Geotextiles in Pavement, Drainage, & Embankment Applications

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CHAPTER 1

INTRODUCTION

1-1. Purpose

This manual describes various geotextiles, test methods for evaluating their properties, and recommended design and installation procedures.

1-2. Scope

This manual covers physical properties, functions, design methods, design details and construction procedures for geotextiles as used in pavements, railroad beds, retaining wall earth embankment, rip-rap, concrete revetment, and drain construction. Geotextile functions described include pavements, filtration and drainage, reinforced embankments, railroads, erosion and sediment control, and earth retaining walls. This manual does not cover the use of other geosynthetics such as geo- grids, geonets, geomembranes, plastic strip drains, composite products and products made from natural cellulose fibers.

1-3. References

Appendix A contains a list of references used in this manual.

1-4. Geotextile Types and Construction

a. Materials. Geotextiles are made from polypropylene, polyester, polyethylene, polyamide (nylon), polyvinylidene chloride, and fiberglass. Polypropylene and polyester are the most used. Sewing thread for geotextiles is made from Kevlar[1] or any of the above polymers. The physical properties of these materials can be varied by the use of additives in the composition and by changing the processing methods used to form the molten material into filaments. Yarns are formed from fibers which have been bundled and twisted together, a process also referred to as spinning. (This reference is different from the term spinning as used to denote the process of extruding filaments from a molten material.) Yarns may be composed of very long fibers (filaments) or relatively short pieces cut from filaments (staple fibers).

b. Geotextile Manufacture.

(1) In woven construction, the warp yarns, which run parallel with the length of the geotextile panel (machine direction), are interlaced with yarns called till or filling yarns, which run perpendicular to the length of the panel (cross direction as shown in fig 1-1). Woven construction produces geotextiles with high strengths and moduli in the warp and fill directions and low elongations at rupture. The modulus varies depending on the rate and the direction in which the geotextile is loaded. When woven geotextiles are pulled on a bias, the modulus decreases, although the ultimate breaking strength may increase. The construction can be varied so that the finished geotextile has equal or different strengths in the warp and fill directions. Woven construction produces geotextiles with a simple pore structure and narrow range of pore sizes or openings between fibers. Woven geotextiles are commonly plain woven, but are sometimes made by twill weave or leno weave (a very open type of weave). Woven geotextiles can be composed of monofilaments (fig 1-2) or multifilament yarns (fig 1- 3). Multifilament woven construction produces the highest strength and modulus of all the constructions but are also the highest cost. A monofilament variant is the slit-film or ribbon filament woven geotextile (fig 1-4). The fibers are thin and flat and made by cutting sheets of plastic into narrow strips. This type of woven geotextile is relatively inexpensive and is used for separation, i.e., the prevention of intermixing of two materials such as aggregate and fine-grained soil.

(2) Manufacturers literature and textbooks should be consulted for greater description of woven and knitted geotextile manufacturing processes which continue to be expanded.

(3) Nonwoven geotextiles are formed by a process other than weaving or knitting, and they are generally thicker than woven products. These geotextiles may be made either from continuous filaments or from staple fibers. The fibers are generally oriented randomly within the plane of the geotextile but can be given preferential orientation. In the spunbonding process, filaments are extruded, and laid directly on a moving belt to form the mat, which is then bonded by one of the processes described below.

(a) Needle punching. Bonding by needle punching involves pushing many barbed needles through one or several layers of a fiber mat normal to the plane of the geotextile. The process causes the fibers to be mechanically entangled (fig 1-5). The resulting geotextile has the appearance of a felt mat.

(b) Heat bonding. This is done by incorpo-

[1] Kevlar is a registered trademark of Du Pont for their aramid fiber.

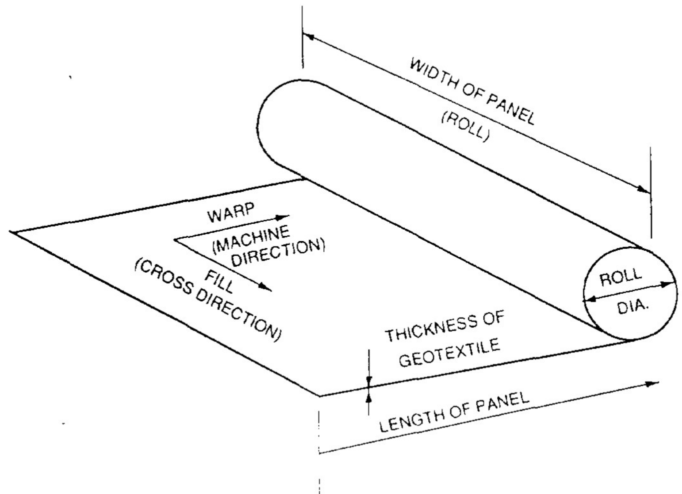

Figure 1-1. Dimensions and Directions for Woven Geotextiles.

rating fibers of the same polymer type but having different melting points in the mat, or by using heterofilaments, that is, fibers composed of one type of polymer on the inside and covered or sheathed with a polymer having a lower melting point. A heat-bonded geotextile is shown in figure 1-6.

(c) Resin bonding. Resin is introduced into the fiber mat, coating the fibers and bonding the contacts between fibers.

(d) Combination bonding. Sometimes a combination of bonding techniques is used to facilitate manufacturing or obtain desired properties.

(4) Composite geotextiles are materials which combine two or more of the fabrication techniques. The most common composite geotextile is a nonwoven mat that has been bonded by needle punching to one or both sides of a woven scrim.

1-5. Geotextile Durability

Exposure to sunlight degrades the physical properties of polymers. The rate of degradation is reduced by the addition of carbon black but not eliminated. Hot asphalt can approach the melting point of some polymers. Polymer materials become brittle in very cold temperatures. Chemicals in the groundwater can react with polymers. All polymers gain water with time if water is present. High pH water can be harsh on polyesters while low pH water can be harsh on polyamides. Where a chemically unusual environment exists, laboratory test data on effects of exposure of the geotextile to this environment should be sought. Experience with geotextiles in place spans only about 30 years. All of these factors should be considered in selecting or specifying acceptable geotextile materials. Where long duration integrity of the material is critical to life safety and where the in-place material cannot easily be periodically inspected or easily replaced if it should become degraded (for example filtration and/or drainage functions within an earth dam), current practice is to use only geologic materials (which are orders of magnitude more resistant to these weathering effects than polyesters).

1-6. Seam Strength

a. Joining Panels. Geotextile sections can be joined by sewing, stapling, heat welding, tying, and gluing. Simple overlapping and staking or nailing to the underlying soil may be all that is necessary where the primary purpose is to hold the material in place during installation. However, where two sections are joined and must withstand tensile stress or where the security of the connection is of prime importance, sewing is the most reliable joining method.

b. Sewn Seams. More secure seams can be produced in a manufacturing plant than in the field. The types of sewn seams which can be produced in the field by portable sewing machines are presented in figure 1-7. The seam type designations are from Federal Standard 751. The SSa seam is referred to as a “prayer” seam, the SSn seam as a “J” seam, and the SSd as a “butterfly” seam. The double-sewn seam, SSa-2, is the preferred method for salvageable geotextiles. However, where the edges of the geotextile are subject to unraveling, SSd or SSn seams are preferred.

c. Stitch Type. The portable sewing machines used for field sewing of geotextiles were designed as bag closing machines. These machines can produce either the single-thread or two-thread chain stitches as shown in figure 1-8. Both of these stitches are subject to unraveling, but the single-thread stitch is much more susceptible and

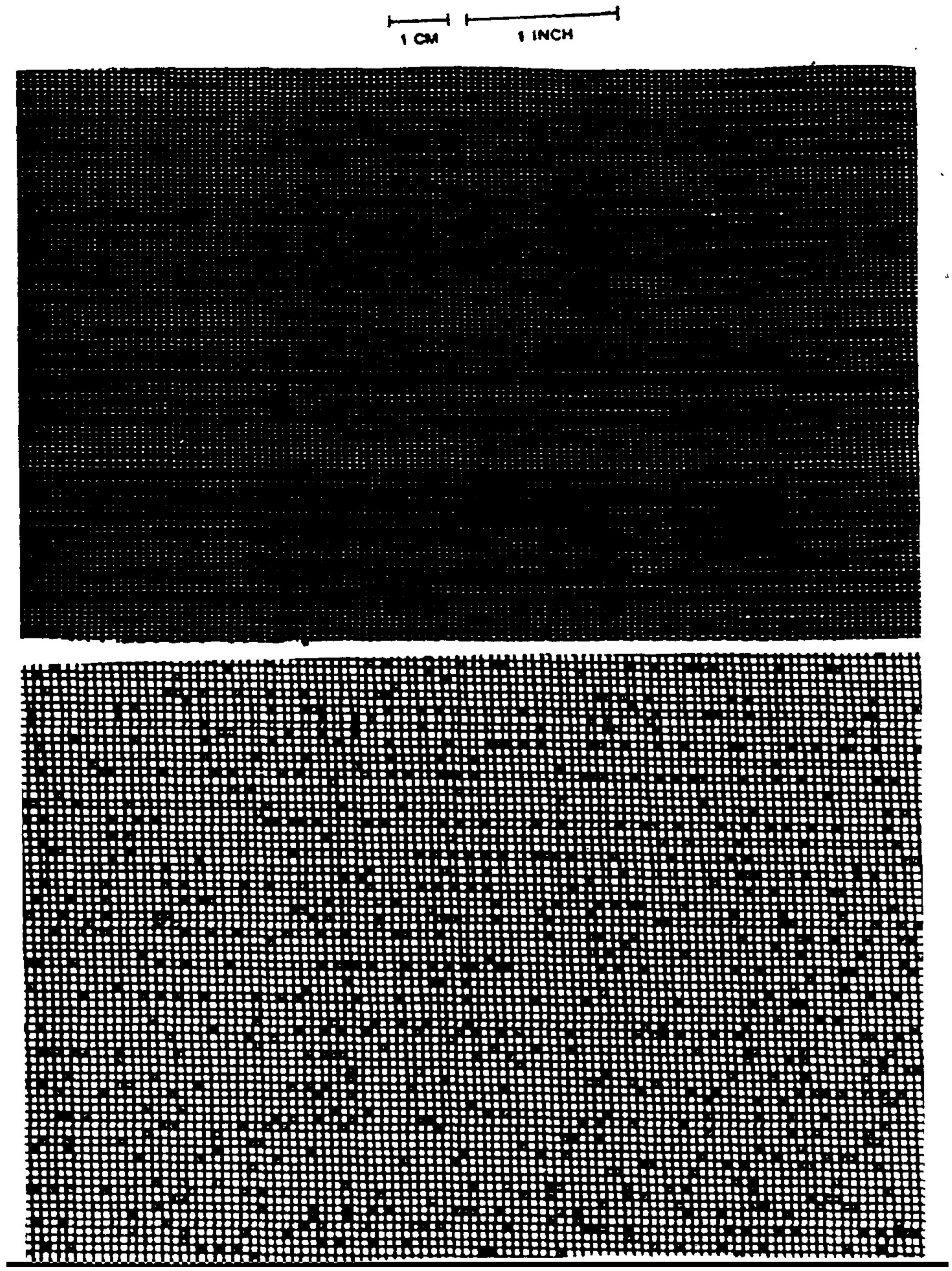

Figure 1-2. Woven Monofilament Geotextiles Having Low Percent Open Area (Top), and High Percent Open Area (Bottom).

must be tied at the end of each stitching. Two rows of stitches are preferred for field seaming, and two rows of stitches are absolutely essential for secure seams when using the type 101 stitch since, with this stitch, skipped stitches lead to complete unraveling of the seam. Field sewing should be conducted so all stitching is exposed for inspection. Any skipped stitches should be over-sewn.

d. Sewing Thread. The composition of the thread should meet the same compositional performance requirements as the geotextile itself, although it may be desirable to permit the thread to be made of a material different from the geotextile being sewn. Sewing thread for geotextiles is usually made from Kevlar, polyester, polypropylene, or nylon with the first two recommended despite their greater expense. Where strong seams are required, Kevlar sewing thread provides very high strength with relative ease of sewing.

1-7 Geotextile Functions and Applications.

a. Functions. Geotextiles perform one or more basic functions: filtration, drainage, separation,

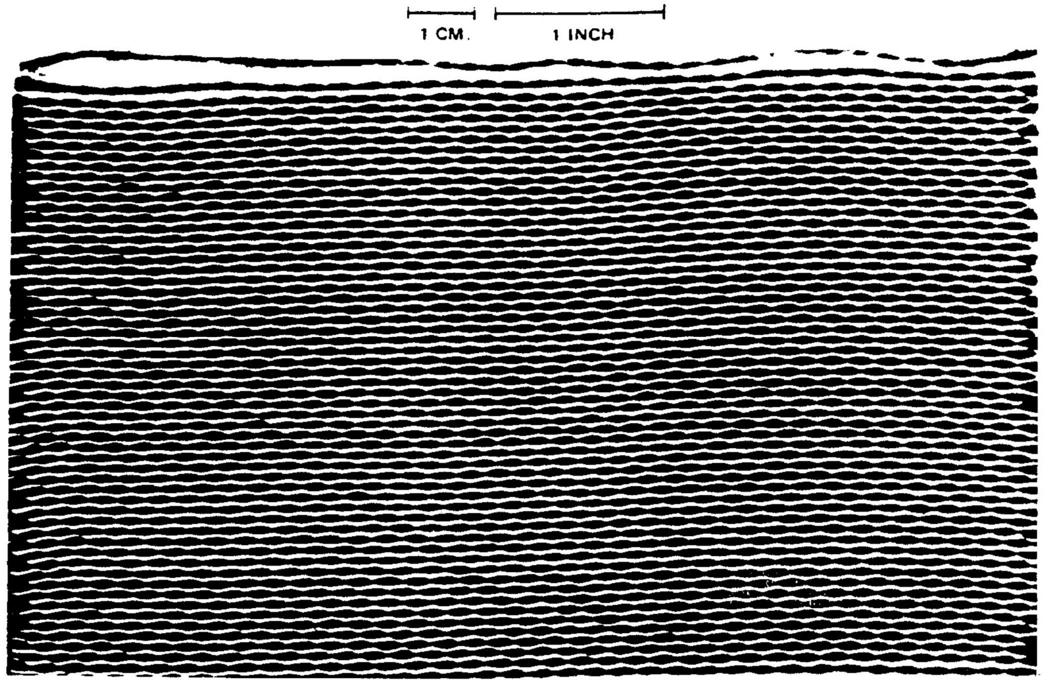

Figure 1-3. Woven Multifilament Geotextile.

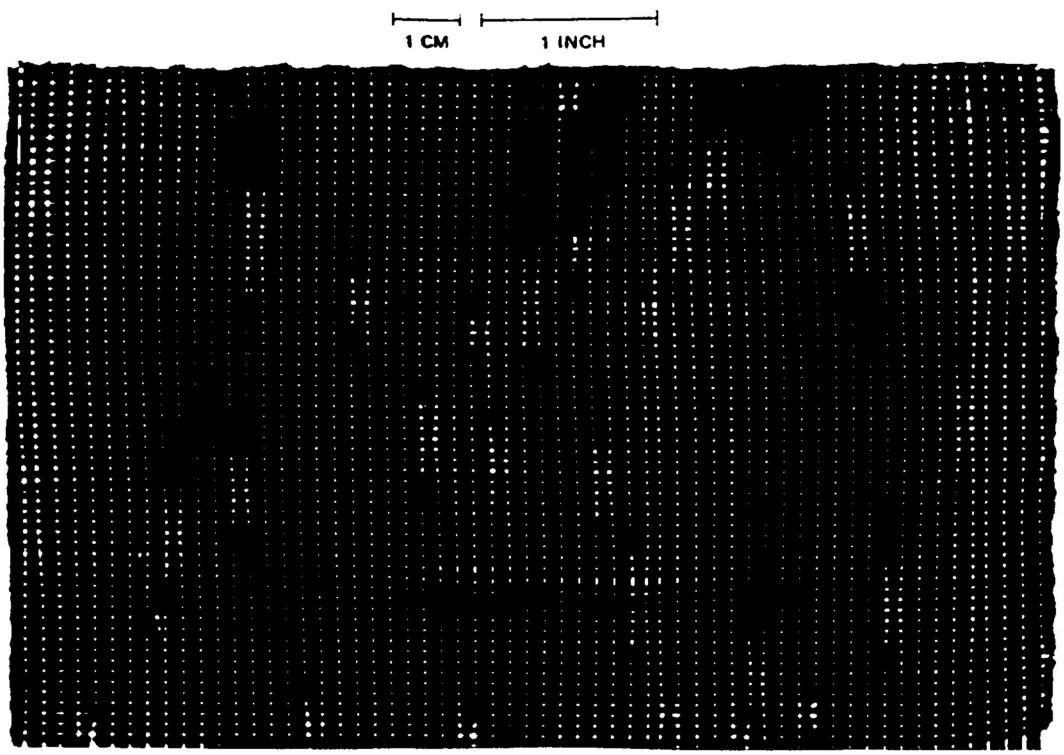

Figure 1-4. Woven Slit-Film Geotextile.

erosion control, sediment control, reinforcement, and (when impregnated with asphalt) moisture barrier. In any one application, a geotextile may be performing several of these functions.

b. Filtration. The use of geotextiles in filter applications is probably the oldest, the most widely known, and the most used function of geotextiles. In this application, the geotextile is

Figure 1-5. Needle-Punched Nonwoven Geotextile.

placed in contact with and down gradient of soil to be drained. The plane of the geotextile is normal to the expected direction of water flow. The capacity for flow of water normal to the plane of the geotextile is referred to as permittivity. Water and any particles suspended in the water which are smaller than a given size flow through the geotextile. Those soil particles larger than that size are stopped and prevented from being carried away. The geotextile openings should be sized to prevent soil particle movement. The geotextiles substitute for and serve the same function as the traditional granular filter. Both the granular filter and the geotextile filter must allow water (or gas) to pass without significant buildup of hydrostatic pressure. A geotextile-lined drainage trench along the edge of a road pavement is an example using a geotextile as a filter. Most geotextiles are capable of performing this function. Slit film geotextiles are not preferred because opening sizes are unpredictable. Long term clogging is a concern when geotextiles are used for filtration.

c. Drainage. When functioning as a drain, a geotextile acts as a conduit for the movement of liquids or gases in the plane of the geotextile. Examples are geotextiles used as wick drains and blanket drains. The relatively thick nonwoven geotextiles are the products most commonly used. Selection should be based on transmissivity, which is the capacity for in-plane flow. Questions exist as to long term clogging potential of geotextile drains. They are known to be effective in short duration applications.

d. Erosion Control. In erosion control, the geotextile protects soil surfaces from the tractive forces of moving water or wind and rainfall erosion. Geotextiles can be used in ditch linings to protect erodible fine sands or cohesionless silts. The geotextile is placed in the ditch and is secured in place by stakes or is covered with rock or gravel to secure the geotextile, shield it from ultraviolet light, and dissipate the energy of the flowing water. Geotextiles are also used for temporary protection against erosion on newly seeded slopes. After the slope has been seeded, the geotextile is anchored to the slope holding the soil and seed in-place until the seeds germinate and vegetative cover is established. The erosion control function can be thought of as a special case of the combination of the filtration and separation functions.

e. Sediment Control. A geotextile serves to control sediment when it stops particles suspended in surface fluid flow while allowing the fluid to pass through. After some period of time, particles accumulate against the geotextile, reducing the flow of fluid and increasing the pressure against the geotextile. Examples of this application are silt fences placed to reduce the amount of sediment carried off construction sites and into nearby