying soft ground from the better quality aggregate placed to create the working platform. Stabilization is realized by the reinforcing function of the geosynthetic which helps limit the amount of rutting caused by construction or operational traffic. Stabilization is usually required for soft, saturated foundation soils; therefore, the functions of filtration and separation must also be provided.

The empirical design procedure for separation, as outlined in Holtz et al. (2008), requires evaluating the following items: subgrade conditions, gradation of the base and subgrade soils, geotextile survivability and opening requirements, filtration requirements, and constructability requirements. Holtz et al. (2008) also provides design guidance for stabilization applications, which are appropriate for non-pavement applications such as haul roads, temporary working platforms and embankment support.

The following modifications to Section 630 were suggested as part of this review.

- Consider expanding the title to include both embankment and working platform roadway support, and reinforcement.
- Call out Sewing Thread as a specific material in the Materials section and provide specifications.
- Include a provision to increase the time for geosynthetics are allowed to be in direct sunlight from 5 to 14 days, in the Geotextile Placement section, to match standard practice.
- Include provision to prohibit geotextiles from getting wet, especially when freezing temperatures are expected.
- In the Geotextile Placement subsection, consider delineating between a. Separation and Stabilization applications and b. Reinforcement applications.
- Include language to make it easier for the Engineer or AKDOT&PF representative to inspect sewn seams, in the Joining subsection.
- Update reference to newest FHWA design manual (FHWA NHI-10-024), in the Joining subsection.
- Include provision to place the beginning of each new roll beneath the previous roll to prevent advancing fill from lifting the geotextile, in the Construction section.
- Include language prohibiting placement of large or frozen materials from being dropped directly onto geotextiles without a cushion to prevent excessive damage to the geosynthetic, in the Material Placing and Handling subsection. Table 5-2 in Holtz et al. (2008) and Table 4 in the AASHTO M288 (2006) can be used to determine cover

thicknesses necessary to improve construction survivability based on bearing capacity of the soil platform.

- Add option to compact material on top of the geotextile in a manner approved by the Engineer.
- Include provision to fill deeper ruts (> 3 inches deep) during construction with additional material and compact to specified density, in the Material Placing and Handling subsection. AKDOT&PF May also want to prohibit the use of vibratory compaction in areas prone to pumping.
- In the Geotextile Repair subsection, consider delineating between a. Separation and Stabilization applications and b. Reinforcement applications. Further add to subsection a) the option to sew or bond according to Subsection 630-3.01.3. Likewise, restrict bonding geotextiles in reinforcement applications in subsection b).
- Measurements of material should be made based on the square yard of ground surface covered.
- Payment for materials should be designated by Class. Also add two additional pay items to include geotextile reinforcement Type 1 and Type 2.

Subsurface Drainage and Erosion Control (Section 631)

Geotextiles are commonly used as a filtration layer in conjunction with aggregate drainage layers. Geotextile filters are used in applications such as trench and slope interceptor drains, blanket drains, pavement edge drains, abutment and retaining wall drains, and sheet drains under roadway base course aggregates (Holtz et al., 2008). The geotextile filter restricts movement of soil particles as water flows into the drain structure and is collected and/or transported downstream. The design of geosynthetics in pavement drainage mainly takes into consideration the grain size distribution of soil to be drained and the geosynthetic filtration characteristics.

Erosion of soil is caused by the agents of wind, water and gravity. Geotextiles help control erosion by retaining soil particles and dissipating the erosive energy of the attacking agent. Erosion control applications include riprap-geotextile systems, slope protection, scour protection, tidal protection, protection of hydraulic structures such as culverts, and more. The principal function of the geotextile in erosion control is filtration. The AASHTO M288 document (AASHTO, 2006) provides specifications for this application (Table 6 – Permanent Erosion Control Geotextile Requirements) and contains soil retention, permeability, permittivity, clogging, and survivability criteria in a similar format as for filtration applications. Chapter 3 of Holtz et al. (2008) addresses the design details associated with erosion control using geotextiles and geosynthetic erosion control mats.

Currently, Alaska combines subsurface drainage and erosion control into one specification document (Section 631). The Alaska specification refers to AASHTO M288 specifications (AASHTO, 2006) to determine applicable materials for this application (Table 2 – Subsurface Drainage Geotextile Requirements). Subsurface drainage geosynthetics (i.e., geocomposite drains) are not specified in Section 729, and should be included. The following modifications to Section 631 are suggested.

- Call out Sewing Thread as a specific material in the Materials section and provide specifications.
- Include provisions to specify that the trench walls are to be smooth and stable, in the Surface Preparation subsection.
- Include provisions to improve the placement of geotextiles so that they are not damaged, are tight against the trench walls, have no wrinkles, and may be held in place with securing pins.
- Include a provision to increase the time for geosynthetics are allowed to be in direct sunlight from 5 to 14 days, in the Geotextile Placement subsection, to match standard practice.
- Include provisions to specify the direction of installation of erosion control geotextiles with respect to water flow, wave action and runoff, in the Erosion Control subsection in Geotextile Placement subsection within Construction.
- Include language to make it easier for the Engineer or AKDOT&PF representative to inspect sewn seams, in the Joining subsection.
- Update reference to newest FHWA design manual, in the Joining subsection.
- Include provision to specify conformance to field sewn requirements of Table 1 in AASHTO M288.
- Include language in the Placement of Cover Material subsection to place cover material and armor from the bottom to the top of the slope to keep from overstressing the geotextile during construction. Also, add language to prohibit stones from rolling downslope atop of the geotextile to prevent excessive damage to the geosynthetic. For the same reason, include language in the Placement of Cover Material subsection prohibiting grading the cover material or riprap once it has been placed on the geosynthetic.
- Expand language in the footnote associated with Table 631-1 to increase the minimum thickness of the gravel cushion layer from 4 inches to 6 inches.

- Include language in the second footnote associated with Table 631-1 to allow the minimum cushion thickness to be determined in addition to the drop height.

Paving Fabric (Section 632)

Geotextiles (most often non-woven, needle-punched) can be used to minimize crack propagation or act as a moisture barrier between adjacent layers of asphalt concrete. According to Aldrich (1986), as referenced by Holtz et al. (2008), geosynthetic pavement interlayers tend to perform better in warmer climates. Furthermore, these treatments are not intended to solve freeze-thaw issues. However, pavement overlay systems employed in colder climates that have actively used crack sealing as a technique to keep water from infiltrating into the pavement, have noted success. It is therefore recommended that the performance of such construction practices be verified under Alaska's climatic conditions. To properly specify a particular paving fabric, the AASHTO M-288 specifications should be consulted. High strength geogrids can also be used as a stress relief layer in joint repair. In this case, the special specification provided in Section 6 in Holtz et al. (2008) can be used. Special geocomposites (typically woven or non-woven geotextiles with asphalt membranes) also exist for this purpose and are specified similar to geotextiles. Upon review of the information gathered from Alaska, no specifications exist for this line of products, but the AASHTO M-288 specification for paving fabrics can be used by Alaska; however, it should be noted that high strength paving fabrics and geogrids will not solve thermal cracking problems in pavements. The following modifications to Section 632 are suggested.

- Modify the maximum temperature requirements to match the AASHTO M288 (i.e., maximum temperature of 320 F in the distributor tank).
- Include provision to allow application procedures to be specified by the Engineer and/or Paving Fabric manufacturer.
- Include provisions in the Fabric Placement subsection to overlap geotextile joints to ensure full closure of the joint, but not to exceed 6 inches of overlap.
- Include provisions in the Fabric Placement subsection to specify that it is the Contractor's responsibility to remove and replace damaged geotextiles.
- Include provisions in the Bituminous Surface Course Overlay subsection to specify that the hot-mix asphalt temperature should not exceed the manufacturer's recommendations to avoid damaging the paving fabric.

Silt Fence (Section 633)

Geotextile silt fences are used for temporary runoff and sediment control. They are designed to retain surface runoff for long enough to allow suspended sand and silt size particles to settle out before reaching the fence and for the remaining water to drain through the fence. Silt fences are used throughout Alaska by DOT&PF personnel and are covered by Section 633 in the Alaska state specifications. Chapter 4 of Holtz et al. (2008) covers the use of geosynthetics used as temporary runoff and sediment control. Applications covered include silt fences, silt and turbidity curtains, and erosion control blankets. The specifications for the physical properties of silt fences can be found in AASHTO M-288 specification (AASHTO, 2006), as referenced in the Alaska specifications, Section 729-2.04. Details of this application are also provided in Alaska Drawing E-13.00 (1996). Alaska drawing E-00.00 (1982) illustrates how to install erosion control mesh adjacent to a highway to encourage and protect new roadside vegetation. This application needs to be expanded to capture more relevant and current material. Other suggested changes to Section 633 are listed below.

- Include Prefabricated Silt Fence in the Materials Section with the idea that it should meet Section 633 requirements.
- Include Support Mesh Between Posts in the Materials Section. The material should be 14-gage steel wire with a maximum mesh opening size of 6 inches by 6 inches or can consist of prefabricated polymeric mesh of equivalent strength.
- Specify in the Post Installation subsection that posts can be driven to the depths specified in the Plans and resist maximum expected hydraulic and material sediment loads without damage.
- Specify in the Geotextile Placement subsection that polymeric mesh can be used to support the geotextile as a substitute for wire. Also include language to specify that, if used, the support mesh should be properly supported (e.g., with sandbags).
- Include language in the Geotextile Placement subsection to make the height of the geotextile at least 30 inches above the ground.
- Consider increasing the thickness of trapped sediment to 1/3 to 1/2 the total height of the fence, rather than 4 inches as currently specified in the Maintenance section.

Geogrid Soil Reinforcement (Section 634)

Section 634 of the Alaska specifications covers the use of geogrids when used as reinforcement. Holtz et al. (2008) covers the use of geogrids to reinforce embankments, roadbeds, pavements and slopes. AASHTO R50-09 provides guidance for efficient utilization of geogrids as reinforcement for aggregate base layers of flexible pavements structures, although Alaska DOT&PF does not currently use geogrids for base reinforcement. Table 729-1 in the Alaska specifications limits broader participation by geosynthetic manufacturers other than the punched and drawn or extruded grids. This table needs to be expanded and updated to include other products that will perform adequately as soil reinforcement. Chapter 5 of Holtz et al. (2008) thoroughly discusses the use of geogrids in roadways and pavements. Table 5-5 in this document specifically addresses the properties of the geosynthetic needed to survive construction for stabilization and reinforcement applications. There are also two sections in Chapter 5 that outline a suggested standard specification for geogrids when used as subgrade stabilization and reinforcement. These recommendations were used to develop a more robust specification for Alaska DOT&PF. High strength reinforcement applications such as support of embankments over soft subgrades and reinforcement of soils slopes usually require design evaluation to establish performance strength requirements for either geogrids or geotextiles that can be used in these applications. However, construction survivability is still required, and unless test sections are performed, the minimum properties in Holtz et al. (2008) should be required in addition to design strengths.

While geotextiles are predominantly used for separation and stabilization applications in Alaska, geogrids have also been successfully employed in stabilization applications. However, AKDOT&PF's specifications only address the use of geotextiles for this purpose. If geogrids are to be considered for use as stabilization layers, then the general geogrid parameters pertinent for this application must be included within the Alaska specifications. Likewise, geotextiles have successfully been used in reinforcement applications, and future specifications should include provisions to allow this. Other suggested changes to Section 634 are listed below.

- Include provisions in the Geogrid Placement subsection to specify that the geogrid be rolled out in the direction of advancing construction, parallel to the centerline of the roadway or according to the Plans. Other suggested changes to this subsection include:
    - not dragging the geogrid across the subgrade to avoid excessive damage,
    - installing the material in the longest continuous practical length free from folds, creases or wrinkles to make sure it is able to immediately carry induced loads, and
    - to hold the geogrid in place with pins, staples, sandbags or piles of granular materials to keep it from moving during placement of material above the geogrid.
- Include provision in the Geogrid Placement subsection to place the beginning of each new roll beneath the previous roll to prevent advancing fill from lifting during construction.
- Include provision in the Geogrid Placement subsection to stagger end overlaps by at least 10 feet in adjacent rolls to maintain continuity of reinforcement.
- Add "Very Soft Ground" section to the Placing and Spreading Cover Material subsection which is defined as material with a CBR < 1.0. The following construction sequence should be added to this new subsection to prevent mud waves from developing during

construction. *End-dump material onto previously placed material and spread over the geogrid with a low ground pressure dozer to the depth permitted. Do not dump material directly onto the geogrid. To prevent a mud wave, end-dump fill along the edges of the geogrid to form toe berms or access roads that extend one to two panel widths ahead of the remainder of the embankment fill placement. After constructing the two berms, spread fill in the area between the toe berms by placing material parallel to the alignment and symmetrical from the toe berms inward toward the center to maintain a U-shaped leading edge (i.e., concave outward) to contain the mud wave. Limit height of dumped piles above the geogrid to avoid local bearing failure. Traffic on the first lift should be parallel to the embankment alignment. Do not allow construction equipment to turn on the first lift. Compact first lift by tracking in place with dozers or end-loaders. Compact with specified compaction equipment once embankment is at least 2 feet above the original ground.* It may also be valuable to add a graphic to go along with this verbiage (such as Figure 7-8 on page 7-49 of the FHWA Design and Construction Guidelines (Holtz et al., 2008)).

- Rework the language in the Soft Ground subsection of the Placing and Spreading Cover Material subsection to prevent equipment from end-dumping material directly on the geogrid, but rather to end-dump the material on previously placed material and use low-ground pressure equipment to spread the material on top of the geogrid. This subsection should also include language to prevent wrinkling or movement of the geogrid, and to further specify how to spread the end-dumped material along the centerline and toward the edges.
- Add stabilization application type and Class designation to payment table.
- Add reinforcement application types and Class designation to payment table.

Geosynthetics (Section 729)

Several modifications are suggested for Section 729 (Geosynthetics) based on the review of each of the specifications for AKDOT&PF. Each of these modifications is listed below accompanied by an explanation.

- Arrange main headings by material type (geotextile or geogrid) to generally follow the other sections.
- Add Reinforcement application to Section 729-2.01. Consider adding the material properties summarized in the newly proposed Table 729-1 which was created using information from an existing AKDOT&PF special provision.

- Replace geogrid specification with one that allows greater participation by other geogrid manufacturers. The original geogrid specification was written to allow only biaxial integrally-formed geogrids formed by the punched and drawn or extruded methods and made of polypropylene or high-density polyethylene. Because there are a wide variety of geogrid products that will work in stabilization and reinforcement applications, it is suggested that this geogrid specification be more generic to allow materials with more than two orthogonal tensile elements at each node, various manufacturing processes (woven, welded, knitted, integrally-formed and extruded). Suitable geogrids must consist of a regular network of connected polymer tensile elements with aperture geometry sufficient to provide significant mechanical interlock with the surrounding material. Geogrids must also be dimensionally stable so that it is able to retain its geometry during construction. Finally, the geogrid structure must resist ultraviolet degradation and all forms of chemical and biological degradation encountered in the soil in which it is buried.
- Geogrids used in stabilization applications must meet certain survivability requirements and physical requirements. It is suggested to include geogrid survivability specifications that require minimum values of ultimate multi-rib tensile strength, junction strength, and ultraviolet stability (retained strength) based on Class 1 or Class 2 subgrade conditions (a reference to Table 4 in AASHTO M288 to determine survivability class as a function of subgrade conditions, construction equipment and lift thickness is suggested as a footnote to Table 729-1). It is suggested to replace the physical requirements from the original AKDOT&PF geogrid specification (originally listed in Table 729-1 from the 2004 Alaska specification) with specifications that are discussed below (now listed in new Tables 729-2 and 729-3).
    - It is suggested to allow minimum strength requirements in Table 729-2 to be determined from tests performed on the material in the direction of the ribs. This will allow materials that have structures with more than two principal strength directions to be considered for a particular application. It is suggested, however, that original minimum strength requirements remain the same until sufficient research has been conducted to possibly adjust these values.
    - It is suggested to increase aperture size to include products that have apertures between 0.5 to 3.0 inches. This suggested change would increase the upper bound from 2.0 inches to 3.0 inches to include products whose aperture sizes are sufficient to provide interlock, especially with aggregates with larger stones. The designer should take into account the aggregate size above and below the geosynthetic to properly specify geogrid aperture sizes that will not allow the

aggregate to pass easily through the material but will provide sufficient opening sizes to allow for proper interlock between the aggregate and the geogrid.

  - It is suggested to specify the percent open area as part of the physical requirements of geogrids used in stabilization and reinforcement applications.
  - It is not necessary to specify rib thickness as long as the strength requirements listed in the suggested survivability specification are followed; therefore it is recommended to remove this requirement from the specification.
  - It is suggested to include an ultraviolet stability requirement to the survivability specification to ensure geogrid products will retain sufficient strength when exposed to direct sunlight.
  - It is suggested to specify the tensile strength and junction strength requirements in the geogrid survivability specifications rather than as physical requirements.
  - It is suggested to add a footnote to the Table 729-3 to clarify that the aperture size is measured as the spacing between parallel ribs. This will allow materials that have structures with more than two principal strength directions to be considered for a particular application.

- Geogrids used in reinforcement applications must meet certain survivability requirements, but material physical properties are determined using design. Like the stabilization application, it is suggested that the geogrid survivability specifications for the reinforcement application requires minimum values of ultimate multi-rib tensile strength, junction strength, and ultraviolet stability (retained strength) based on construction survivability class.

Deep Patch

A repair technique known as a deep patch has been used in the western U.S. and Alaska to address settlement and shallow failures in both fill and natural slopes. While the use of the deep patch repair method was initiated in the 1980s, it was more recently developed into a procedure originally recommended by Musser and Denning (2005) of the Forest Service. More recently, this method was modified and updated to include a more robust design procedure for the deep patch method (Cuelho et al., 2012). Based on this method, both biaxial and uniaxial geogrids are applicable materials for reinforcement. The strength requirements of the geogrids are determined using the aforementioned design methodology. At this time, it is anticipated that geogrids used by AKDOT&PF for reinforcing elements in deep patches will be specified using special provisions. Suggested specifications for reinforced slope applications are listed in Holtz et al. (2008), which can be augmented to specify the appropriate reinforcement for deep patch applications.

Geosynthetic Specifications

There are various classifications of specifications: generic, performance, approved list, and approved supplier, or some combination thereof (Holtz et al., 2008). Generic specifications are the most common and perhaps the most preferred since they are based on the geosynthetic material properties needed to provide a stable and safe design. Performance specifications are expensive and time consuming because they require testing of the geosynthetics in a situation resembling the field application; therefore, they are not often used, except for critical projects. Approved list specifications (i.e., qualified products lists – also known as QPLs) are advantageous because the testing is done on all applicable products beforehand for standard applications, which reduces time, error, and last-minute substitutions. Minimum testing should be performed for quality control (e.g., to assure that products have not been changed or substitutions have not been made). The National Transportation Product Evaluation Program (NTPEP) evaluates a number of geotextiles for transportation applications on a regular basis, and can be used by states to develop their own approved product list. Finally, the approved supplier specification type can be useful for proprietary systems.

Geosynthetic specifications seem to fall into three main categories: 1) general material acceptance and handling requirements, 2) physical, index and performance properties, and 3) construction and acceptance requirements. Construction requirements include seam and overlap requirements, placement procedures, repair procedures, and acceptance and rejection criteria (Holtz et al., 2008). Also included in the specifications are the measurement and payment procedures.

Alaska geosynthetic specifications listed in Table 1 were thoroughly reviewed and changes were suggested to update the specification to:

1) improve clarity and flow, make formatting and layout consistent with other Alaska specifications, and maintain active voice,

2) update content to make it more consistent with standard practice, design, recent developments in materials and design, and existing state and federal specifications, and

3) make it consistent with the unique Alaska conditions or standard practices.

Highlighted colors associated with each of these changes (i.e., yellow, green and pink) are used to designate the type of modifications or suggested changes that were made in each of the specifications, as respectively illustrated above. Each of the modified Alaska specifications is presented below for consideration by AKDOT&PF staff. The written resources (listed below) primarily used during the review process are a culmination of decades of research and practice from manufacturers, designers, researchers and practitioners. Utilizing these resources, therefore, helps substantiate the recommended changes to AKDOT&PF's specifications. If further endorsement by geosynthetic manufacturers is desired, it is recommended to approach the Geosynthetics Manufacturers Association (GMA) industry group, which currently represents over 80 member companies, for a balanced review.

- Federal Highways Geosynthetic Design and Construction Guidelines Reference Manual, FHWA-NHI-07-092 (Holtz et al., 2008),
- AASHTO M288 Specifications for Geotextiles in Highway Applications (AASHTO, 2006),
- Federal Highways Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines, FHWA NHI-10-024 (Berg et al., 2009),
- Strategic Highway Research Program (SHRP2) website www.GeoTechTools.org.
- other state and federal department of transportation geosynthetic specifications (e.g., AL, CO, IN, IA, MO, MT, NE, NH, NY, ND, OK, PA, WA and WI),
- discussions with industry experts, and
- discussions with Alaska DOT&PF staff.

SECTION 511

MECHANICALLY STABILIZED EARTH (MSE) WALLS

511-1.01 DESCRIPTION. Furnish and install mechanically stabilized earth wall.

511-2.01 MATERIALS. Meet the following:

Class A Concrete	Section 501
Precast and Cast-in-Place Concrete Panels	Section 501
Reinforcing Steel	Section 503
Structural Steel	AASHTO M 270
Modular Concrete Block Unit	Subsection 704-2.04
Pipe and Perforated Pipe	Section 706
Geotextile for Drainage	Subsection 729-2.02
Geogrid	Subsection 729-2.05
Geocomposite Drainage System	As Specified
Porous Backfill Material	Subsection 703-2.10
Structural Fill	Subsection 703-2.13

1. Structure Backfill and Foundation Fill. Meet Subsection 703-2.13 ~~07~~, Structural Fill ~~Selected Material, Type A~~. Use materials with a sodium sulfate soundness loss less than 15 ~~30~~% after five ~~four~~ cycles as determined by AASHTO T 104 and free of shale or other particles of low durability.

   ~~When using backfill material with 80% passing the 3/4 inch sieve, the minimum angle of internal friction on the portion of the backfill select material finer than the No. 10 sieve must not be less than 34 degrees, as tested by AASHTO T 236.~~

   When using geosynthetic reinforcement, use backfill material with a pH range between 3 and 9 as determined by AASHTO T 289. When using steel soil reinforcement, use backfill material meeting the following electrochemical requirements:
   - pH of 5 to 10 (AASHTO T 289)
   - Resistivity not less than 30 ohm-meters (AASHTO T 288)
   - Chlorides not greater than 100 ppm (AASHTO T 291)
   - Sulfates not greater than 200 ppm (AASHTO T 290)

2. Wall Members. Provide facing consisting of precast concrete panels, modular concrete block units, cast-in-place concrete, or welded wire fabric, as specified.

   Manufacture concrete panels with a minimum 28-day concrete compressive strength of 4,000 psi and thickness of 5.5 inch. Finish the exposed face with a smooth ~~ordinary~~ finish or as detailed in the Plans. For the face not exposed to view, provide a uniform surface finish free of open pockets of aggregate or surface distortions in excess of 1/4 inch and a minimum concrete cover of 1.5 inch over concrete reinforcing steel. Locate soil reinforcement connection hardware during concrete placement to avoid contact with the panel reinforcing steel. Shop-fabricate welded wire fabric reinforcement from cold-drawn wire meeting AASHTO M 32 and conforming to the specifications for welded wire fabric in accordance with ~~the finished fabric meeting~~ AASHTO M 55.

3. Soil Reinforcement.

   Use approved geogrid reinforcement that meets the requirements listed in Subsection 729-2.04 or as specified in the Plans.

Galvanize all steel soil reinforcement and any steel connection hardware to meet AASHTO M 111. Manufacture steel strip reinforcement by hot rolling to meet ASTM A 572, Grade 450, or approved alternate.

4. Working Drawings. Submit all working drawings and design calculations, sealed by licensed Engineer, including:
   a. Earthwork requirements including specifications for material and compaction of backfill.
   b. Details and ~~of~~ revisions or additions to drainage systems or other facilities required to accommodate the system.
   c. Existing ground elevations verified by the Contractor for each location involving construction wholly or partially in original ground.
   d. Complete design calculations substantiating that all proposed designs satisfy the design parameters in the Contract documents.
   e. Complete details of all elements required for the proper construction of the system, including complete material specifications.
   f. Complete plan and elevation sheets including dimensions, details and cross-sections necessary to construct the wall.
   g. Details of the facing treatments and connections between facing elements and soil reinforcement.

   Prohibit work on earth retaining systems for which working drawings are required until such drawings have been approved.

511-3.01 CONSTRUCTION.

1. Excavation and Backfill. Excavate and backfill earth retaining systems to meet Section 205. Compact the material as specified under Subsection 203-3.04. Do not use studded (i.e., sheep's foot, pad foot) rollers for compacting the backfill material atop soil reinforcement.

2. Drainage. Provide a drainage system at the base of the wall along its back-face with outlet works at sags in the profile and at the low ends of the system ~~gutter~~.

   a. Weep Holes. Place a minimum of 2 cubic feet of porous backfill material encapsulated with geotextile at each weep hole. Cover joints between retaining wall facing elements ~~panels~~, which function as weep holes, with geotextile meeting the requirements in subsection 729-2.01 for Subsurface Drainage and as specified in the Working Drawings. Dry and thoroughly clean the face panels that are to receive the geotextile.

   b. Drainage Blankets. Construct drainage blankets consisting of porous backfill material encapsulated in geotextile, collector pipes, outlet pipes, or ~~and~~ cleanout pipes. Construct and compact the subgrade to receive the geotextile so it is free of loose or extraneous material and sharp objects that may damage the geotextile. Stretch, align, and place the fabric in a wrinkle-free manner. Overlap adjacent borders of the fabric from 12 to 18 inches. Repair torn or punctured fabric by covering the damaged area with a piece of fabric large enough to cover the damaged area and meet the overlap requirement.

      Place the porous backfill material in horizontal layers and thoroughly consolidate by the ~~same~~ methods specified in Subsection 205-3.03. Prohibit ponding or jetting of porous backfill material or structural ~~back~~fill material. Maintain a minimum of 6 inches of porous backfill material, ~~structural~~ backfill select material, or embankment material between the fabric and the equipment during material spreading and compaction ~~of the porous backfill material~~.

      Place perforated collector pipe, when required, within the porous backfill material to the flow line elevations shown. Place outlet pipes at sags in the flow line and at the low end of the collector pipe. Construct rock slope protection, when required, at the end of outlet pipes, as shown on the

Plans. Place cleanout pipes at the high ends of collector pipes.

c. Geocomposite Drainage Systems. Place and secure the geocomposite drainage material tightly against the excavated face, lagging or back of wall. Protect the drainage material against physical damage and grout leakage when concrete is to be placed against geocomposite drainage material. Use geocomposite material as specified in the Working Drawings.

3. Retaining Wall Construction. Construct mechanically stabilized earth walls consisting of a facing system to which steel or polymeric soil reinforcement is connected. Provide facing consisting of precast concrete panels, cast-in-place concrete, modular concrete blocks or welded wire fabric.

Install geosynthetic ~~polymeric~~ soil reinforcement in accordance with ~~under~~ Section 634.

When constructing cast-in-place concrete facing, embed soil reinforcement which extends beyond the temporary facing into the facing concrete.

Form welded wire facing by bending the horizontal soil reinforcement 90 degrees upward to form the wire face. Connect the vertical portion of the welded fabric forming the face to the next upper level of soil reinforcement. Place a separate backing mat and hardware cloth immediately behind the vertical portion of soil reinforcement.

Provide a precast reinforced or cast-in-place concrete leveling pad at each panel foundation level. Place panels or wire fabric and support to achieve the final position.

Place and compact structural fill ~~structure backfill~~ material at the same time as placement of facing and soil reinforcement, without distortion, damage, or displacement of the facing or soil reinforcement. Use light compaction equipment within 3 feet of the back face of the wall and compact in thinner layers if necessary to achieve specified levels of compaction. Backfill to an elevation approximately 1-1/4 inch above the facing connection level before placing the next level of soil reinforcement. Roughly level the structural fill material before placing the soil reinforcement. Uniformly tension all soil reinforcement to remove any slack in the connection or material prior to placing the next lift of structural fill. At the end of the day, place the final layer of structural fill sloping away from the wall face to provide rain and runoff drainage away from the face of the wall.

Where required, install joint filler, bearing pads, and joint-covering material concurrently with face panel or modular concrete block placement.

Furnish and install instrumentation for monitoring corrosion, where specified.

511-4.01 MEASUREMENT. Measure by the square foot of wall face (Section 109). The vertical height of each section is measured on the outer face from the bottom of the lowermost face element to the top of the wall.

511-5.01 PAYMENT. Payment will be made at the contract unit price per square foot of wall.

Excavation and backfill are paid for under Section 205.

Payment will be made under:

Pay Item	Pay Unit
511(1) Mechanically Stabilized Earth Wall	Square Foot

703-2.13 STRUCTURAL FILL. Aggregate containing no muck, frozen material, roots, sod or other deleterious matter and with a plasticity index not greater than 6 as tested by ATM 204 (*Determination of Liquid Limit test*) and ATM 205 (*Determination of Plastic Limit, Plasticity Index*). Meet the following gradation as tested by ATM 304:

TABLE 703-13
REQUIREMENTS FOR GRADING FOR STRUCTURAL FILL MATERIAL

SIEVE	PERCENT PASSING BY WEIGHT
3 in.	100
3/4 in.	75-100
No. 4	25-55
No. 16	10-30
No. 200	0-6

704-2.04 MODULAR CONCRETE BLOCK UNIT. Concrete block units sound and free of cracks or other defects that may interfere with proper placement of units or that may impair their strength or durability..

Dimensional requirements (e.g., thickness, size, dimensional tolerances).

Cement requirements (e.g., Type I, II, or III in accordance with ASTM C 150 or AASHTO equivalent.

Concrete strength requirements (e.g., 28-day compressive strength of at least x,xxx psi in accordance with ASTM C 140 or AASHTO equivalent).

Durability requirements (e.g., freeze-thaw durability of xxx units (ASTM C 1372 or AASHTO equivalent)).

SECTION 630

GEOTEXTILES FOR EMBANKMENT AND ROADWAY SEPARATION, ~~AND~~ STABILIZATION AND REINFORCEMENT

630-1.01 DESCRIPTION. Prepare ground surfaces, and furnish and place geotextiles for ~~embankment~~ separation and/or stabilization, as shown in the Plans.

630-2.01 MATERIALS. Use materials that conform to the following:

Geotextiles and Sewn Seam Strength ~~Sewing Thread~~ Subsection 729-2.01

Sewing Thread. Use high strength polypropylene, or polyester. Do not use nylon thread. Use thread of contrasting color to that of the geotextile itself.

630-3.01 CONSTRUCTION.

1. Surface Preparation. Prepare ground surface by removing ~~removal of~~ stumps, brush, boulders, and sharp objects. Fill holes and large ruts with material shown on the Plans or as approved.

2. Geotextile Placement. Unroll geotextile directly onto the prepared surface. Stretch geotextile to remove any creases or wrinkles. Do not expose geotextiles to sunlight ~~the elements~~ for longer than 14 ~~5~~ days after removal of protective covering. Do not allow geotextiles to get wet prior to installation when freezing temperatures are anticipated.

   a. Separation and Stabilization. Lay geotextile for embankment separation and stabilization parallel to roadway centerline. On horizontal curves, place in segment lengths not exceeding those listed in Table 630-1, with butt ends cut to match and sewn or overlapped. On tangents, straighten the geotextile and sew or overlap butt ends.

   b. ~~Stabilization~~ Reinforcement. Lay geotextile for embankment ~~stabilization~~ reinforcement perpendicular to the roadway centerline. Join segments by sewing or an approved bonding or attachment process.

TABLE 630-1
GEOTEXTILE PLACEMENT ON CURVES

Degree of Curve	Maximum Segment Length (ft.)
1	125
2	90
3	75
4	65
5	55
6	50

3. Joining. Join adjacent geotextiles for ~~embankment~~ separation by sewing or overlapping as required on the Plans. Overlap geotextiles in the direction shown on the Plans. Join adjacent geotextiles for stabilization by sewing as required on the Plans. Use other attachment methods, if approved.

   a. Sew seams with a Butterfly or J-Seam using ~~. Use~~ a double-thread chain stitch (lock stitch). Bring adjacent sections of geotextile together and fold so that the stitching penetrates four layers of geotextile for the full seam length. Make the stitching line 1-1/4 inches (±1/4 inch) from the folded edge of the seam and at least 1/2 inch from the free edge of the geotextile.

Sew seams so that they are up can be easily inspected by the Engineer. Illustrations showing correct stitch formation and seam configurations are provided in Figure 1-2 (page 1-28) of the FHWA publication, *Geosynthetic Design & Construction Guidelines*, FHWA-NHI-07-092, August 2008.

b. Overlap sections by a minimum of 3 feet. Place the beginning of each new roll beneath the previous roll to prevent the advancing fill from lifting the geotextile.

4. Material Placing and Spreading. During placing and spreading, maintain a minimum depth of 12 inches of cover material at all times between the fabric and the wheels or tracks of the construction equipment or as shown in the Plans.

Spread the material in the direction of the upper overlapped geotextile ~~fabric overlap~~. Maintain proper overlap and fabric continuity. If sewn or bonded seams are used, place the cover material and spread in only one direction for the entire length of the geotextile. On weak subgrades spread the cover material simultaneously with dumping to minimize the potential of a localized subgrade failure. Do not drop larger stones or frozen soil chunks from a height of more than 1 foot. Use a protective layer of soil at least 6 inches deep directly on top of the geotextile if soil particles or frozen soil chunks exceed 1 foot in diameter, unless the Engineer approves the procedure following a demonstration showing the geotextiles are not damaged by the procedure.

Compact using a smooth drum roller or in a manner approved by the Engineer. Do not allow construction equipment to make sudden stops, starts, or turns on the cover material. Fill any ruts over 3 inches deep occurring during construction with additional aggregate material and compact to the specified density.

5. Geotextile Repair.

a. Separation and Stabilization. Overlay torn area with geotextile with a minimum 3 foot overlap around the edges of the torn area or sew and bond according to Subsection 630-3.01.3. Ensure that the patch remains in place when material is placed over the affected area.

b. ~~Stabilization~~ Reinforcement. Sew ~~or bond~~ according to Subsection 630-3.01.3.a.

630-4.01 METHOD OF MEASUREMENT. ~~By multiplying plan neat line width by the measured length in final position parallel to installation centerline along the ground surface.~~ Measure geotextile by the square yard of ground surface actually covered. No allowance will be made for overlap, whether at joints or patches.

630-5.01 BASIS OF PAYMENT. Payment will be made at the contract unit price per square yard. Material used to fill ruts and holes will also be paid for at the unit price for the type of material used.

Payment will be made under:

Pay Item	Pay Unit
630(1) Geotextile, Separation, Class _____	Square Yard
630(2) Geotextile, Stabilization, Class _____	Square Yard
630(3A) Geotextile, Reinforcement – Type 1	Square Yard
630(3B) Geotextile, Reinforcement – Type 2	Square Yard

SECTION 631
GEOTEXTILES FOR SUBSURFACE
DRAINAGE AND EROSION CONTROL

631-1.01 DESCRIPTION. Prepare ground surface, and furnish and place geotextiles for subsurface drainage and erosion control, as shown in the Plans.

631-2.01 MATERIALS. Use materials that conform to the following for the class specified in the bid schedule:

Geotextiles and Sewn Seam Strength ~~Sewing Thread~~ Subsection 729-2.01

Sewing Thread. Use high strength polypropylene, or polyester. Do not use nylon thread. Use thread of contrasting color to that of the geotextile itself.

631-3.01 CONSTRUCTION.

1. Surface Preparation. Prepare ground surface by removing stumps, brush, boulders, and sharp objects. Fill holes and large ruts with material shown on the Plans or as approved. Construct smooth and stable trench walls.

2. Geotextile Placement. Unroll geotextile directly onto the prepared surface. Place geotextile to remove any creases or wrinkles. Place geotextile in a manner which will ensure intimate contact between the trench wall and the geotextile. The geotextile may be held in place with securing pins at 3-foot spacing along all edges (but not closer than 2 inches from the edge) to prevent movement during construction. Do not expose geotextiles to the elements for longer than 14 ~~5~~ days after removal of protective covering.

   a. Subsurface Drainage. In trenches, after placing the geotextile and drain aggregate, fold the geotextile over the top of the aggregate to produce a minimum overlap of 12 inches, for trenches greater than 12 inches wide. In trenches less than 12 inches wide, make the overlap equal to the width of the trench. Then cover the geotextile with the subsequent course of material.

   b. Erosion Control. Place and anchor geotextile on the approved surface so it will not be torn or excessively stretched by placement of the overlying materials. Anchor the terminal ends of the geotextile using key trenches or aprons at the crest and toe of slope, as shown on the Plans. Other temporary or permanent anchoring methods may be used, subject to approval. Place geotextile with the machine direction parallel to the direction of water flow (normally parallel to the slope for erosion control runoff and wave action, and parallel to the stream or channel).

3. Joining. Join geotextile by sewing or overlapping. Joining by bonding or other attachment methods may be used, subject to approval.

   a. Sew seams with a Butterfly or J-Seam using ~~. Use~~ a double thread chain stitch (lock stitch). Bring adjacent sections of geotextile together and fold so that the stitching penetrates four layers of geotextile for the full seam length. Make the stitching line 1-1/4 inches (±1/4 inch) from the folded edge of the seam and at least 1/2 inch from the free edge of the geotextile. Sew seams so that they can be easily inspected by the Engineer or representative. Illustrations showing correct stitch formation and seam configurations are provided in Figure 1-2 (page 1-28) of the FHWA publication, *Geosynthetic Design & Construction Guidelines*, FHWA-NHI-07-092, August 2008. Conform both factory and field sewn seams to the strength requirements of

Table 1 as outlined in the AASHTO M288 for subsurface drainage and erosion control applications.

b. Overlap sections by a minimum of 3 feet. Overlap successive geotextile sheets in the direction of flow so that the upstream sheet is placed over the downstream sheet and/or upslope over downslope. In trenches, where overlapped seams are constructed in the longitudinal trench direction, make the overlap equal to the width of the trench.

4. Placement of Cover Material ~~Material Placing and Spreading~~. Following placement of the geotextile on the prepared surface, place cover material of the type shown on the Plans. Place the cover material and armor from the bottom to the top of the slope using ~~Use~~ methods for placing cover material which minimize tearing and/or excessive stretching of the geotextile. In underwater applications, place the geotextile and the required thickness of cover material in the same day. Maintain proper overlap and geotextile continuity. Do not exceed the allowable drop heights for cover material shown in Table 631-1. Do not allow stones to roll down the slope on the geotextile. Do not grade the slope in a way that will disturb the cover material or armor stone once it has been placed.

TABLE 631-1

INDIVIDUAL STONE Max. Weight (lbs)	**ALLOWABLE DROP HEIGHT (ft)**	
	UNPROTECTED GEOTEXTILE	PROTECTED GEOTEXTILE*
< 5	3	3
5-250	0	3
> 250	0	0**

*Protected geotextile is defined as having a gravelly covering (cushion layer) ~~of 4 inches minimum thickness~~ at least 6 inches thick.

**If stones greater than 250 pounds must be dropped or if a height of drop greater than 3 feet is required, then perform field trials to determine the minimum cushion thickness and/or maximum height of safe drop without damaging the geotextile.

Maintain a minimum depth of 12 inches of cover material between the geotextile and the wheels or tracks of the construction equipment.

5. Geotextile Repair. Overlay torn area with geotextile with a minimum 3 foot overlap around the edges of the torn area. Ensure that the patch remains in place when material is placed over the affected area.

631-4.01 METHOD OF MEASUREMENT. Measure geotextile by the square yard of ground surface actually covered. No allowance will be made for overlap, whether at joints or patches.

631-5.01 BASIS OF PAYMENT. Payment will be made at the contract unit price per square yard. Material used to fill ruts and holes will also be paid for at the unit price for the type of material used.

Payment will be made under:

Pay Item	Pay Unit
631(1) Geotextile, Drainage, Class ______	Square Yard
631(2) Geotextile, Erosion Control, Class ______	Square Yard

SECTION 632

PAVING FABRIC

632-1.01 DESCRIPTION. Furnish and install geotextile paving fabric where shown on the Plans.

632-2.01 MATERIALS. Use materials that conform to the following:

Paving Fabric	Subsection 729-2.03
Asphalt Cement	Subsection 702-2.01 (for grade of asphalt used in the overlay)

632-3.01 CONSTRUCTION.

1. Surface Preparation. Prepare the surface on which the fabric is to be placed as follows:

   a. Fill all potholes and cracks wider than 1/4 inch with an approved asphalt emulsion and sand slurry.

   b. Remove excess asphalt material, loose aggregate, and other foreign materials from the surface.

2. Application of Sealant. Apply asphalt sealant by distributor meeting all requirements set forth under Subsection 402-3.02. Apply the asphalt sealant uniformly at 0.20 to 0.30 gallons per square yard and at a minimum temperature of ~~between~~ 295 °F ~~min.~~ and maximum temperature of 320 ~~325~~ °F in the distributor tank, or as directed by the Engineer and/or Paving Fabric manufacturer. Do not apply asphalt material on a wet surface or when the ambient air temperature is below 45 °F or when other conditions would prevent proper application.

3. Fabric Laydown Equipment. Use approved mechanical laydown equipment to place fabric.

4. Fabric Placement. Place fabric directly on top of the asphalt sealant (tack coat) before the sealant has cooled and lost its tackiness. Lay fabric in full rolls without wrinkles and/or folds. Place the fabric per the manufacturer's recommendations. Overlap geotextile joints to ensure full closure of the joint, but do not exceed 6 inches of overlap. Overlap transverse joints in the direction of paving. Apply 0.20 gallons per square yard of additional asphalt sealant beneath all fabric joints. Removal and replacement of damaged geotextiles is the responsibility of the Contractor.

5. Bituminous Surface Course Overlay. Place the bituminous surface course closely following the fabric laydown to avoid exposure of uncovered fabric overnight or to traffic or inclement weather. Do not allow the temperature of the hot-mix asphalt to exceed manufacturer's recommendations. If asphalt sealant bleeds through the fabric before the placement of the overlay, apply sand or bituminous surface course evenly over the affected area to prevent fabric pick-up by construction equipment. Prevent paver or other construction equipment from turning and/or pivoting on the fabric.

632-4.01 METHOD OF MEASUREMENT. Measure paving fabric by the surface area of pavement covered. No allowance will be made for overlap, whether at joints or patches. ~~Overlapping of fabric is subsidiary.~~

632-5.01 BASIS OF PAYMENT. Payment will be made at the contract unit price per square yard.

Pay Item	Pay Unit
632(1) Paving Fabric	Square Yard

SECTION 633

SILT FENCE

633-1.01 DESCRIPTION. Furnish, place, maintain, and remove temporary silt fence as shown in the Plans or as directed.

633-2.01 MATERIALS. Use materials that conform to the following:

Geotextile	Subsection 729-2.04 ~~2~~
Posts	Wood, steel, or approved synthetic material.
Prefabricated Silt Fence	May be used if the system meets Section 633 requirements.
Support Mesh Between Posts	If required, 14 gage steel wire with a maximum mesh opening size of 6 inches by 6 inches or prefabricated polymeric mesh of equivalent strength.

633-3.01 CONSTRUCTION.

1. Post Installation. Use posts that can be driven to the depths specified in the Plans and resist the maximum expected hydraulic and sediment material loads without damage. Place posts a maximum of 8 feet apart and drive a minimum of 18 inches into the ground.

2. Geotextile Placement. Install geotextile on posts in a vertical position and support by a wire ~~fence or self-support system~~ or polymeric mesh if additional support is shown on the Plans or is deemed necessary by the contractor. Set the geotextile at the height specified in the Contract. Secure the bottom 18 inches of the geotextile on the upslope side of the posts and support system ~~fence~~ as shown on the Plans. Backfill trench used to secure the bottom with tamped soil. Join adjacent sections of geotextile only at posts with a minimum of 6 inches overlap.

633-3.02 MAINTENANCE. Maintain the integrity of the fence as long as it is necessary to contain sediment runoff. Inspect daily and correct any deficiencies immediately. Remove and dispose of fence when adequate vegetative growth ensures ~~insures~~ no further erosion of the slopes. Cut off the fabric at ground level and remove the wire and posts. When thickness of trapped sediment is in excess of 4 inches above the ground, either remove sediment from the site or spread sediment uphill of the fence and seed all exposed soil immediately, following the requirements of Section 618.

633-4.01 METHOD OF MEASUREMENT. Measure silt fence the length of fence installed (Section 109). No allowance will be made for overlap, whether at joints or patches.

633-5.01 BASIS OF PAYMENT. The contract price includes maintenance, removal and disposal of the fence, and seeding.

Payment will be made under:

Pay Item	Pay Unit
633(1) Silt Fence	Linear Foot

SECTION 634

GEOGRID FOR EMBANKMENT AND ROADWAY STABILIZATION AND REINFORCEMENT

634-1.01 DESCRIPTION. Furnish and install geogrid material as ~~at locations~~ shown on the Plans.

634-2.01 MATERIALS. Use materials that conform to the following:

Geogrid Subsection 729-2.04 ~~5~~

~~CONSTRUCTION REQUIREMENTS~~

~~634-3.01 WEATHER LIMITATIONS. Do not expose geogrid to the elements for longer than 14 days after removal of protective covering.~~

634-3.01 CONSTRUCTION ~~REQUIREMENTS~~

1. ~~634-23.02~~ Surface Preparation.

   a. Soft Ground (CBR ≤3 ~~1-3~~). Prepare surface by removal of stumps, brush, boulders, and sharp objects. Fill holes and large ruts with material shown on the Plans or as approved.

   b. Firm Ground (CBR >3). Compact and finish subgrade or subbase prior to placement of the geogrid.

2. ~~634-3.03~~ Geogrid Placement. Unroll geogrid directly onto the prepared ground surface in the direction of advancing construction, parallel to the centerline of the roadway or according to the Plans. Do not drag the geogrid across the subgrade. Install the geogrid in the longest continuous practical length, free from folds, creases or wrinkles. Hold the geogrid in place with pins, staples, sandbags or piles of granular material. Do not expose geogrids to the elements for longer than 14 days after removal of protective covering.

   a. Soft Ground (CBR ≤3). Overlap geogrid panels ~~at all joints~~ a minimum of 24 inches at all joints with the upper geogrid in the direction that fill will be placed. Tie panels together securely with cable ties or hog rings at 20 foot intervals.

   b. Firm Ground (CBR >3). Overlap geogrid panels a minimum of 12 inches at all joints in the direction that fill will be placed. Tie panels together securely with manufacturer-recommended pins or bars. Hand-tension geogrid and stake to the ground at the edges, overlaps, and in the center of each roll, at 30 foot intervals**.**

   Place the beginning of each new roll beneath the previous roll to prevent the advancing fill from lifting the geogrid. Stagger end overlaps at least 10 feet from other end overlaps in adjacent rolls.

3. ~~634-3.04~~ Placing and Spreading Cover Material. Do not operate equipment directly on the unprotected geogrid. Spread fill material in the direction of the fabric overlap. Compact using a smooth drum roller. Do not allow construction equipment to make sudden stops, starts, or turns on the cover material.

   a. Very Soft Ground (CBR < 1). End-dump material onto previously placed material and spread over the geogrid with a low ground pressure dozer to the depth permitted. Do not dump material directly onto the geogrid. To prevent a mud wave, end-dump fill along the edges of the geogrid to form toe berms or access roads that extend one to two panel widths ahead of the remainder of the embankment fill placement. After constructing the two berms, spread fill in the area between the toe berms by placing material parallel to the alignment and symmetrical from the toe berms inward toward the center to maintain a U-shaped leading edge (i.e., concave outward) to contain the mud wave. Limit height of dumped piles above the geogrid to avoid local bearing failure. Traffic on the first lift should be parallel to the embankment alignment. Do not allow construction equipment to turn on the first lift. Compact first lift by tracking in place with dozers or end-loaders. Compact with specified compaction equipment once embankment is at least 2 feet above the original ground.

b. Soft Ground (1 ≤ CBR ≤ 3). End-dump ~~back dump~~ material onto previously placed material and ~~the geogrid.~~ spread over the geogrid ~~material ahead~~ with a low ground pressure dozer to the depth permitted. Place the end-dumped material along the roadway centerline and spread it outward to the roadway edges to prevent the development of wrinkles or movement of the geogrid during construction. Fill in any ruts that form during construction. Do not cut down the fill adjacent to the ruts.

c. Firm Ground (CBR > 3). Maintain a minimum depth of 6 inches of cover material at all times between the fabric and the wheels or tracks of the construction equipment.

4. ~~634-3.05~~ Geogrid Repair. Overlay torn area with geogrid with a minimum 3 foot overlap around the edges of the torn area and secure as recommended by the geogrid manufacturer.

634-4.01 METHOD OF MEASUREMENT. ~~By the square yard, in final position, determined by multiplying plan neat line width by the measured length parallel to installation centerline along the ground surface, for installations acceptably completed.~~ Measure geogrids by the square yard of ground surface actually covered. No allowance will be made for overlap, whether at joints or patches.

634-5.01 BASIS OF PAYMENT. Payment will be made at the contract unit price per square yard.

Material used to fill ruts and holes will be paid for at the unit price for the type of material used. Payment will be made under:

Pay Item	Pay Unit
634(1) Geogrid, ~~Type ___~~Stabilization, Class _____	Square Yard
634 (2) Geogrid, Reinforcement, Class _____	Square Yard

SECTION 729

GEOSYNTHETICS

729-2.01 GEOTEXTILE FOR SUBSURFACE DRAINAGE, SEPARATION, STABILIZATION, EROSION CONTROL AND REINFORCEMENT.

1. Subsurface Drainage. Meet AASHTO M 288 for Subsurface Drainage.
2. Separation. Meet AASHTO M 288 for Separation, except provide a minimum permittivity of 0.05 sec^{-1}.
3. Stabilization. Meet AASHTO M 288 for Stabilization, except provide a minimum permittivity of 0.08 sec^{-1}.
4. Erosion Control. Meet AASHTO M 288 for Permanent Erosion Control.
5. Reinforcement. Meets the requirements in Table 729-1 for Type 1 or Type 2.

TABLE 729-1
GEOTEXTILE REINFORCEMENT PROPERTIES

Property	Test Method	Units	Requirement[a]	
			Type 1	Type 2
Grab Tensile	ASTM D4632	lb.	200/200	400/400
Grab Elongation	ASTM D4632	% (MD)	10	10
Wide Width Tensile	ASTM D4595	lb/in. (ultimate)	200/200	400/400
Wide Width Tensile	ASTM D4595	lb/in. (@ 5% strain)	100/100	200/200
Puncture	ASTM D6241	lb.	500	1500
Trapezoidal Tear	ASTM D4533	lb.	100	150
AOS	ASTM D4751	U.S. sieve size	#30[b]	#30[b]
Permittivity	ASTM D4491	sec^{-1}	0.20	0.20
Flow Rate	ASTM D4491	$gal./min./ft^2$	10	10

[a] Minimum Average Roll Values (MARV) in machine direction (MD) / cross-machine direction (XD) unless otherwise specified

[b] Maximum average roll value

~~**729-2.02 GEOTEXTILE SUBSURFACE DRAINAGE AND EROSION CONTROL.**~~

729-2.02 4 SILT FENCE. Meet AASHTO M 288 for Temporary Silt Fence.

729-2.03 PAVING FABRIC. Meet AASHTO M 288 for Paving Fabric.

729-2.04 ~~5~~ GEOGRID EMBANKMENT STABILIZATION AND REINFORCEMENT. Provide geogrid consisting of a regular network of connected polymer tensile elements with aperture geometry sufficient to provide significant mechanical interlock with the surrounding material. Provide dimensionally stable geogrid that is able to retain its geometry during construction. Provide geogrid structure that resists ultraviolet degradation and all forms of chemical and biological degradation encountered in the soil in which it is buried.

Package, label, handle, and store geogrid material according to ASTM D 4873.

1. Stabilization. Provide geogrid that meets the survivability requirements in Table 729-2 and meets the physical requirements in Table 729-3.
2. Reinforcement. Provide geogrid that meets the survivability requirements in Table 729-2 and as shown in the Plans.

~~Biaxial polymer grid, specifically fabricated for use as a soil reinforcement, having high tensile strength, modulus, and stiffness in both principal directions. Use a single- layered, integrally-formed grid structure. Use either extruded or punched and drawn polypropylene or high density polyethylene. Geogrid must be UV-stabilized, chemically inert, and meets the physical requirements in Table 729-1.~~

TABLE 729-2
GEOGRID SURVIVABILITY REQUIREMENTS

Property	Test Method	Units	Requirement	
			CLASS 1	CLASS 2
Ultimate Multi-Rib Tensile Strength[a]	ASTM D 6637	lb./ft.	1230	820
Junction Strength[a]	ASTM D7737	lb.	25	25
Ultraviolet Stability (Retained Strength)	ASTM D 4355	%	50% after 500 hours of exposure	

[a] Minimum Average Roll Value (MARV) in any rib direction.

TABLE 729-3 ~~TABLE 729-1~~
GEOGRID PHYSICAL REQUIREMENTS

Property	Test Method	Units	Requirement
Percent Open Area	COE, CW-02215	%	50 – 80
Aperture Size[a]	Direct measure	in.	0.5 – 3.0

[a] measured as the spacing between parallel ribs.

PROPERTY	REQUIREMENT	TEST METHOD
Average Aperture Size, MD[(1)] XD[(2)]	 0.8-2.0 in. 0.8-2.0 in.	I.D Calipered Maximum Inside Dimension
Installation Damage Resistance	80%[(3)]	Sample per D5818 Test per D6637
Rib Thickness, min. (Nominal)	40 mils	Rib Thickness Calipered Minimum
Tensile Strength, min. At 2% Strain At 5% Strain	MD & XD 400 lb/ft 800 lb/ft	ASTM D6637
Junction Strength, min.	90%[(4)]	GRI GG-GG2

[(1)] MD: Machine Direction which is along roll length.
[(2)] XD: Cross machine direction which is across roll width.
[(3)] 80% relative to pre-installation Tensile Strength values. Perform Test install using GP or GW Class soil.
[(4)] 90% relative to Ultimate Tensile Strength as determined by ASTM D6637

Recommendations for Future Work

The use of geosynthetics, introduction of new products, new design techniques and applications are still developing. Because of this, it is recommended that the Alaska DOT&PF continue tracking geosynthetics as they develop or are implemented on a broader scale, especially as they relate to geosynthetics specifications. A list of potential items to be addressed over time, but beyond the scope of this project, is presented below.

- AKDOT&PF may consider adjusting their filtration requirements based on pore size rather than on apparent opening size. ASTM has developed a test method for pore size distribution (ASTM D6767). This method provides much better characterization of complete pore size of a geotextile filter and may eventually replace AOS. The method also allows for the permeability of the geotextile to accurately be determined based on the porosity of the material. ASTM is currently balloting the AOS and permittivity standards where this procedure is inserted as an option to the current standard test procedures. Likewise, AKDOF&PF may allow this standard to be used as an option for obtaining ASO and permittivity as an interim step.
- The authors are finalizing a study of geosynthetics used as subgrade stabilization and are specifically researching material properties of geosynthetics as they relate to their performance in this application. Information from this project may affect which physical properties are required in Section 634.
- The incorporation of geosynthetics in base reinforcement applications and their use in mechanistic-empirical design of pavements are still evolving. As this design tool and application evolve, AKDOT&PF may consider broadening their use of geogrids and geocomposites as base reinforcement.
- Oftentimes, construction takes place at temperatures below what AASHTO M288 and other specifications were created. Additional research is needed to establish material properties of the geosynthetic that are more appropriate for cold-weather construction, especially as they relate to a specific class of construction. For example: how do colder temperatures affect the minimum materials tensile properties and junction strength as it relates to survivability. This cold weather testing would benefit AKDOT&PF as they specify certain materials in anticipation of cold weather construction.
- Dewatering of pavements during construction of embankments in wet areas and drainage in pavements using prefabricated drains should be considered in AKDOT&PF's specification. Where free draining base is not used, not readily available and/or relatively expensive, geosynthetics with lateral drainage capability (transmission function) may be placed at the subgrade-base interface to 1) provide drainage of the subgrade when a

poorly draining, dense graded base course is used; and/or 2) to promote quicker drainage of the base course. For the first case of poorly draining bases, where water in a wet subgrade cannot readily drain upward into the base, geosynthetics that allow some drainage in its plane (i.e., thick nonwoven or hydrophilic woven geotextiles or geocomposites) would also allow for pore water pressure dissipation. For the second case, drainage geocomposites with sufficient compressive strength to support traffic without excessive deformation and with adequate flow capacity can be used to enhance drainage of the roadway system. Additional information on the design of these alternatives is covered in Holtz et al. (2008) as well as FHWA Geotechnical Aspects of Pavements (Christopher et al., 2006).

- As geosynthetic reinforced soil-integrated bridge systems (GRS-IBS) have taken hold in many states in the past several years, the AKDOT&PF may consider including standard specifications for this application. An interim implementation guide was published by FHWA in June 2012 (Adams et al., 2012) and sample guide specifications for this application were published by FHWA in August 2012 (FHWA, 2012).
- High strength geotextile have often been successfully used as reinforcement. AKDOT may consider including these types of products in addition to geogrids in their standard specifications.
- Geocomposites are referred to in Alaska Specification 511 (MSE walls) in section 511-3.01 (Construction) as part of the drainage system associated with this application; however, there are no material specifications associated with geocomposites. If these materials are frequently specified, AKDOT&PF should consider including these materials in their standard specifications rather than relying on special provisions. Specifications for geocomposite drains used in MSE walls are covered in FHWA NHI-10-024 (Berg et al., 2009).
- Another pavement overlay type application, concrete interlayer geotextile, which was developed and is a standard of practice in Europe, has recently been used in the US. In this application, a heavyweight nonwoven (14-16 oz/yd^2) is replacing all or part of a traditional asphalt concrete layer (typically 1" to 3" thick) as an interlayer under new PCC slabs, either over a cement or lime treated base in totally new pavements, or over an existing concrete or composite (concrete and asphalt) pavement, where the new PCC slab becomes an un-bonded overlay (Hall et al., 2007).

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