

# 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 fact sheet 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 term *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 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.

## 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 materials 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 non-woven, 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. Materials commonly made out of non-woven fabric include upholstered furniture coverings and cloth interiors of automobiles. 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 Non-woven geotextile fabric is more likely to stretch than woven geotextile. It has the ability to let water flow along the plane of the geotextile.

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 is less likely to stretch, and does not let water flow as freely as non-woven geotextiles.

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 be 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. However, a layer of geotextile cannot be used as a substitute for using an adequate thickness of free draining soil (like clean sand) to reduce frost heaving.

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.

## 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 grain size distribution of the subgrade and the subbase as well as the permeability of the geotextile.

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.**

## *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 solid 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? That is, can the geotextile support the men and equipment during gravel placement?
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 layer. In most cases, gravel can be applied by driving either forward or backward with an end dump truck. **Always** avoid driving onto the geotextile with any equipment. A minimum of one foot of cover is typically recommended. If the geotextile is ripped or torn during gravel placement, place a piece of geotextile over the torn area to cover three feet in all directions from the tear.

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). If rutting of the subbase occurs after the geotextile has been placed, the ruts should be filled with new gravel. Do not attempt to regrade the existing surface without adding new gravel since you may tear the geotextile. See figure 6 below.

## **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 opening 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.

#### **Geotextiles for erosion control**

Geotextiles can be used many ways for erosion control. One of these is with rip-rap along stream banks, lake shores, and other bodies of water to keep finer soils beneath the rip-rap from eroding (Figure 10). Geotextiles recommended for erosion control should

have permeability, resistance to abrasion, and high resistance to ultraviolet rays as primary considerations.

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 rip-rapping in ditches.

Geotextile/rip-rap 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 rip-rap 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 rip-rap 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 rip-rap/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 rip-rap without the fabric bubbling, shifting or slipping.

Always begin placing rip-rap 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 rip-rap 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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