Geotextiles in Road Construction/Maintenance and Erosion Control

Textiles were first applied to roadways in the days of the Pharaohs. Even they struggled with unstable soils which rutted or washed away. They found that natural fibers, fabrics or vegetation improved road quality when mixed with soils, particularly unstable soils. Only recently, however, have textiles been used and evaluated for modern road construction. This booklet clarifies the confusion over terms and definitions of geotextiles, and discusses their common roadway and erosion control applications.

In the 1920's the state of South Carolina used a cotton textile to reinforce the underlying materials on a road with poor quality soils. Evaluation several years later found the textile in good workable condition. They continued their work in the area of reinforcement and subsequently concluded that combining cotton and asphalt materials during construction reduced cracking/raveling, and failure of the pavement and the base course.

When synthetic fibers became more available in the 1960's, textiles were considered more seriously for roadway construction and maintenance. As these new synthetic fabrics evolved, there was confusion over terms and definitions. Textiles and membranes now have reasonably well-accepted definitions in the construction industry, due mostly to the work of Dr. Jean Pierre Giroud.

Giroud created the original terms *geotextile* and *geomembrane*, using the Latin prefix *geo* meaning soil. Later the term *geosynthetic* came into popular use, and the three terms were used interchangeably, creating confusion. The following definitions have been accepted by the American Society for Testing and Materials (ASTM) Subcommittee on Geotextile and Geotextile Applications, and are now commonly accepted.

A **geotextile** is any *permeable* textile material used with foundation, soil, rock, earth, etc. that is an integral part of a constructed project, structure or system. It may be of made of synthetic or natural fibers.

In contrast, a **geomembrane** is a continuous membrane-type liner or barrier. It must have sufficiently *low permeability* to control migration of fluid in a constructed project, structure or system.

A geotextile is designed to be **permeable** to allow the flow of fluids through it or in it, and a geomembrane is designed to **restrict** the fluid flow.

Geotextile-related materials are fabrics formed into mats, webs, nets, grids, or formed plastic sheets (Figure 1). They are considered to be different from geotextiles.

A **geomatrix** is a composite of geotextile and geotextile-related materials which may be used in a variety of applications including: reinforcement of base materials, erosion control, or subsurface drainage control.

A **geosynthetic** is a fabric of *manufactured fibers* used in conjunction with foundation soil, rock, or earth on any constructed project, structure or system. It can be a geotextile, a geomembrane or a combination of the two.

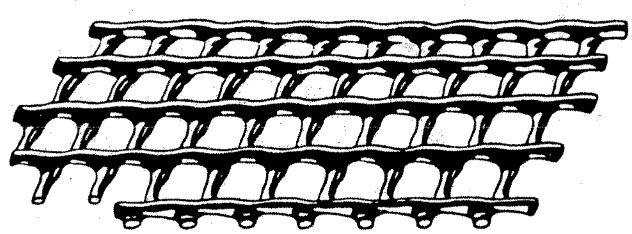

Figure 1. Geotextile related materials. Net.

Geotextiles and their application

Modern geotextiles are usually made from synthetic polymers—polypropylenes, polyesters, polyethylenes, and polyamides—which do not decay under biological and chemical processes. This makes them useful in road construction and maintenance. Geotextiles can also be made of natural fibers, but the synthetic materials are most commonly used.

The makeup of these fabrics determines their best application, so it is important to understand their characteristics. Geotextiles can be produced as a nonwoven, a knitted, or a woven fabric. We will focus on the nonwoven and woven fabrics since knitted fabric is rarely used. Whether the fabric is woven or non-woven is an important characteristic in choosing a geotextile for a particular use.

The **nonwoven fabric**, which looks like a felt fabric, is an arrangement of fibers either oriented or randomly patterned in a sheet. These fabrics can be manufactured in a variety of ways, bonding fibers together using chemical, thermal or mechanical processes (Figure 2). The bonding methods do not significantly change the function of the fabric. Nonwoven geotextile fabric has a lower tensile strength than woven geotextiles, and is more likely to stretch. It has the ability to let water flow laterally within itself.

The **woven geotextile**, which looks like burlap, is a sheet made of two sets of parallel strands systematically interlaced to form a thin, flat fabric. The strands may be slit film which are flat, or monofilaments which are round (Figure 3). The way these two sets of yarns are interlaced determines the weave pattern which in turn determines the best application for that woven fabric.

Weave patterns come in a virtually unlimited variety which do affect some properties of the fabric. However, a buyer will specify properties of the fabric such as porosity, strength and elongation, not weave pattern. In general a woven geotextile has a higher tensile strength, is less likely to stretch, and does not let water flow as freely as nonwoven geotextiles.

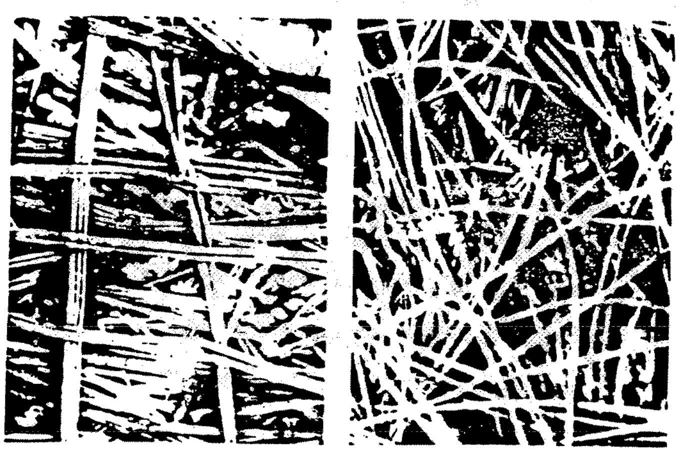

Figure 2. Nonwoven geotextile fabrics. L: thermally bonded. R: needle-punched.

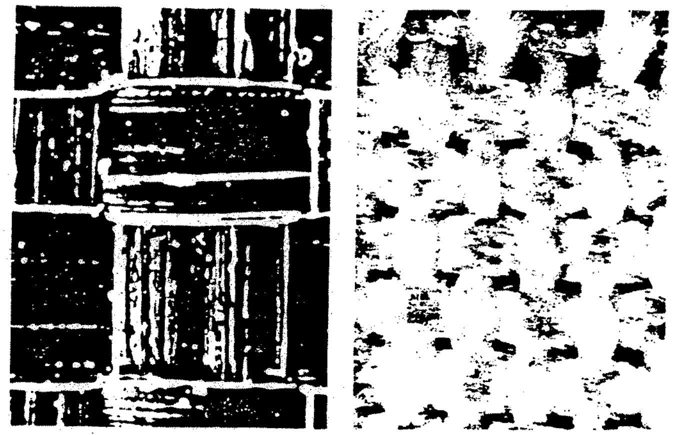

Figure 3. Woven geotextile fabrics. L: woven slit film. R: woven multifilament.

In the road industry there are four primary uses for geotextiles: separation, drainage, filtration and reinforcement. (See Table 1.) In **separation**, inserting a properly designed geotextile will keep layers of different sized particles separated from one another. In **drainage**, water is allowed to pass either downward through the geotextile into the subsoil, or laterally within the geotextile which functions as a drain. How it is used depends on the drainage requirements of the application. In **filtration**, the fabric allows water to move through the soil while restricting the movement of soil particles. In **reinforcement**, the geotextile can actually strengthen the earth or it can increase apparent soil support. For example, when placed on sand it distributes the load evenly to reduce rutting.

Geotextiles now are most widely used for stabilizing roads through separation and drainage. When the native soil beneath a road is very silty, or constantly wet and mucky, for example, its natural strength may too low to support common traffic loads, and it has a tendency to shift under those loads. Although the subgrade may be reinforced with a base course of gravel, water moving upward carries soil fines or silt particles into the gravel, reducing its strength. Geotextiles keep the layers of subgrade and base materials separate and manage water movement through or off the roadbed.

In general, geotextile applications are changing rapidly as research shows results and manufacturing processes improve. Before you install a geotextile in any application be sure to get research details or talk with someone with experience.

Geotextile Applications

Primary Function	Application	Secondary Function(s)
Separation	Unpaved roads (temporary and permanent)	Filter, drains, reinforcement
	Paved roads (secondary and primary)	Filter, drains
	Construction access roads	Filter, drains, reinforcement
	Working platforms	Filter, drains, reinforcement
	Railroads (new construction)	Filter, drains, reinforcement
	Railroads (rehabilitation)	Filter, drains, reinforcement
	Landfill covers	Reinforcement, drains
	Pre-loading (stabilization)	Reinforcement, drains
	Marine causeways	Filter, drains, reinforcement
	General fill areas	Filter, drains, reinforcement
	Paved and unpaved parking facilities	Filter, drains, reinforcement
	Cattle corrals	Filter, drains, reinforcement
	Coastal and river protection	Filter, drains, reinforcement
	Sports fields	Filter, drains
Drainage-Transmission	Retaining walls	Separation, filter
	Vertical drains	Separation, filter
	Horizontal drains	Reinforcement
	Below membranes (drainage of gas and water)	Reinforcement
	Earth dams	Filter
	Below concrete (decking or slabs)	
Reinforcement	Pavement overlays	
	Concrete overlays	
	Subbase reinforcment in roadways and railways	Filter
	Retaining structures	Drains
	Membrane support	Separation, drains, filter
	Embankment reinforcement	Drains
	Fill reinforcement	Drains
	Foundation support	Drains
	Soil encapsulation	Drains, filter, separation
	Net against rockfalls	Drains
	Fabric retention systems	Drains
	Sand bags	
	Reinforcement of membranes	
	Load redistribution	Separation
	Bridging non-uniform soft soil areas	Separation
	Encapsulated hydraulic fills	Filter, reinforcement
	Bridge piles for fill placement	
Filter	Trench drains	Separation, drains
	Pipe wrapping	Separation, drains
	Base course drains	Separation, drains
	Frost protection	Separation, drainage, reinforcement
	Structural drains	Separation, drains
	Toe drains in dams	Separation, drains
	High embankments	Drains
	Filter below fabric-form	Separation, drains
	Silt fences	Separation, reinforcement
	Silt screens	Separation
	Culvert outlets	Separation
	Reverse filters for erosion control	Separation, drains
	seeding and mulching	
	beneath gabions	
	ditch armoring	
	embankment protection: coastal, rivers and streams, lakes	
	Vertical drains (wicks)	Separation

Table 1. Applications and controlling functions of geotextiles

Geotextiles for separation

In separation functions geotextiles keep fines in the subgrade from migrating into the base course. Tests show that it takes only about 20% by weight of subgrade soil mixed into the base course to reduce its bearing capacity to that of the subgrade.

This problem usually is due to the movement of large amounts of water. When large loads cross the surface of the roadway they set up a pumping action which accelerates this water movement and soil particle migration, and speeds up the failure of the road. (See Figure 4.)

Two important criteria for selecting a geotextile for separation are permeability and strength. The geotextile used for separation must allow water to move through it while retaining the soil fines or sand particles. It should let water pass through it at the same rate or slightly faster than the adjacent soil. It must also retain the smallest soil particle size without clogging or plugging. Figure 4 is a diagram of the application of a geotextile as a separator. To select a geotextile you will need to know the size of soil particles and the permeability of the fabric.

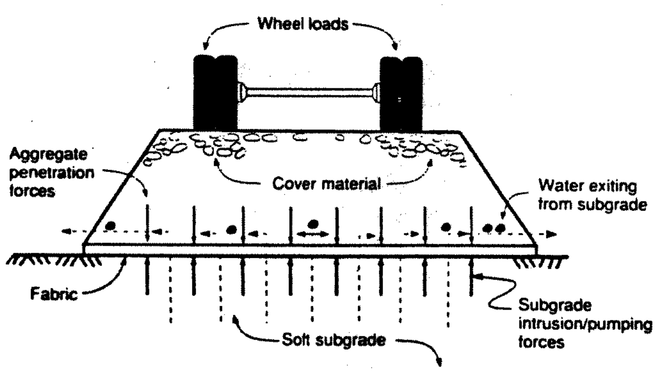

Figure 4. Geotextile in separation application. Traffic loads pump water upward. Geotextile restricts movement of fines, permits water drainage.

In selecting a specific geotextile for separation you must consider its basic strength properties. Be sure to take into account how its physical properties will survive the construction process as well as how it will survive the pressures of traffic on the gravel cover and enhance the life of the road. These strength properties are described in manufacturers' literature and design manuals in a variety of terms including burst and abrasion resistance, and puncture, grab, and tearing strength.

Be sure, when you use fabric for separation that you do not assume in the pavement design that it will also provide structural support. It will not.

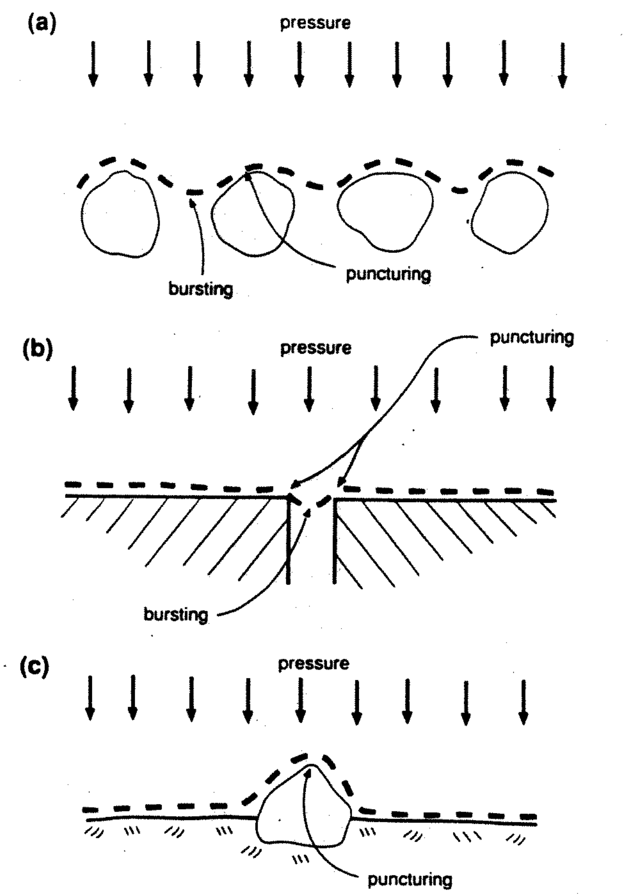

Figure 5. Typical situations of a geotextile separator between fine soil and (a) stone bed; (b) solid material such as concrete, rock or boards with cracks or gaps; (c) isolated stones.

Design considerations for using geotextiles in separation

When using geotextiles, consider the following.

1. What has been the past performance of geotextiles in similar types of soil?
2. You will need to know soil characteristics and the permeability of the subgrade, and match them to the permeability criteria of the geotextile.
3. Select the fabric strength requirements on the basis of constructability. More specifically, it must withstand placement and survive the construction period without puncturing, tearing, bursting, abrading, etc. Is the fabric sufficiently workable for the specific application?

4. Use standard load guidelines for designing pavement strength **with no allowance for the geotextile.**
5. In an existing roadway, check to see if additional subbase was added previously for extra structural support to counter the soil weakness and reduce rutting under construction equipment to three inches. If so, reduce that subbase by 30%-50% and include a geotextile in the design between the subgrade and subbase.
6. Select the cover carefully. If you will be applying a surface course, you may use a cleaner aggregate with less than 15% fines. If this will be a gravel road and traffic will travel directly on the aggregate, then you must provide more fines (at least 15%) or the aggregate will whip off the fabric.

Installation for separation

Shape the roadway and establish the crown. Roll the fabric down the road. Standard roll widths usually make it necessary to use one roll per lane of road. If there is much wind, you may need to weight the sides and end with shovels full of gravel, or use spikes to pin the fabric down. Overlap the fabric at the centerline as recommended by the manufacturer's instructions. The absolute minimum overlap recommended is 12 inches. Overlap the end of the preceding roll over the top of the next roll in the direction that the gravel will be spread to minimize wrinkles and shoving of the geotextile during spreading and blading of gravel.

Dump and spread the gravel or base course material using normal methods. But make sure you do so in the direction of the laps. When two or more rolls are used side by side, always dump aggregate on the top layer and blade over the lap to the next lower layer. In most cases, gravel can be applied by driving either forward or backward with an end dump truck.

In unusual conditions, particularly in extremely wet and soft areas, end dump trucks should back up while depositing gravel. This allows the truck to be driven on the gravel rather than on the fabric and will minimize rutting of the subgrade by the truck tires (Figure 6).

Once the base material has been applied over the geotextile, begin blading. Be careful that the blade does not dig into the base course and displace or rupture the fabric (Figure 7).

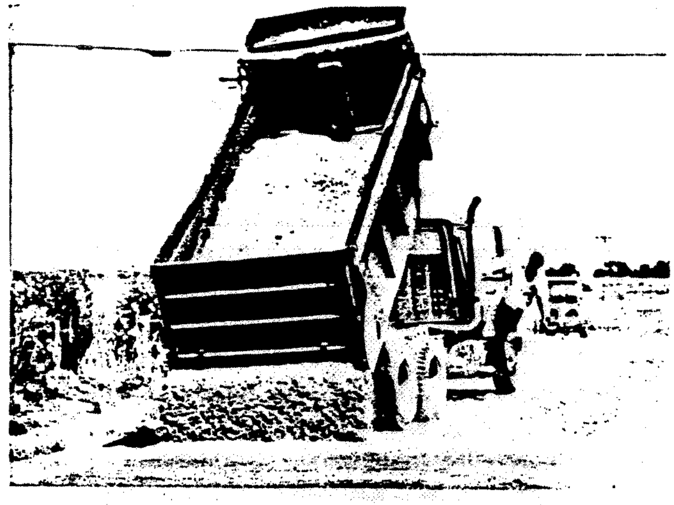

Figure 6. Under unusual conditions end dump trucks should back up while depositing gravel on geotextiles.

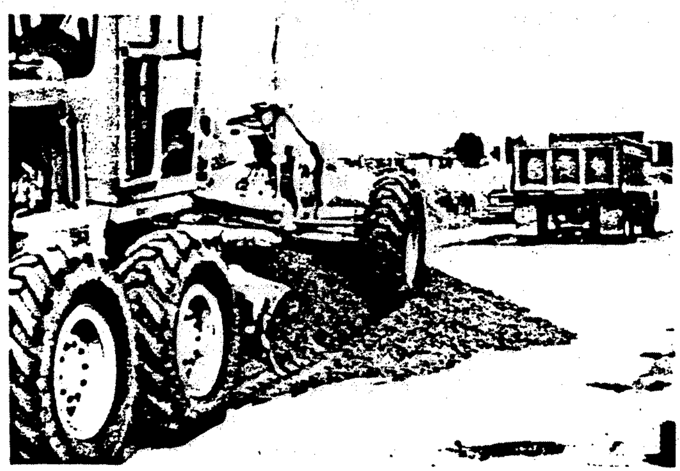

Figure 7. Blade aggregate from the top geotextile layer over the lap to the next lower layer.

Geotextiles in runoff and sediment control

Most units of government are responsible for erosion, runoff and sediment control, both during construction and afterwards until vegetation is established. A variety of statutes, ordinances and other regulations establish this responsibility. You can use geotextile fabrics as silt fences to hold back sediments carried in snow melt or precipitation runoff, and in seeding and mulching operations.

Erecting a silt fence can be relatively simple, but should follow certain standards:

1. Select a geotextile fabric permeable enough that runoff will flow through the fence and not overtop or bypass it.
2. The perforations or permeability should be small enough to retain the smallest soil particle, but not so small as to plug immediately. Monitor silt fences periodically and remove silt so the fences will remain effective.
3. Erect silt fences with adequate support to withstand the hydraulic pressures it will bear from one side during peak runoff periods. Space supporting posts two to ten feet apart and use wire to reinforce the downstream side of the geotextile. Figure 8 shows the steps in silt fence construction.

Geotextiles have also been very successful in seeding and mulching operations when properly applied. There are no design standards or comparative records for this use which recommend one specific type of geotextile over another. Where you anticipate intense precipitation, it might be worthwhile to consider using geotextile-related materials—mats and grids, or meshes—instead of just a geotextile fabric because they are less likely to wash down the hill.

Where you anticipate rapid vegetation growth, consider using geotextiles made of natural materials which will degrade rapidly. In other situations, the synthetic fabrics will become entwined with the plants' root systems providing permanent erosion protection. In either case the mats or fabrics will permit seedlings to root and grow through the openings without any negative consequences.

Figure 9 shows a typical installation for a mulch and seed protection system. It is very important here that the fabric be in close contact with the soil. Staples or pins can be used to secure the fabric. It is also important to keep runoff water from undercutting the fabric ends at the top and bottom of the hill. Thoroughly secure fabric ends by imbedding them in small trenches, or use staples, pins or any method which will keep them in place.

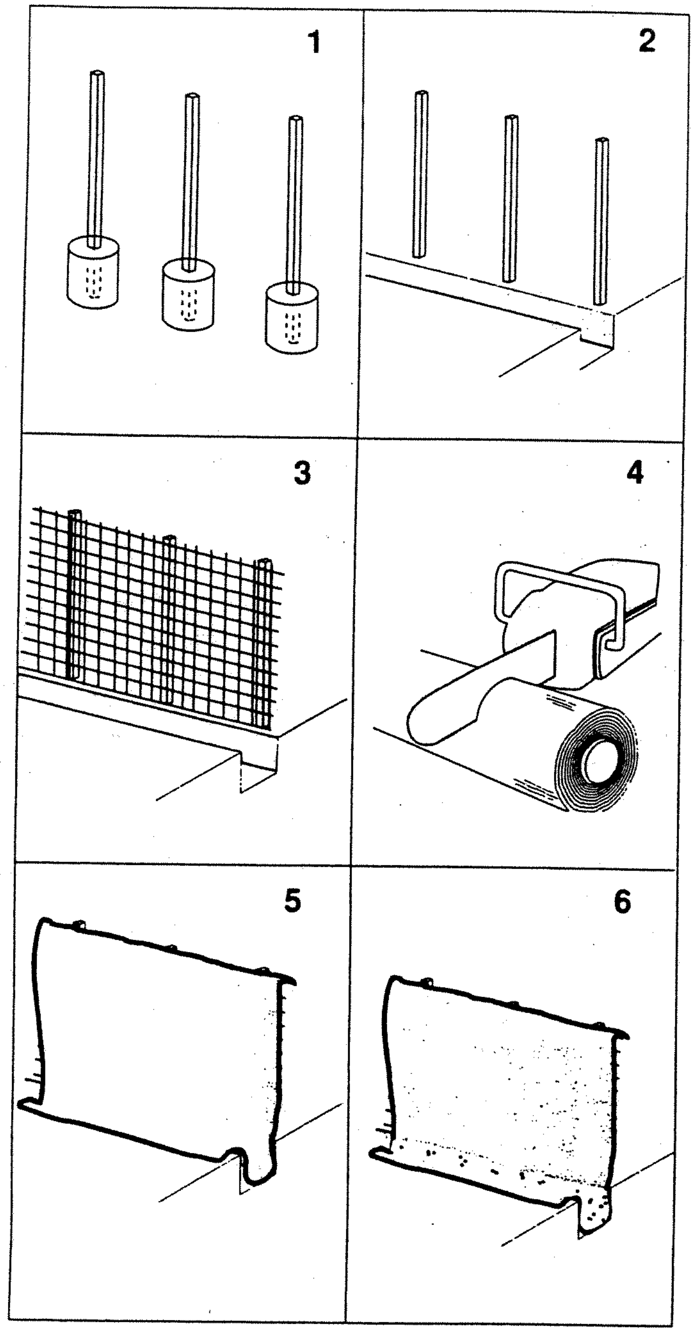

Figure 8. Steps in construction of a silt fence:
1– Set posts 2–10' apart (for long term heavy loading conditions concrete can be used).
2– Dig trenches minimum of 6" wide x 6" deep on upstream side.
3– Install wire screen on upstream side of posts. Wire screen may be omitted if geotextile meets proper standards for minimum fabric strength.
4– Cut geotextile to proper width.
5– Install geotextile on upstream side of wire screen, and line trench as shown.
6– Backfill trench with natural material and tamp.

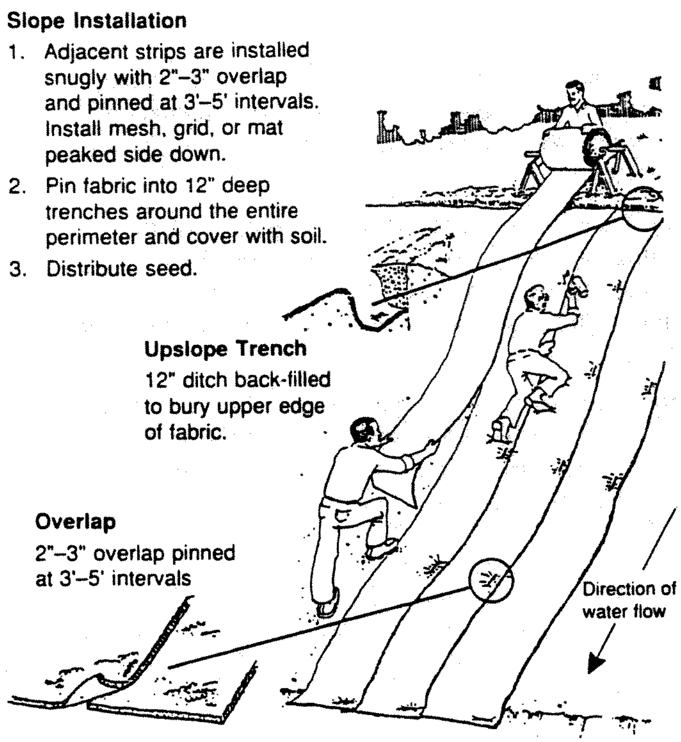

Figure 9. Typical installation of a mulch and seed protection system.

Geotextiles for erosion control

Geotextiles can be used many ways for erosion control. One of these is with riprap along stream banks, lake shores, and other bodies of water to keep finer soils beneath the riprap from eroding (Figure 10). Geotextiles recommended for erosion control should have permeability, resistance to abrasion, and high resistance to ultraviolet rays as primary considerations.

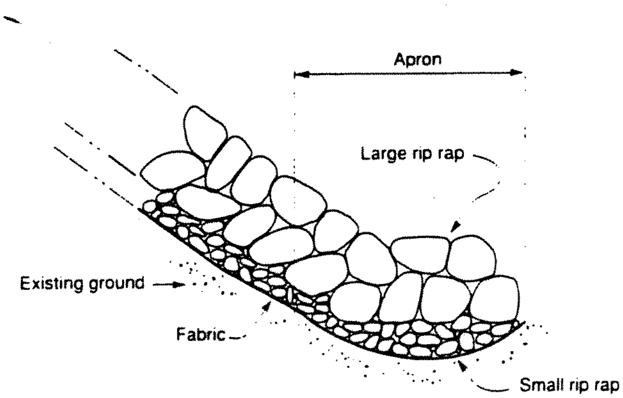

Figure 10. Typical erosion control system for lake shore, stream bank, culvert outfall or ditch protection.

Erosion control covers a variety of conditions from high velocity stream flow to heavy wave action, to less severe conditions. All conditions should be considered before selecting a fabric.

The following instructions describe how to install geotextiles on stream banks and similar steep slopes. These may be modified for applying geotextiles in less severe conditions such as riprapping in ditches. Geotextile/riprap installations may also be used in specifically designed systems to protect against scouring around bridge piers and abutments, and in other water installations.

To install geotextiles for any riprap system:

- Before starting, review such design considerations as wave action, bank steepness, etc.
- Identify soils by particle size and permeability as these will determine certain geotextile specifications.
- Identify the size of riprap planned for this application.
- Review past weather and climate conditions for such information as levels of ice, wave action, and amount of sunlight for their effect on riprap/geotextile installations. Ultraviolet rays in sunlight deteriorate most synthetic materials. If exposure to ultraviolet rays is anticipated, select a geotextile with high resistance to ultraviolet rays.
- Depending on the type of installation and the care it will need, you may have to consider abrasion to ensure that the geotextile will survive installation.

The protected soil surface should be as smooth as possible. Remove large stones, roots and other materials that might project and puncture or tear the fabric during construction and installation. Then place the fabric loosely and overlap it as required. Sewing the seams is preferable. Pin or weight down the fabric so that you can place the riprap without the fabric bubbling, shifting or slipping.

Always begin placing riprap at the base of the slope and move upward, and from the center of the textile strip to its side edges. Do not allow stones weighing over 100 pounds to roll. Specify a minimal drop height of one foot for stones up to 250 pounds and no freefall for stones exceeding 250 pounds. If fabric is on a cushion layer, height drops can be up to three feet for stones less than 250 pounds, with no freefall for stones greater than 250 pounds. Avoid machine grading or any method of shifting riprap after it is placed unless the fabric is covered sufficiently to avoid damage.

Summary

With experience, geotextiles are being used more often in road construction and maintenance. Certain fundamental considerations are necessary for success in any application. You must know the soils to select the proper geotextile. Study the application thoroughly to determine the severity of conditions facing the geotextile.

In many installations, permeability may override concern for durability and resistance to bursting, puncturing and tearing. In other installations, such as a separator in a road where the geotextile will be subjected to severe loads, durability is of concern. Permeability should also always be considered in separation uses to allow moisture to move freely through the system. This avoids excessive hydrostatic pressures which cause soil failure.

Most geotextile system failures result from improper installation, improper selection of fabrics, a change of conditions from the original design, or a combination of these factors.

Many states have successfully used geotextiles for stabilization. Here, too, you should carefully determine the type and frequency of usage for these roads since heavy, high speed traffic could cause premature failure of the system.

Manufacturers' technical manuals will help guide you in installation techniques and fabric selection for that manufacturer's products. These are good references for designing a geotextile system.

References

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