200F-9

Geosynthetic Design

Design Manual
Chapter
Geotechnical Design
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> ***Quick Tips:***
>
> - Soils Design Section will outline where (approx. Station) and what type of geosynthetics (i.e., engineering fabrics) should be used along the project alignment in the S3 Event.
> - All geosynthetics used in project applications must meet the requirements of Section 4196 of the Standard Specifications.

The term "geosynthetics" refers to all synthetic, usually polymeric (i.e., polyethylene, polyvinylchloride, and polypropylene), engineering fabrics used in various geotechnical applications such as drainage, reinforcement, separation, and erosion control applications. Geosynthetic terminology is outlined in ASTM D4439. This chapter only provides general guidelines for design of geosynthetics. More detailed information can be found in Geosynthetic Design and Construction Guidelines, FHWA NHI-07-092/ FHWA HI-95-038.

In general, the Soils Design Section will outline where (approx. Station) and what type of geosynthetics (i.e., engineering fabrics) should be used for the project in the S3 event submittal (see Section 200B-3) based on the subsurface and groundwater conditions encountered along the project alignment and the intended application. For site-specific geosynthetic design, Geosynthetic Design and Construction Guidelines, FHWA NHI-07-092/ FHWA HI-95-038 should be used. All geosynthetics used in project applications must comply with Materials I.M. 496.01 for inspection and acceptance and meet the requirements of Section 4196 of the Standard Specifications.

> **Note:** This section only addresses geosynthetics with a geotechnical application. Geosynthetics used for asphalt overlays or silt fencing are not covered in this section.

Geosynthetic Material Types

Geosynthetic materials comprise four basic groups: geotextiles; geogrids; geomembranes; and geocomposites. These material types are explained in more detail in the following sections.

Geotextiles

Geotextiles are subdivided into two categories: woven and nonwoven. Woven geotextiles are made of either: monofilament, multi-filament, or fibrillated yarns; or slit film tapes. This category of geotextiles is manufactured similarly to cloth or other textiles, using traditional weaving techniques. Woven fabrics exhibit high tensile strength, high modulus, and low strain characteristics. They are used for separation and reinforcement.

In nonwoven geotextile manufacturing, the polymeric fibers or filaments are continuously extruded and spun, blown or otherwise, placed onto a moving conveyor belt, and needle punched or heat bonded to create a non-woven product. Non-woven fabrics typically have high permeability and high strain characteristics. They are used to provide filtering or separation.

Geogrids

Geogrids are formed by a regular network of tensile elements with openings of sufficient size to allow interlock with the surrounding fill materials. Geogrids can be manufactured in three ways: extrusion; knitting or weaving; and welding. All of these manufacturing techniques allow geogrids to be oriented such that the principal strength is in one direction (uniaxial geogrids) or in both directions (biaxial geogrids). The primary purpose of geogrids is to provide soil reinforcement in embankments and modular/segmental walls, as well as subgrade stabilization and/or separation of aggregate and soil materials.

Geomembranes

Geomembranes, unlike geotextiles and geogrids, are manufactured with a single solid sheet of geosynthetic material. Geomembranes are used as either a low permeability or an impermeable boundary to prevent the movement of fluids. The primary use of geomembranes is in the design and construction of landfills; however, geomembranes have selected uses on transportation projects, such as being used as an impermeable barrier above lightweight EPS (geofoam) materials.

Geocomposites

Geocomposites are the combination of two or more geosynthetic materials combined together, such as geotextiles and geogrids. Most geocomposites are used in for drainage applications. Prefabricated vertical drains (PVDs) and drainage boards (similar to MiraDrain) are an example of geocomposites. Included in geocomposites are the three dimensional polymeric cell structures called geocells/geonets.

Geosynthetic Applications

Filtration/Erosion Control

Geotextiles (woven and nonwoven) are used as separators and filters to prevent soils from migrating into drainage aggregate or pipes, while maintaining water flow through the system. Geotextiles are also used below riprap and other armor materials to prevent erosion of the soils from the stream bank. 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. To provide good 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 C_u.

C_u = Coefficient of Uniformity.

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

$B = 1$	$C_u \leq 2$ or $C_u \geq 8$
$B = 0.5C_u$	$2 \leq C_u \leq 4$
$B = {}^{8}/_{C_u}$	$4 < C_u < 8$

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 requires consideration. The selection of the correct filter is based on the critical/severe nature of the project as outlined in FHWA NHI-07-092.

For less critical applications and less severe conditions:

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

where:

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

k_{soil} = Coefficient of permeability of soil.

For critical applications and severe conditions:

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

where $k_{geotextile}$ and k_{soil} are the same as above.

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. Table 1 contains approximate fines content and recommended permittivity requirements based on previous experience.

Table 1: Typical Permittivity (Ψ) Requirements (from FHWA NHI-07-092).

percent passing No. 200 sieve	Ψ (sec^{-1})
< 15	≥ 0.5
15 to 50	≥0.2
> 50	≥ 0.1

Drainage

Nonwoven needle punched geotextiles and geocomposites can also provide drainage by allowing water to drain from or through low permeability soils. The primary application of the use of geotextiles for drainage is in dissipation of excess pore pressures or hydrostatic head. In some cases, the nonwoven geotextile will need to be thick enough to allow the flow of water through the geotextile material itself. In other cases, the geotextile must transmit enough flow through to the underlying core material (such as wick drain or drainage board). Thus, the geotextile will need to be sized to have enough flow rate or transmissivity to achieve the required drainage. Table 4196.01-2 of Section 4196 of the Standard Specifications provides the minimum strength, permittivity, and engineering properties required for fabrics used as subsurface drainage.

Separation/Erosion Control

Geosynthetic materials, primarily geotextiles, are used to prevent the migration of fines from subgrade soils into granular bases. The geotextile should be selected to prevent the migration of fines based on the AOS criteria outlined in the filtration section above. Table 4196.01-3 of Section 4196 of the Standard Specifications provides the minimum strength, permittivity, and engineering properties required for fabrics used as embankment erosion control or separation. In addition, geogrids may also be used as a separator to prevent the migration of granular materials (aggregate) into fine-grained, soft subgrade soils. However, this application will not prevent the migration of fines from the subgrade soil into the aggregate.

Reinforcement

Both geotextiles and geogrids are used as reinforcement. These materials add tensile strength to a soil matrix, thus providing a more competent and stable material. The geotextile or geogrid reinforcement should be designed and sized for the anticipated loading condition. Table 4196.01-5 of Section 4196 of the Standard Specifications provides the minimum strength and engineering properties required for fabrics used as subgrade stabilization reinforcement. To achieve the required reinforcement, overlapping of the geotextile/geogrids will be required and should meet the following guidelines:

- CBR < 1.0 (man walking sinks 2 to 3 inches): minimum 3 foot overlap.
- CBR 1.0 to 3.0 (pickup truck ruts ½ to 1 inch): minimum 2 foot overlap.
- CBR > 3.0 (loaded dump truck ruts no more than 3 inches): minimum 1 foot overlap.

Reference Documents

1. ASTM, 2006, Standard Terminology for Geosynthetics, D 4439, ASTM International.
2. Holtz, R.D., Christopher, B.R., and Berg, R.R., 1995, Geosynthetic Design and Construction Guidelines, Federal Highway Administration, FHWA HI-95-038.
3. Holtz, R.D., Christopher, B.R., and Berg, R.R., 2008, Geosynthetic Design and Construction Guidelines, Federal Highway Administration, FHWA NHI-07-092.

Chronology of Changes to Design Manual Section:

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