630 Geosynthetics

630.1 General

The following geosynthetic applications are discussed in this chapter:

- Separation, filtration, and stabilization
- Pavement subgrade
- Subsurface drainage
- Erosion
- Mechanically-stabilized earth (MSE) retaining walls
- Reinforced soil slopes

630.1.1 Design Approach

The Federal Highway Administration (FHWA) recommends the following systematic approach to designing with geosynthetics:

1. Define the purpose and scope of the project.
2. Investigate and establish geotechnical site conditions.
3. Establish application criticality, severity, and performance criteria and identify external influences on performance.
4. Formulate trial designs and compare alternatives.
5. Create design models and parameters and perform analyses.
6. Select the most effective design based on analyses, cost considerations, construction feasibility, etc.
7. Prepare detailed geosynthetic specifications and plan details including key property requirements and installation procedures.

8. Hold preconstruction and construction follow-up meetings with New Mexico Department of Transportation (NMDOT) field inspectors and contractors.
9. Review and comment on the acceptance of proposed geosynthetic materials based on manufacturer certification and/or laboratory testing.
10. Carefully monitor construction, paying particular attention to potential damage to geosynthetics caused by field operations.
11. Inspect the finished application after any significant events that could affect performance.

630.2 References

- American Association of State Highway Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications, current edition.
- AASHTO Standard Specification for Geotextile Specification for Highway Applications M288, 2015.
- American Society for Testing and Materials (ASTM) Standard Terminology for Geosynthetics, D4439.
- Design Guideline for Flexible Pavements with Tensar Geogrid Reinforced Bases, Tensar Corporation, March, 1987.
- FHWA Publication No. FHWA-NHI-10-024, Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Slopes - Volume I, November 2009.
- FHWA Publication No. FHWA-NHI-10-025 Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Slopes - Volume II, November 2009.
- FHWA Publication No. FHWA-HI-95-038 Geosynthetic Design and Construction Guidelines, April 1998.
- FHWA Publication No. FHWA-NHI-07-092 Geosynthetic Design and Construction Guidelines, August 2008.
- FHWA Publication No. FHWA-HRT-11-027 Geosynthetic Reinforced Soil Integrated Bridge System Synthesis Report, January 2011.

- FHWA Publication No. FHWA-HRT-11-026 Geosynthetic Reinforced Soil Integrated Bridge System Interim Implementation Guide, June 2012.
- NMDOT Geotechnical Manual- Requirements and Guidelines for Highway Structure Foundation Investigation and Subsurface Exploration, NMDOT, 1990 – This document includes NMDOT requirements and guidelines for highway structure foundation investigation and subsurface exploration. This manual is outdated and the NMDOT is in the process of updating it. Until the NMDOT Geotechnical Manual has been updated, geotechnical work conducted on behalf of the NMDOT should be done using the current edition of the AASHTO LRFD Bridge Design Specifications.
- NMDOT Special Provision for Geosynthetic Reinforced Soil-Integrated Bridge System (GRS-IBS Bridge Abutment), Section 506-B.
- NMDOT Special Provision Modifying Standard Specifications for Highway and Bridge Construction, Section 506, Engineered Retaining Wall System, 2014.
- NMDOT Special Provision Modifying Standard Specifications for Highway and Bridge Construction, Section 604 Reinforced Soil Slope, 2014.
- NMDOT Standard Specifications for Highway and Bridge Construction, Section 506, MSE Retaining Structures, current edition.
- NMDOT Standard Specifications for Highway and Bridge Construction, Section 604, Soil and Drainage Geotextiles, current edition.

Additional information related to pavement design is contained in Chapter 620 of the Design Manual.

630.3 Definitions

Geosynthetic terminology is outlined in ASTM D4439, Standard Terminology for Geosynthetics. Geosynthetics comprise four groups—geotextiles, geogrids, geomembranes, and geocomposites—and are described as follows:

- Geotextile - A permeable geosynthetic comprised solely of textile materials (nonwoven or woven, comprised of various synthetic polymers, and manufactured by numerous processes).
- Geogrid - A geosynthetic formed by a regular network of tensile elements and apertures typically used for reinforcement functions (may be uniaxial, biaxial, or triaxial in reinforcement direction).
- Geomembranes - An impermeable geosynthetic, typically used to control migration of moisture or fluids, and composed of various polymer compositions, surface textures, and welding/overlap methods.
- Geocomposite - A geosynthetic material manufactured of two or more geosynthetic materials; for example, a drainage geocomposite formed by heat bonding a filter geotextile and a drainage geonet together.

The FHWA provides thorough definitions and detailed descriptions of geosynthetic manufacturing processes and identifying terms.

630.4 Separation, Filtration, and Stabilization

Geotextiles (woven and nonwoven) are used for:

- Separation and/or stabilization for pavement subgrade/base.
- Filters to prevent soils from migrating into drainage aggregate or pipes, while maintaining water flow through the system.
- Prevention of erosion of the soils from a stream bank, when used below riprap and other armor materials.

For a geotextile to function as a separator or filter, the apparent opening size (AOS) must be smaller than the smallest size particle to be retained and still allow for the flow of water through the geotextile material. For the geotextile to perform as required for filtration and separation, a geotextile should meet the criteria provided in the following equation:

$AOS \leq BD_{85(soil)}$

where:

AOS = Apparent opening size.

$D_{85(soil)}$ = Diameter of soil particle for which 85 percent are smaller.

B = Dimensionless coefficient related to Cu.

Cu = Coefficient of Uniformity.

For both woven and nonwoven geotextiles in granular soils, B is determined from the following equations:

$B = 1$	$Cu \leq 2$ or $Cu \geq 8$
$B = 0.5Cu$	$2 \leq Cu \leq 4$
$B = 8/Cu$	$4 < Cu < 8$

For fine-grained soils, B is a function of the type of geotextile:

Woven:	$B = 1$
Nonwoven:	$B = 1.8$

In addition to AOS, the permeability and permittivity of the geotextile is evaluated. Selection of the correct filter is based on the critical/severe nature of the project as outlined in FHWA Geosynthetic Design and Construction Guidelines, August 2008.

For less critical applications and less severe conditions:

$k_{geotextile} \geq k_{soil}$

where:

$k_{geotextile}$ = Coefficient of permeability of the geotextile.

k_{soil} = Coefficient of permeability of the soil.

For critical applications and severe conditions:

$k_{geotextile} \geq 10k_{soil}$

The permittivity, Ψ, requirements depend on the fines content of the soil to be filtered. The more fines in the soil, the greater the permittivity required. Exhibit 630-1 contains approximate fines content and recommended permittivity requirements.

Exhibit 630-1
Typical Permittivity (Ψ) Requirements (FHWA NHI-07-092)

Percent Passing No. 200 Sieve	Ψ(sec-1)
< 15	≥ 0.5
15 to 50	≥0.2
> 50	≥ 0.1

630.5 Pavement Subgrade

Guidelines for use of geosynthetics in pavement subgrade applications are contained in Chapter 620 of the Design Manual.

Geosynthetics in pavement subgrade applications are covered in detail in FHWA Geosynthetic Design and Construction Guidelines, August 2008. In addition, the geotextile and/or geogrid for subgrade/base reinforcement should be designed, constructed, and specified in accordance with the Design Guideline for Flexible Pavements with Tensar Geogrid Reinforced Bases, Tensar Corporation, March, 1987. Geotextiles (woven and nonwoven) used for separation and/or stabilization for pavement subgrade/base should be designed to perform as required for filtration meeting the criteria provided in Section 630.4.

Separation and stabilization geotextiles shall meet the requirements of Sections 604.2.4 Separation Geotextiles, 604.2.5 Stabilization Geotextiles, and 604.3.8 Separation/Stabilization Geotextiles of the NMDOT's Standard Specifications for Highway and Bridge Construction, current edition. In addition, the survivability class of the separation and stabilization geotextile shall be in accordance with AASHTO's Standard Specifications for Geotextiles M288.

630.6 Subsurface Drainage

Nonwoven needle-punched geotextiles and geocomposites provide drainage by carrying water in the plane of the geosynthetic as a conduit (transmissivity). The geotextile will be designed to have enough flow rate or transmissivity to achieve the required drainage. Geotextiles may be used for drainage applications to dissipate excess pore pressures or hydrostatic head and also to provide pavement subgrade drainage. Nonwoven geotextile may need to be thick enough to allow the flow of water through the geotextile material itself or the geotextile may be designed to transmit flow to underlying core material such as wick drains or drainage board.

The drainage geotextiles and/or geocomposites should be designed, constructed, and specified in accordance with FHWA's Geosynthetic Design and Construction Guidelines, August 2008.

Drainage geotextiles should also meet the requirements of Sections 604.2.2 and 604.3.5, Subsurface Drainage Geotextiles of NMDOT's Standard Specifications for Highway and Bridge Construction. In addition, the survivability class of the drainage geotextile shall be in accordance with AASHTO's Standard Specifications for Geotextiles, M288.

630.7 Erosion

Geosynthetics minimize surficial soil particle movement due to the flow of water over the surface of bare soil or due to the disturbance of soil caused by construction activities. Geotextiles used as silt fences or placed beneath riprap on soil slopes achieve these functions. Silt fences keep eroded soil particles on the construction site whereas geotextiles placed beneath riprap on soil slopes prevent erosion from taking place. In general, permanent erosion control methods are only used where more natural means (like the use of biodegradable vegetation mats to establish vegetation to prevent erosion) are not feasible. These functions control some of the geosynthetic properties, such as AOS, permittivity, and in some cases load-strain characteristics.

Erosion geotextiles and/or geogrids should be designed, constructed, and specified in accordance with FHWA's Geosynthetic Design and Construction Guidelines, August 2008. Erosion geotextiles should also meet the requirements of Sections 604.2.3 and 604.3.7 Erosion Control Geotextiles of NMDOT's Standard Specifications for Highway and Bridge Construction, current edition. In addition, the survivability class of the erosion geotextile shall be in accordance with AASHTO's Standard Specifications for Geotextiles, M288.

630.8 MSE Retaining Walls

Geosynthetics may be used in the reinforced soil mass of MSE retaining walls using high strength geotextiles and/or geogrids to strengthen the soil mass. High tensile-strength geosynthetics provide the necessary soil reinforcement in pullout, connection strength, and environmental conditions over the service life of the retaining wall. Guidelines for use of geosynthetic reinforced soil in MSE walls are covered in FHWA's Geosynthetic Design and Construction Guidelines, August 2008.

The nominal long-term geosynthetic design strength should be based on a combined strength reduction factor (RF) that includes strength reduction of the geosynthetic reinforcement due to installation damage, creep, and chemical aging as covered below:

$$Tal = Tult/RF$$

where:

$$RF = RF_{ID} \times RF_{CR} \times RF_{D}$$

and:

Tal = nominal long-term reinforcement design strength.

$Tult$ = minimum average roll value (MARV) ultimate tensile strength.

RF = combined strength reduction factor to account for potential long-term degradation due to installation damage, creep, and chemical aging.

RF_{ID} = strength reduction factor to account for installation damage to geosynthetic reinforcement.

RF_{CR} = strength reduction factor to prevent long-term creep rupture of geosynthetic reinforcement.

RF_{D} = strength reduction factor to prevent rupture of geosynthetic reinforcement due to chemical and biological degradation.

The chemical and biological aging strength reduction factor is dependent on whether the soil is determined to be chemically aggressive or non-aggressive in accordance with the current edition of the AASHTO LRFD Bridge Design Specifications. Independent product-specific data from which strength reduction factors may be determined can be obtained at the AASHTO National Transportation Product Evaluation Program website here.

Geosynthetics in the application of MSE retaining walls should be designed, constructed, and specified in accordance with FHWA's Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Slopes - Volume I, 2009, or FHWA Publication No. FHWA-HRT-11-026, Geosynthetic Reinforced Soil Integrated Bridge System Interim Implementation Guide, June 2012, as applicable. The design of geosynthetic reinforced soil MSE walls should be in conformance with the current edition of the AASHTO LRFD Bridge Design Specifications.

Geosynthetics in MSE wall applications should also meet the requirements of NMDOT's Special Provision Modifying Standard Specifications for Highway and Bridge Construction, Section 506 Engineered Retaining Wall System, 2014.

Geosynthetics in geosynthetic reinforced soil integrated bridge systems should meet the requirements of NMDOT's Special Provision for Geosynthetic Reinforced Soil-Integrated Bridge System (GRS-IBS Bridge Abutment), Section 506-B, 2014.

630.9 Reinforced Soil Slopes

Geosynthetics may be used in the reinforced soil mass of reinforced soil slopes using high-strength geotextiles and/or geogrids to strengthen the soil mass. High tensile-strength geosynthetics provide the necessary soil reinforcement in pullout, connection strength, and environmental conditions over the service life of the reinforced soil slope. Guidelines for use of geosynthetics in reinforced soil slopes are covered in FHWA's Geosynthetic Design and Construction Guidelines, August 2008.

The nominal long-term geosynthetic design strength should be based on a combined strength RF that includes strength reduction of the geosynthetic reinforcement due to installation damage, creep, and chemical aging as covered in Section 630.8.

The chemical and biological aging strength reduction factor is dependent on whether the soil is determined to be chemically aggressive or non-aggressive in accordance with the current edition of the AASHTO LRFD Bridge Design Specifications. Independent product-specific data from which strength reduction factors may be determined can be obtained from AASHTO's National Transportation Product Evaluation Program website here.

Geosynthetics in the application of reinforced slopes should be designed, constructed, and specified in accordance with FHWA's Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Slopes - Volume II, 2009 and in accordance with FHWA's Geosynthetic Design and Construction Guidelines, August 2008. The design of geosynthetic reinforced soil slopes should be in conformance with the current edition of the AASHTO LRFD Bridge Design Specifications.

Geosynthetics in reinforced soil slope applications should also meet the requirements of the applicable NMDOT Special Provision Modifying Standard Specifications for Highway and Bridge Construction, Section 604 Reinforced Soil Slope, 2014.