# Nonwoven geotextiles: types and applications

**Joseph E. Fluet, Jr.**

*The author provides a rationale for the use of nonwoven geotextiles and describes the technical and marketing organizations involved in the geotextiles industry.*

Geotextiles have been defined by the American Society for Testing and Materials (ASTM) as "permeable textiles used with geotechnical materials as an integral part of a man-made project, structure, or system." Geotextiles, along with geomembranes, geogrids, geonets, and others, are included in the more generic term "geosynthetics."

In the use of the term "geosynthetics," it is important to distinguish between the industry, the materials, and the discipline. The industry encompasses all the people, facilities, equipment, materials, knowledge, product uses, and economics involved with geosynthetics. It includes manufacturers, distributors, engineers, scientists, researchers, and users of geosynthetics. Geosynthetics are the actual products.

The geosynthetic discipline is related to that body of technical knowledge that has been developed to make it possible to design with geosynthetics, using rational engineering design methods, and to explain the success of geosynthetics using modern scientific concepts and principles. The geosynthetic discipline refers to those scientists and engineers who are concerned with the development of geosynthetic theory and understanding as well as the practical design of products.

## History

To understand this emerging discipline, one must consider its socio-technological roots. The geosynthetics industry is almost as old as civilization itself. The Babylonians used palm fronds and hemp to construct soil-reinforced "ziggurats" more than 3000 years ago, and the Chinese have used reeds to construct a type of corduroy road since prehistoric times.

Though rooted in an ancient industry, the geosynthetics discipline was only recently born—a difficult birth into a large family with divergent views. The geosynthetic discipline has representation from civil, geotechnical, environmental, structural, industrial, mechanical, agricultural, chemical, textile, and plastics engineering fields, as well as from the scientific fields of chemistry, biology, physics, and others. Unfortunately, each of these fields has its own jargon, and the languages and concepts are sometimes confusing.

Fluet is president, GeoServices Inc., Consulting Engineers, Boynton Beach, Fla. 33435.

### Role of the geosynthetics engineer

As a consequence of these divergent interests and perspectives, the early geosynthetics engineer was as much an interpreter and facilitator as a technician. His duties included the study of many different disciplines and the melding of seemingly divergent concepts into design methods and terminology that were usable by the ultimate designers of geosynthetic products—the civil and geotechnical engineers. As a consequence, the geosynthetics discipline, which is founded in textile science, plastics engineering, and other disparate disciplines, has been formulated to be consistent with civil engineering design methods.

As a consequence, many of today's geosynthetic design approaches seem familiar to civil, geotechnical, environmental, and structural engineering designers. In addition to interpreting the jargon and concepts of other disciplines into terms understandable by civil engineers, the geosynthetics engineer has often been called upon to act as a facilitator between the various personalities involved.

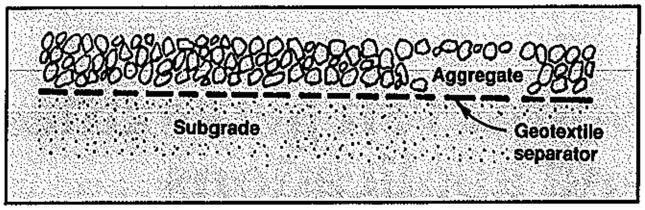
### Role of the manufacturers

The modern geosynthetics industry began in the 1950s as a direct result of manufacturers' efforts. In both Europe and the United States, manufacturers were actively seeking new markets for recently developed polymeric textiles and membranes. A few enterprising souls believed that their materials could be used in civil engineering applications—as replacements for granular filters in erosion control and drainage systems, for instance, and as liners for reservoirs. Their notions were valid, as history has abundantly shown, but acceptance was slow for reasons which were simultaneously cultural and technological.

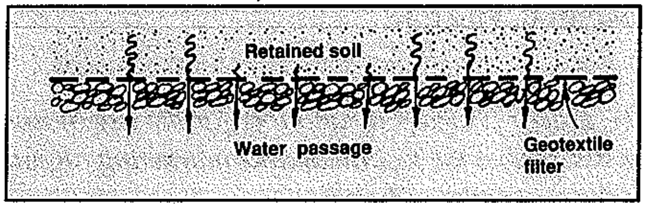
I. Applications for geotextiles

| | |
|---|---|
| Permanent roads | Slope stabilization |
| Temporary roads | Vertical walls |
| Equipment yards | Waste disposal facilities |
| Parking lots | Gas collection systems |
| Drainage systems | Retaining ponds |
| Railroad tracks | Tailings ponds |
| Erosion control systems | Dams |
| Embankments | Dikes |

**1.** Separation: prevents two solid materials from intermixing




**2.** Filtration: retains soil but passes water




In the United States in particular, the manufacturers' representatives approached the civil engineering market with the same attitudes and assumptions that had proved successful in other markets. Unfortunately, this was a commodity approach (smooth talking salesmen hawking new "gimmicks," each of which was touted as "top of the line at a lower price"). Such an approach was, of course, poorly received by the civil engineers.

- They did not understand the textile and plastics jargon, with such terms as "grab tensile strength" and "melt index."
- They had an inherent distrust of any system that was not thoroughly established as the standard state of practice.
- They were wary of salesmen who seemed "slick," not knowledgeable about engineering properties, and ignorant of civil engineering design methods and requirements.

Similarly, the manufacturers were unfamiliar with the practices of the civil engineering industry:

- They were unaware of the liability issues which predispose civil engineers to use only established methods.
- They were unaware that, in the civil engineering industry, sales calls are made first to an architect and then to an engineer, but the product is purchased by a contractor or a developer, and the guarantee is to the final owner.
- They were unaware of the time lag from design to construction. Typically, six months to two years elapses between the sales call and a purchase order, and more time elapses between the purchase order and actual delivery of the material (not to mention the 60–90-day receivables).
- They were unaware that civil engineers bid projects based on specific design methods. Therefore, once a project is awarded to an engineering firm, the design concepts are already established, and no budget exists to consider new design methods or materials.

As a consequence of these cultural and technical obstacles, the industry developed quite slowly at first. Manufacturers could only convince engineers to try the new products on test sites or sites that were out of the mainstream, and even then the manufacturers often had to "buy" the project by offering the materials at or below cost. Fortunately, some manufacturers took this risk, and some successful case histories began to emerge. Armed with these case histories, salesmen approached civil engineers again but were once again rebuffed, this time by the question of how to design with the new materials. It was not enough that the product worked—engineers insisted on rational, quantified design methods.

Commendably, some manufacturers then hired consulting engineers and university professors to develop simple, analytical, and empirical models to describe and quantify the geosynthetic applications. Finally, armed with successful case histories and design models, salesmen were able to convince some cost-minded and/or innovative designers to try more of the products in larger and more complex applications.

**Table I** is a list of some of the manufacturing and marketing organizations that currently support the industry.

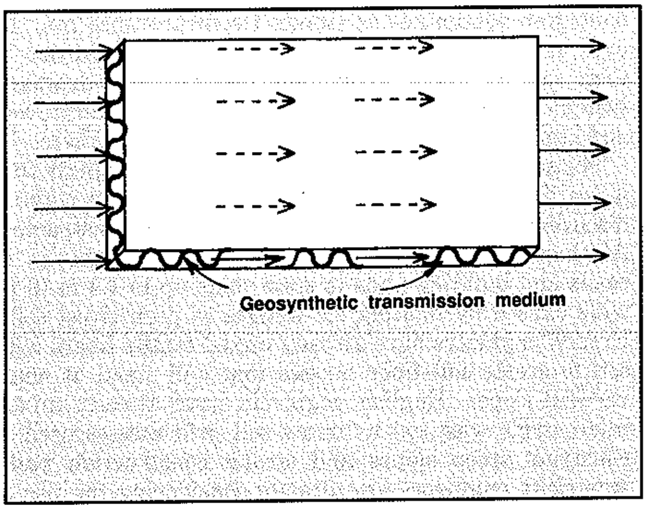
#### Role of research agencies

Credit must also be given to U.S. governmental agencies such as the Federal Highway Administration, the Forest Service, the Bureau of Reclamation, the Environmental Protection Agency, and the Army Corps of Engineers, as well as governmental agencies of many other countries, who funded or conducted much of the research. As a result of government, university, and private research, quantified design methods began to be established, and these encouraged more designers to try geosynthetics.

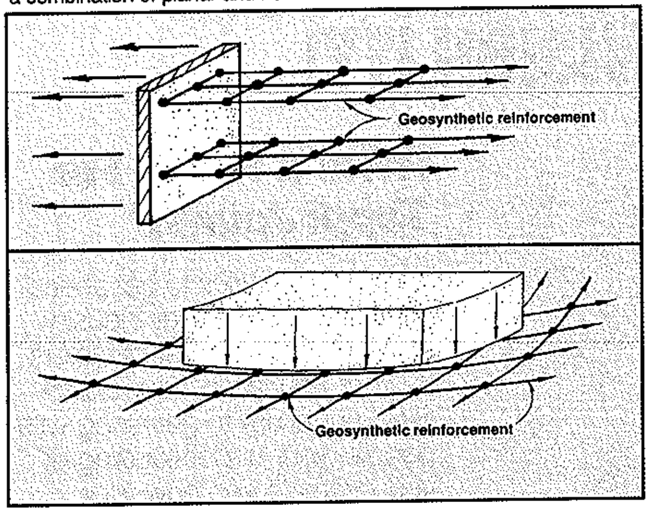
Only recently have we learned to really quantify and understand the engineering functions of geosynthetics, to calculate the engineering stresses involved, and to design with and predict the success of geosynthetics in various engineering applications. It has been this understanding—i.e., the engineering discipline—which has prompted the acceptance of geosynthetics as engineering "state-of-practice" materials.

## Engineering functions of geotextiles

The functions described below are for geotextiles only. Other geosynthetics can serve other functions.




**3.** Transmission: transmits fluids within its own plane




**4.** Reinforcement: (top) supporting a planar load and (bottom) supporting a combination of planar and normal load

### Separation

Separation is the simple segregation of two disparate solid materials. An example is the separation of a roadbed aggregate from the native subgrade. This example is shown in **Fig. 1**.

In this case, the function of the geotextile is simply to prevent the aggregate from penetrating the subgrade, and the subgrade is prevented from fouling the ballast. The assumption is made that subgrade strength is adequate.

### Filtration

The function of the geotextile in filtration is simply to retain soil while allowing the passage of water. This function is illustrated in **Fig. 2**.

To function as a filter, a geotextile must have adequate permeability, retention capability, and resistance to clogging.

### Transmission

The transmission, or lateral drainage, function is applicable where the geotextile is used as a drain—i.e., where the fluid flow is within the plane of the geotextile itself. **Figure 3** illustrates this application.

In addition to the obvious requirement of high transmissivity (permeability × thickness), the geotextile must possess enough dimensional stability to retain its thickness under pressure.

### Reinforcement

In the reinforcement function, the purpose of the geotextile is to reinforce a weak subgrade, as shown in **Fig. 4**. Such an application requires high tensile strength. It often requires high tensile modulus as well as high coefficients of friction between the soil and the geotextile.

## Design and selection rationale

Ideally, civil engineering specifications are directly related to both conditions of exposure and imposed loads. Specifications are prepared which, as closely as possible to the desired factor of safety, meet the design conditions and loads. This is called a generic specification because it is related to the project, not a product.

Unfortunately, in an emerging discipline, product specifications are more often the rule because designers know more about products than design. Product specifications are of two types. The most obvious example is the type which resembles: "ACME 2000 or equal." A less obvious, but also poor, specification is the type which gives the material properties, though not the name of a specific product. From time to time, designers may choose to use a product specification because they are convinced that only one specific product is acceptable. More commonly, however, product specifications are simply the result of good salesmanship. The field of geosynthetics in North America is currently in a transitional phase from product specifications to generic specifications.

In North America, many applications are sufficiently "standard" that it may be possible to prepare a "standard" generic specification. The designer can use this type of specification to select materials for a large percentage of "standard" applications.

In any case, the following design and selection rationale is the most desirable:

1. Conduct an analytical design and determine design values.
2. Use survivability tables to determine survivability values.
3. Specify the higher of these design and survivability values.
4. Specify that the supplier must certify that all property values meet specified values.
5. Specify the frequency for conformance testing and the minimum average roll values.

## Applications

Table I describes some of the many applications for geotextiles. Although most geotextile applications can be fitted into one of these categories, the most important consideration is that new and exciting applications are continually being encountered. For example, landfill lining systems are required by law and may include nonwoven geotextiles as filters. Geomembranes may be used as transmission media and cushions in addition to their use as liners. Also, new geocomposite drainage systems are continually being developed and improved, and almost all include nonwoven geotextiles as filters.

The state of the art continues to advance so rapidly that it is difficult to envision futuristic applications without discovering that they have already been constructed. Alaskan engineers have already used geosynthetics in roads and building pads to span voids up to 1.8 m (6 ft) wide caused by melting ice wedges in permafrost soils. French engineers have already mixed textile fibers with soil to create soil-fiber masses that will stand at near-vertical slopes. English engineers have already mixed micro-grids with soil to create soil-grid masses used to construct steep slopes and strong construction pads. American engineers are already considering the use of geosynthetics in seismic systems because of their excellent flexibility, durability, and strain-rate characteristics. Geosynthetics become stronger at the rapid strain rates which characterize seismic activity. So, whatever the future holds, today's state-of-the-art may well be considered primitive by designers of future geosynthetic systems.

### Future needs

At this time, the geotextile industry and the geosynthetics discipline probably have enough momentum to continue to grow. Apparently, the discipline's single greatest need at this time is improved communications between the geosynthetics discipline and practicing civil and geotechnical engineers. We can most effectively accomplish this task in three ways:

- Prepare and teach short courses and seminars on specific geosynthetic design concepts and methods.
- Organize conferences and symposia to expose all interested parties to the progress in the geosynthetics discipline.
- Increase our participation in committee work for professional organizations such as TAPPI, American Society of Chemical Engineers, and North American Geosynthetics.

By attending conferences, we are fostering better communications. By actively participating in committee work, we can contribute to the profession at large by ensuring that innovations are characterized by technical excellence.□

The author wishes to thank Sherry L. Weinschenk for her assistance in preparing this paper and Jamie G. Prillaman for her review of the paper and Alanna Mozzar for typing the manuscript.

Received for review Feb. 1, 1989.

Accepted Apr. 5, 1989.

Presented at the 1989 Nonwovens Conference.