New York State Department of Transportation's Experience and Guidelines for Use of Geotextiles

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Since the early 1970s, the use of geotextiles by the New York State Department of Transportation has evolved from use as a special item on a job-to-job basis to the establishment of an approved list for use with five application categories. This evolution is described, and a description of each of the five categories is presented. Supporting case histories for each category are also given. The system used to evaluate geotextiles for the approved list is described. Based on the results of laboratory test programs and field experience, a set of design guidelines for the general applications is presented. A discussion of the important steps to follow in using geotextiles, so that improved guidelines and specifications for their use may be developed in the future, is also presented.

During the past 10 years the New York State Department of Transportation (NYSDOT) has been involved in developing technology in order to use filter fabrics for civil engineering applications. During this period the number and varieties of geotextiles have increased to the point whereby the designer and engineer must have a clear understanding as to a geotextile's characteristics in order to specify and use them properly.

The evolution of geotextile use by NYSDOT is described in this paper. Five categories (i.e., underdrain, undercut, bedding, slope protection, and silt fencing) are defined, and supporting case histories are given. Properties (e.g., flow rate, soil retention, strength, and stability) that are important in defining geotextile use for all categories are presented and compared. Minimum acceptance and design guideline values for both general and severe cases are presented along with conclusions and recommendations for future work.

EARLY INVOLVEMENT WITH GEOTEXTILES

The initial use of geotextiles was to solve special problems. During the 1960s and 1970s, NYSDOT was active in constructing new high-quality Interstate roads. The prevention of land and water pollution adjacent to construction sites required building large sedimentation basins to collect water that had suspended solids. The conventional filter criteria design for basin outlets required three filter layers that consisted of sand, pea gravel, and crushed stone, each 1-ft thick. Instead of this configuration, the state recommended the use of an outlet of large crushed stone covered with a woven geotextile that acted as a filter (1).

Geotextiles were selected for use because they would save money and time. If they had not worked, however, it would not have been a major problem to correct the situation by conventional means. These installations were successful because they performed satisfactorily, required less maintenance, and saved approximately $2,000/outlet installation as compared to the conventional layered-aggregate system.

In the early 1970s a geotextile was used to line a stream channel under NY-85 near Delmar, New York. The geotextile was used to line the bottom and sides of the stream, and to date it has prevented erosion, even though much of the stone has been removed by storms. It is believed that erosion prevention is due to the normal slow velocity of the stream at the site.

Another early use of geotextiles was in the repair of a roadway embankment that was failing into an adjacent stream (2). A berm was to be built at the toe of the embankment that would extend over an area of active silt boils caused by an artesian water condition. The problem with the berm construction was how to stop the bubbling of the three large silt boils that had developed at the emabankment toe. It was decided to sew together sections of a geotextile to form a large sheet, which was then placed over the silt boils and sunk by placing crushed stone directly on the geotextile sheet. This installation was successful because it provided an economical way of filling the silt boils where no conventional remedy was available and because it was easy to install.

These types of successful projects convinced NYSDOT that geotextiles were a viable alternative to conventionally designed solutions for geotechnical problems that otherwise would be expensive or impractical. At the same time, there were many unanswered questions about geotextiles and their use. NYSDOT was not confident that all of the important characteristics for geotextile use were known. Because these construction materials were new, and every manufacturer tested the material by their own special tests, how could the characteristics needed for successful field performance be specified in generic terms?

GEOTEXTILE ACCEPTANCE

NYSDOT procedure for allowing the use of geotextiles has gone through a multiphase development. First, approval was done on a job-to-job basis by specifying a particular brand name geotextile or the equivalent to it. In order for a manufacturer's material to be used for a given application on a construction project, it had to have prior approval, which was obtained by contacting the Soils Mechanics Bureau of NYSDOT. The manufacturers had to demonstrate that the material had performed satisfactorily under similar application and site conditions.

During the mid- to late-1970s, the number of geotextiles on the market increased considerably. Many manufacturers and distributors contacted the Bureau about allowing the use of the geotextiles they provided. Unfortunately, there were no criteria for accepting or rejecting a particular material for the "or equal" alternative in the specifications. Thus it was decided to place part of the burden of proof on the manufacturers and distributors. An acceptance procedure was established whereby the manufacturer and distributor that requested approval would have to show that the material's characteristics had been tested, that the material had been successfully used for the proposed applications, and that a product evaluation form was completed. They also had to provide a 5-yd^2 sample of the material for evaluation before consideration for acceptance.

This acceptance procedure provided much needed information about geotextiles from both a testing and field installation standpoint. Because of the great number of geotextiles, geotextile properties had to be identified and evaluated for design purposes. The most valid way to do this was to develop and perform the Bureau's own laboratory tests on the geotextiles and to set up trial installations throughout the state.

Unfortunately, none of this work solved the immediate problem of allowing general use of geotextiles in normal construction contracts. As laboratory and field work were being undertaken, a formal approved list was established based on the Bureau's information and on information provided by manufacturers and distributors. This list was issued through the Materials Bureau of NYSDOT. The approved list provides general acceptance of geotextiles separated by application: underdrain, undercut, bedding, slope protection, and silt fencing.

APPLICATIONS, DEFINITIONS, AND EXPERIENCE

Each of the previously mentioned applications may require the performance of a different geotextile characteristic. Therefore, it is important to understand how NYSDOT defines these applications (3). Definitions for each application are given below along with supporting case histories.

Underdrain

The geotextile is used to line a trench adjacent to a highway pavement that collects free water from underground sources, rainfall, and spring melt. It is intended that the geotextile allow free water entering the trench to pass through, while retaining in situ soil particles in order to prevent clogging or piping of the underdrain system, which could weaken the subgrade and result in substantial damage to the pavement. A typical underdrain section is shown in Figure 1.

In areas where the soil consists of uniform silts or fine sands, piping can be a problem. The use of a geotextile is a practical alternative to constructing the multilayer filter shown in Figure 1. For this application, the soil retention and flow rate (i.e., permeability) characteristics of the geotextile are important to the performance of the underdrain system. The geotextile should also have sufficient strength to withstand the installation process.

Seven underdrain sections were installed in 1975 at Marathon-Willet (near Ithaca) by using combinations of pipe, stone, and various geotextiles. The soils in the area were mixtures of wet gravels, silts, and clays. Plan and section views are shown in Figures 2 and 3. The geotextiles used were all nonwoven and varied greatly in their soil retention and flow characteristics. Seven years after instal-

Figure 1. Typical sections of underdrain system.

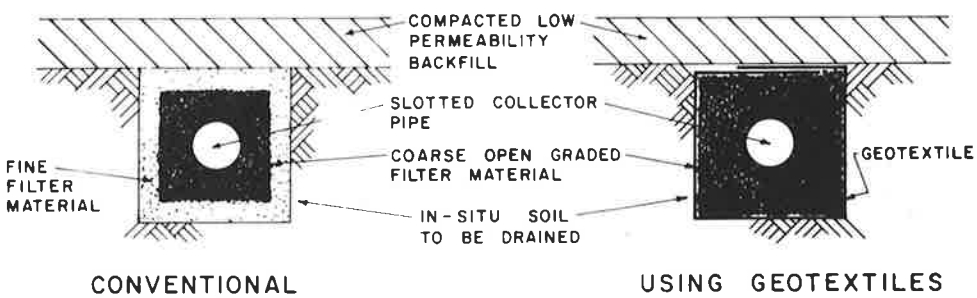


Figure 2. Plan view of underdrain system.

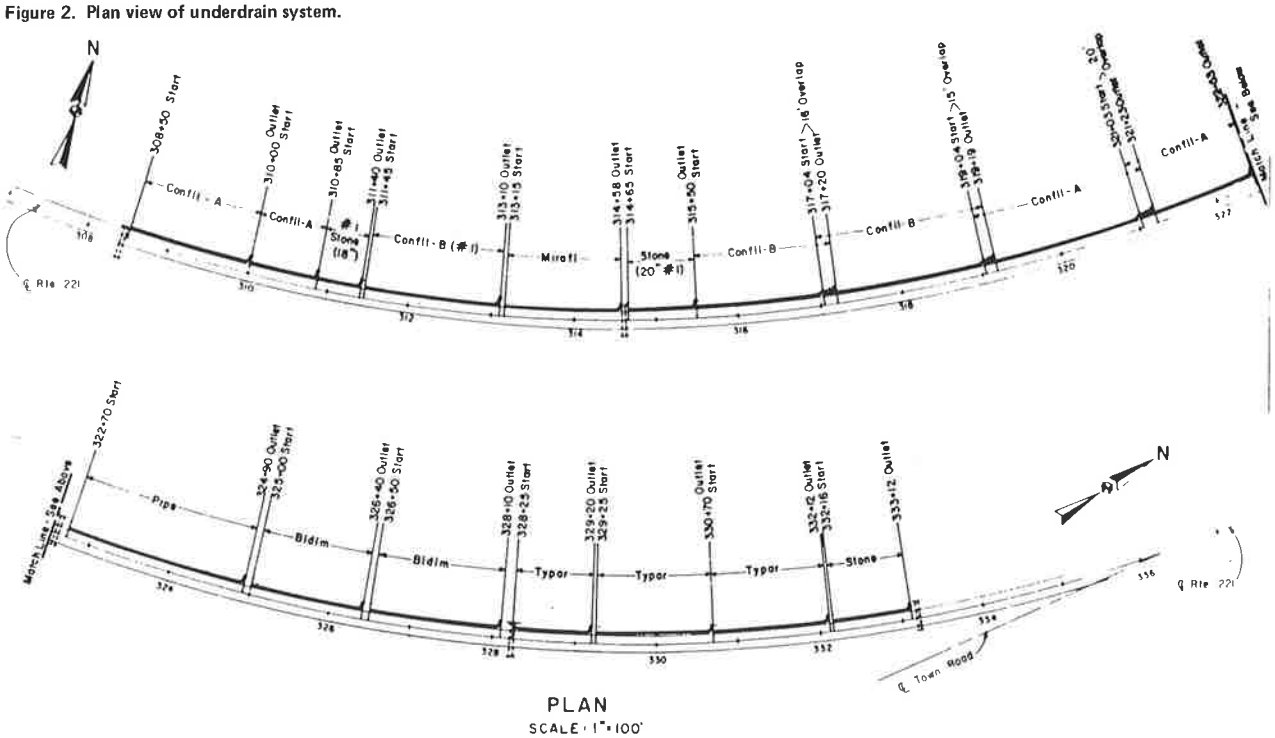


Figure 3. Typical installation details.

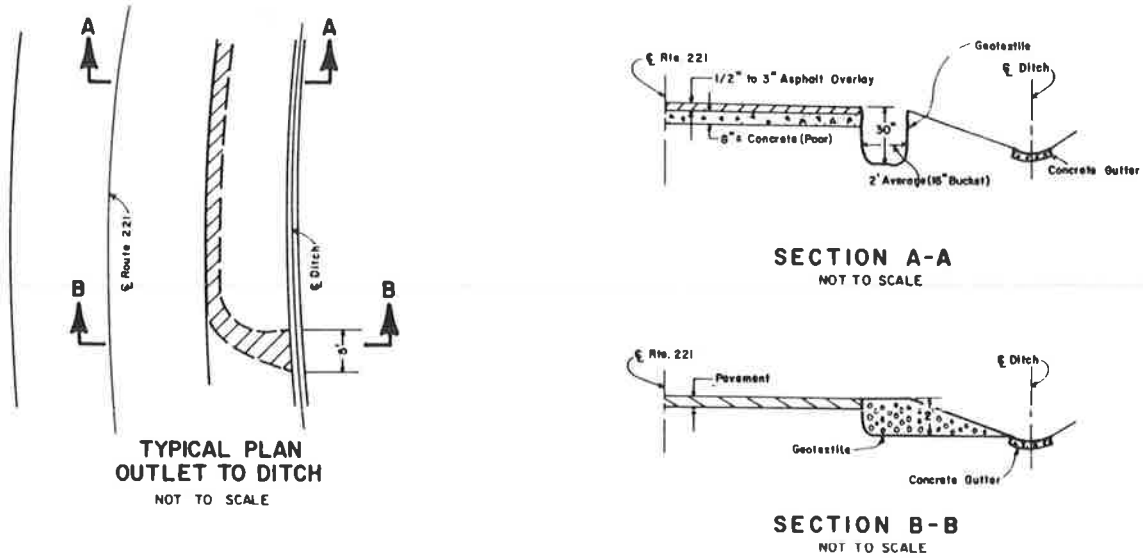
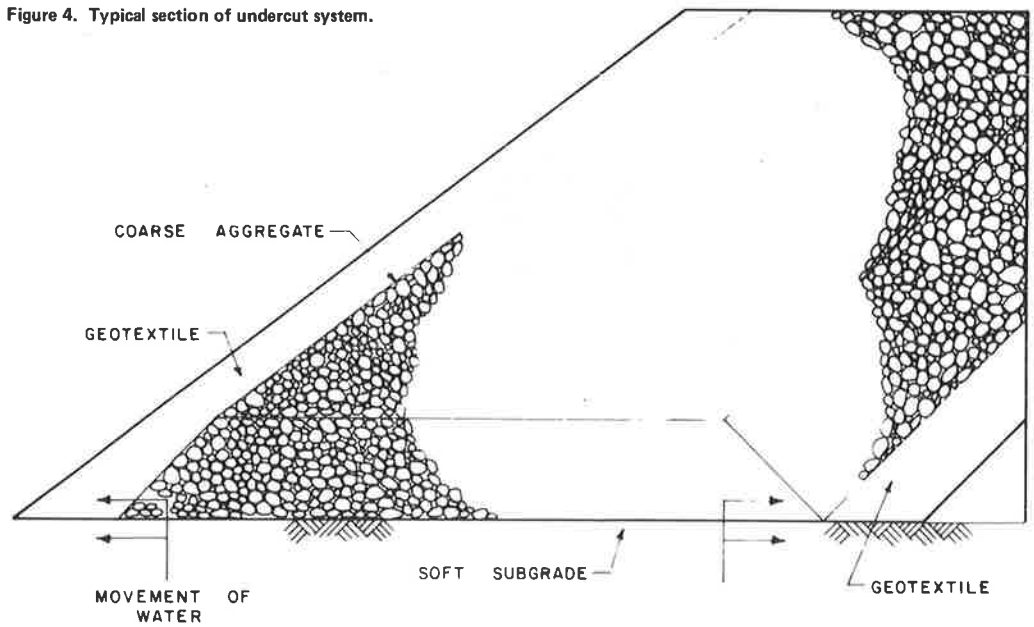


Figure 4. Typical section of undercut system.



lation all underdrains are performing satisfactorily based on observations of water flow at the outlets.

Underdrain sections were installed by the Pennsylvania DOT in 1976. The sections consisted of either (a) an underdrain pipe wrapped with a woven or nonwoven geotextile, which was then placed in a trench and surrounded by stone, or (b) a woven or nonwoven geotextile placed directly in the trench as a lining followed by pipe and stone placement. Typical sections of these installations can be found in Forshey (4,5). In 1977, the Bureau was invited to observe the excavation of these underdrains and to evaluate their performance. Based on the inspection of this site, the following observations were made:

1. All sections had performed satisfactorily. In sections where the underdrain pipe was wrapped with a geotextile, the stone surrounding the pipe was contaminated with soil fines. Although this was not detrimental in this case, it could be for long-term installations. Therefore, in order to prevent contamination, it is recommended that underdrain trenches be lined with a geotextile rather than wrapping the pipe with the geotextile.

2. Nonwoven geotextiles retain more soil fines than do woven geotextiles. This observation was based on the finding that those trenches lined with nonwoven geotextiles had little or no silt deposition within the underdrain system, whereas the trenches lined with the woven geotextiles did. Therefore, it is recommended that only nonwoven geotextiles be used for underdrain applications.

Undercut (Subgrade Stabilization)

The geotextile is used as a separator between wet, unstable, native soils (i.e., silts and fine sands) and a granular material that is to be placed on the geotextile. It is intended that the geotextile allow drainage of excess water from these unstable soils. Once stabilized, these soils will have sufficient bearing capacity for highway construction. A typical undercut installation is shown in Figure 4.

The geotextile must have (a) sufficient perme-

Figure 5. Typical section of bedding system.

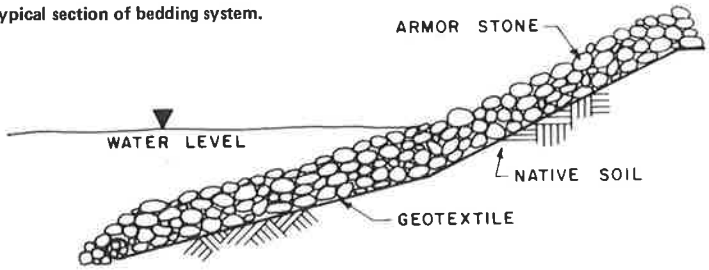
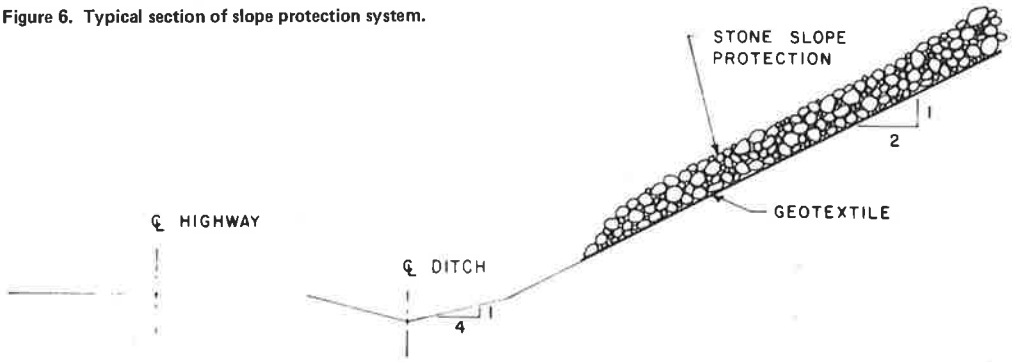


Figure 6. Typical section of slope protection system.



ability to allow drainage, (b) opening sizes that will prevent large amounts of soil from passing through, and (c) sufficient strength to survive installation stresses due to construction equipment.

In 1977 an undercut installation was constructed in Schoharie, New York, where the highway pavement through the village was to be completely replaced. The native soil consisted of a wet, red, fine silt, and when this soil was combined with the traffic loads, cracking in the pavement occurred. It was impossible to raise the final grade of the proposed highway reconstruction because it would disturb the existing road connections, sidewalks, store fronts, and property accesses. The project alternatives were further restricted by the utilities that had been installed at a shallow depth. It would have required a prohibitive expenditure in relocating all existing utilities deeper. To overcome these problems, a nonwoven geotextile was used under 1 ft of granular material. By doing so, the problem area was stabilized, the grade requirements were satisfied, and the utility problems were solved. Therefore, it is recommended that any geotextile that has sufficient strength may be used for undercutting.

Bedding

In shorefront protection, where bedding is used extensively, large rocks are required to withstand wave forces. The larger the rocks, the larger the gaps through which native materials can be lost, thereby reducing or eliminating the protection that the rock affords against the attack of the water.

The geotextile is used to replace the layer(s) of granular materials under the stone filling that is required by conventional filter criteria. The geotextile is intended to prevent the loss of native materials from erosion due to moving water. The geotextile must also allow groundwater in the native soil to drain freely in order to prevent a blow-out due to hydrostatic pressures. A typical bedding installation is shown in Figure 5.

The geotextile must have sufficient permeability, adequate strength to withstand the placement of rock fill materials, and satisfactory soil retention capabilities, especially for granular materials.

Geotextiles for the bedding application are used almost exclusively under stone in rivers, streams, lakes, and canals. Therefore, the conditions under which the geotextile is being used are less severe than those previously mentioned. To date only woven fabrics are allowed for this application because of the satisfactory performance exhibited by woven geotextiles and because of the lack of knowledge on the performance of nonwoven geotextiles.

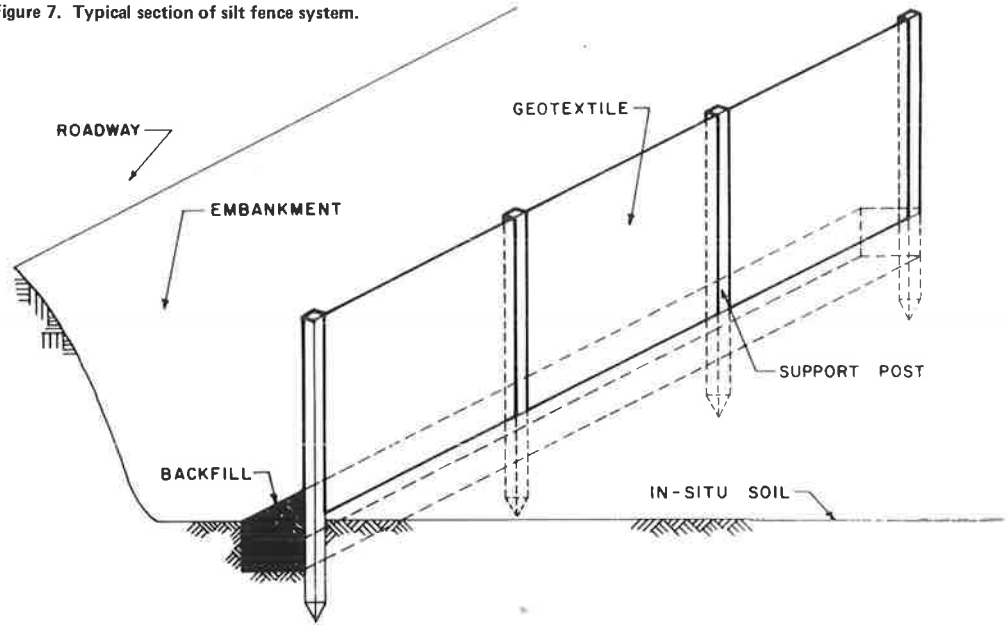
Slope Protection

The geotextile is used as a separator and filter under stone slope protection on highway cut sections. It is intended that the geotextile allow the free drainage of groundwater while holding the in situ fine soil in place. This maintains a stable base on which the stone slope protection can be placed. A typical slope protection installation is shown in Figure 6.

The problem of surface sloughing on a slope is common when the native soil is either wet silts or fine sands. As the water emerges to the exposed face and flows down the slope, it can carry soil particles with it. This will result in a delta soil deposit at the ditch line, with a resulting depression on the slope. Therefore, any soil passing through the geotextile is undesirable.

This problem was initially thought to be due to drainage, and that those geotextiles from the underdrain category could be used. Based on this premise, on one project the geotextile was placed on the high cut slope. A small bulldozer was used to place the 2-ft-thick slope protection blanket. Part way up the slope the entire mass--fabric and stone--failed by sliding into the ditch. It was concluded from this experience that the lack of frictional resistance between the geotextile and the native soil was the cause of the overall failure. It was always apparent that some geotextiles were smoother than others, but it appeared that it would be insignificant to this application.

Figure 7. Typical section of silt fence system.



Consequently, a separate category was established where only needle-punched geotextiles are used for slope protection. These geotextiles must have satisfactory filtration and permeability characteristics and offer satisfactory frictional resistance.

Silt Fencing

The geotextile is used as a barrier to prevent land or water pollution adjacent to a construction site. In NYSDOT contracts, the contractor is responsible for controlling the pollution and contamination of areas adjacent to the construction site. That means, generally, that the contractor is responsible for controlling the runoff waters to minimize erosion of the exposed native materials. This problem has been reasonably met by hay bale check dams and early seeding of slopes.

With the establishment of a silt fence category on the approved list, the contractor is provided another alternative by which to control pollution and contamination. A typical silt fence application is shown in Figure 7.

The contractor must consider three factors when using geotextiles for silt fencing: the flow rate and retention capabilities, the strength, and the resistance to ultraviolet degradation.

LABORATORY TESTING OF GEOTEXTILES

The establishment of the approved list of geotextiles was based on field experience and other information available at that time. As is apparent from the previous discussion, there were certain characteristics common to all five categories that needed to be investigated:

1. Permeability (flow capacity)--(a) geotextile permittivity, and (b) soil and geotextile permeability relation;
2. Soil-retention capabilities--(a) size of openings in geotextiles, and (b) retention in flowing water;
3. Strength characteristics--(a) installation strength, and (b) structural strength; and
4. Geotextile deterioration.

Therefore, laboratory testing was developed to evaluate or model these factors.

Permeability (Flow Capacity)

Geotextile Permittivity

The presence of water and its removal is always a concern in geotechnical design. Therefore, it was only natural to pose the question of how much water could flow through a geotextile. Several different methods of permeability testing were tried. All methods produced erratic results, due mostly to water turbulence and the high air content of the water. After some evaluation and modification, a downward flow device was designed and fabricated that eliminated the turbulent flow previously experienced. It was also found that the use of water de-aired to less than 6 parts per million (ppm) of dissolved oxygen was necessary. As a result of these modifications, more consistent and reproducible results were obtained, which were verified by subsequent testing (6).

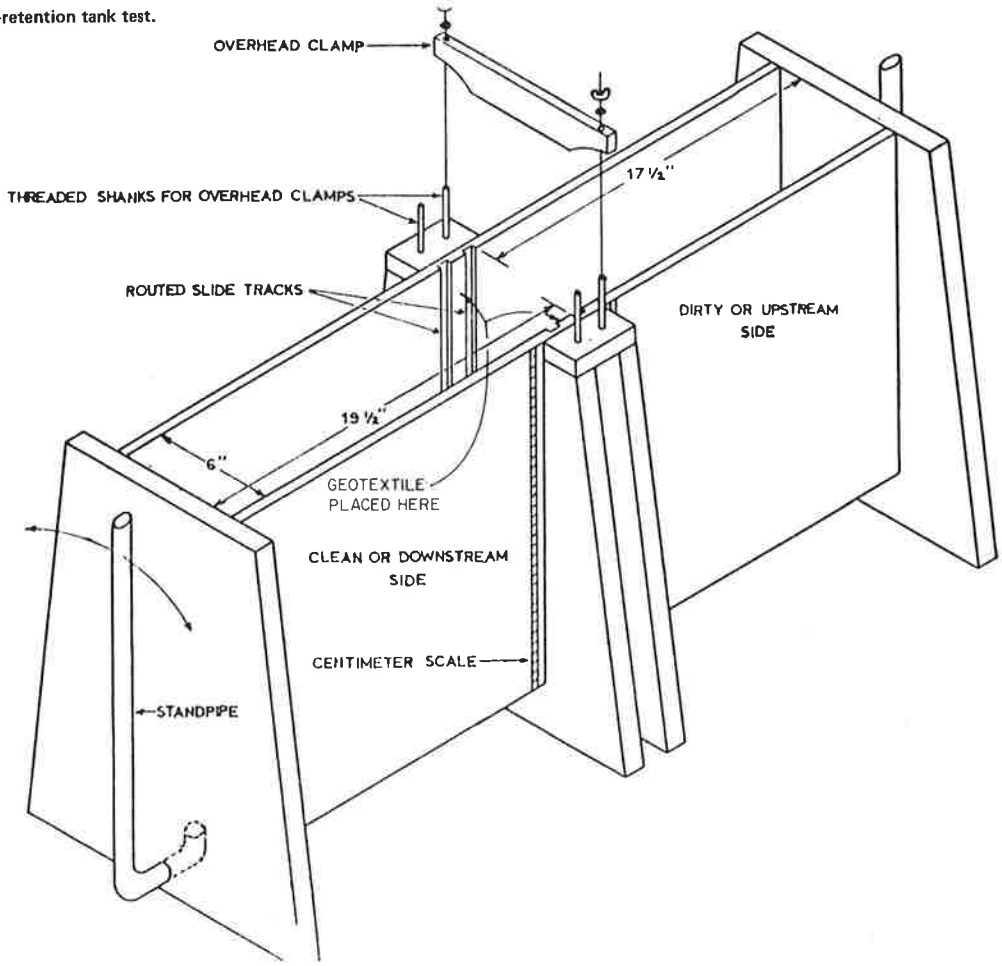
It was also recognized that the use of the value of coefficient of permeability for geotextiles might be misleading due to the varying thicknesses available on the market. It was decided by the ASTM geotextile group to normalize this value, which would give a volumetric flow rate per unit area per unit of head. This term has been defined as the permittivity of a geotextile.

The test provides a means of comparing one geotextile to another. However, it may not necessarily be indicative of its field performance.

Soil and Geotextile Permeability Relation

Once consistent and reproducible results from the permeability tests were obtained, the next logical step was to see what the effects would be on geotextile permeability when soil was placed in contact with it. Several different combinations of geotextiles and soils were tested and compared with the individual geotextile and soil permeabilities. In all cases, it was found that the permeability of the soil, even a coarse sand, controlled the system.

Figure 8. Soil-retention tank test.



Soil-Retention Capabilities

Size of Openings in Geotextiles

The most common method for determining soil particle sizes in soil mechanics is by sieving. It was logical, therefore, to consider this type of test for geotextiles, especially wovens, due to the discrete openings that result from the manufacturing process. The Soil Mechanics Bureau, in conjunction with ASTM, has been investigating the usefulness and appropriateness of the equivalent opening size (EOS) sieving test to determine the maximum opening size in geotextiles. The test consists of shaking various sizes of glass beads through a geotextile. Variables such as shaking time, the order in which glass beads are used (large to small or small to large), the elimination of errors caused by static electricity, and the effects of presoaking the sample before testing have been investigated. In general, the test is appropriate for wovens and thin sheet nonwoven geotextiles. With thicker nonwoven geotextiles, the path of travel for a glass bead is so tortuous that it may become entrapped rather than pass through the geotextile, thus giving a questionable value for the test.

Retention in Flowing Water

A test to study the soil retention capabilities of the geotextiles proposed for use was developed (7). The test apparatus is shown in Figure 8. In one chamber, designated as the upstream side, a predetermined mixture of water and soil was placed. In the other chamber, designated as the downstream side, clean water was placed. Flow was allowed to take place from the upstream side through the geotextile to the downstream side of the tank, with the outflow being collected. By using hydrometers, the amount of soil that passed through the geotextile was estimated.

Discussion of Permeability and Soil-Retention Characteristics

It is important to emphasize that, in order to correctly evaluate the permeability characteristics of a geotextile, each one of the above properties must be collectively examined to have any meaning as to the flow capacity of a geotextile. As an example, an impermeable membrane with a hole punched in its center may have the same flow capacity characteristics as a geotextile. However, the soil-retention capabilities of the two are quite different. Also, the lower the permittivity of the geotextile, the higher the soil-retention capabilities, and vice versa. Thus it is necessary to specify maximum opening size as well as flow rate to properly select a geotextile for a specific use. It has to be realized that there is a constant trade-off of these properties in any design. It is up to the designer or engineer to determine which characteristic is most important to the design.

Strength Characteristics

Installation Strength

To be installed, all geotextiles must be manipulated

by equipment and people. This manipulation can cause rips and tears that will disrupt the continuity of the geotextile. As a result, a geotextile may not perform as intended. Therefore, it is important that geotextiles have sufficient strength to withstand the installation process. For most of the geotextiles on the market, the ASTM D1682 grab tensile test provides an adequate indication of the installation strength.

Structural Strength

Grab Tensile

Initially, results of ASTM D1682 were used to determine the tensile strength of geotextiles. This test was indicative of the quick, sharp loading that a general textile might undergo. However, it was not indicative of the long-term uniform loading over a wide area that a geotextile might undergo. The test was useful for comparing relative strengths for installation purposes, but it was not potentially useful for design purposes.

Wide Width Tensile Strength

The standard grab tensile test method did not appear suitable for the engineering needs of NYSDOT. Therefore various other methods to measure tensile strength are being investigated. Initially, 1-in.- and 2-in.-wide x 6-in. gauge-length tensile tests were run. Due to the low aspect (width/length) ratio, some of the geotextile specimens underwent severe "neck down." As a result, high elongation values were obtained that gave erroneous strength values.

Further investigation led to the current test method based on an 8-in.-wide by 4-in. gauge-length sample. Because of the higher aspect ratio of the samples tested, this test appears to give the most realistic values for design purposes. The only major problem is the slippage between the jaws experienced with the stronger geotextiles, which will increase the variability of the results obtained. This problem has been minimized by placing four or five pins across the width of the jaws. (Note that details of this new test are from a 1981 unpublished draft report, Wide Width Tensile Strength of Geotextiles, from the Soil Mechanics Bureau, NYSDOT.)

Long-Term Strength (Creep Strength)

The elongation characteristics of a geotextile are important when designing structures such as geotextile-reinforced embankments and retaining walls where the long-term stresses that would be applied to the geotextile may be high. Tests consisted of running a peak strength test on a 2-in.-wide x 4-in. gauge-length specimen. Once this peak strength was determined, the same size specimens were placed in a static loading frame, and loads corresponding to 25, 50, and 75 percent of the peak strength were applied. Deflection data were recorded, and a deflection versus time curve was plotted for either failure or 100 hr. The results obtained are used to determine a geotextile's relative tendency for creep. The results to date have not given numbers that can be used in design.

Geotextile Deterioration

Most plastic polymers used in producing geotextiles are not affected by mild acids, bases, or chemicals encountered in normal highway construction. However, as with most plastics, exposure to sunlight will have a significant effect on the life expectancy of a geotextile. Therefore, the ultraviolet stability characteristics of geotextiles have been investigated. It is generally accepted that geotextiles degraded in a weatherometer do not provide a direct time correlation to what actually takes place in the field. However, plotting a degradation versus time curve for both weatherometer and field exposure results from an ASTM round-robin test program showed that geotextiles degrade in the same pattern for both cases. Therefore, the relative tendency of a geotextile to deteriorate from ultraviolet exposure may be determined from the weatherometer test.

SPECIAL PROJECTS

Although laboratory testing provides NYSDOT with a means of relatively evaluating and accepting geotextiles for general use, it also provides values that may be applied in critical design problems. In such cases, the design criteria for geotextile performance must be carefully evaluated. Two such projects were the design of a geotextile reinforced wall and a pollution containment system.

Geotextile Reinforced Wall

On NY-71 and NY-22 in Columbia County, New York, the existing roadway embankment had been steepened and, as a result, shallow shear failures were occurring. Criteria for treatment of the site were stabilization of the failure areas, low future maintenance, additional shoulder width, and safe traffic control during construction. A geotextile reinforced-earth wall was recommended as an economical alternative to conventional tied-back sheet-pile walls.

Basic geotextile reinforced-earth-wall design consists of alternating layers of crushed stone and horizontal layers of geotextile that are placed a specified distance behind a theoretical failure plane (8). The geotextile provides reinforcement for the wall. Factors such as wall height, geotextile strength, and the friction angle of the crushed-stone fill control the thickness of the crushed-stone layers. Also, as this was intended to be a permanent structure, it was necessary to evaluate the long-term creep behavior of the geotextile used.

The wall height of this project was approximately 17 ft and the geotextile tensile strength was 75 lb/in. Crushed stone was used for its high permeability and frictional characteristics. This resulted in the wall being constructed in 6- and 9-in. lifts, with each lift being formed by the fabric overlapping the face of the wall that retains the crushed-stone fill. On completion, the wall face was shotcreted to prevent possible vandalism and exposure to the elements (see Figure 9).

Instrumentation installed at the site has indicated that the wall was performing satisfactorily.

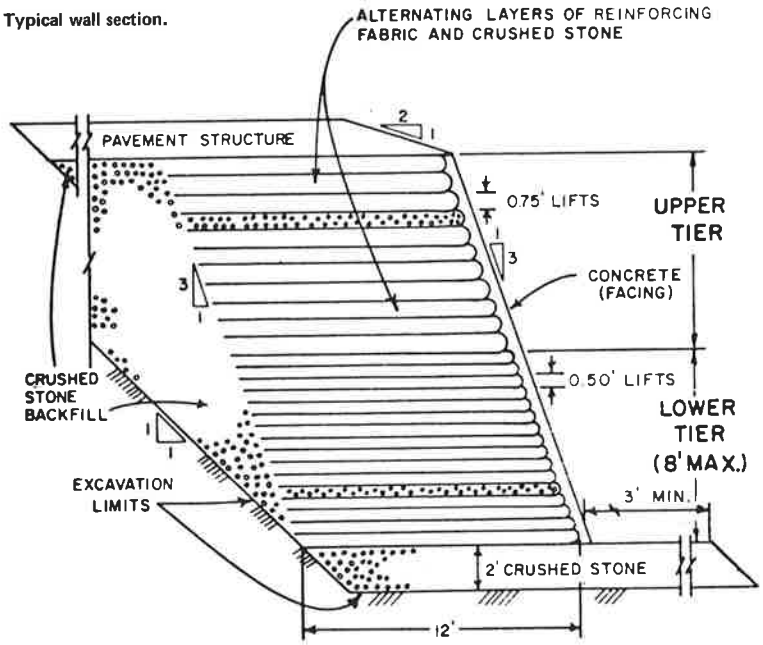
This installation emphasizes the following significant points:

1. Laboratory test values for geotextiles can be used in the design of reinforcement for an earth wall by using conventional analyses, and
2. The design and construction of this geotextile reinforced-earth wall was technically feasible, operationally practical, and cost effective.

Pollution Containment System

The design of the proposed old Westside Highway replacement on Manhattan Island, New York City, calls for extensive construction in the Hudson River. In order for this construction to take place, strict environmental controls must be main-

Figure 9. Typical wall section.



tained. Of primary concern is the control of pollution of the Hudson River.

To control the pollution during construction, it was initially proposed that a nonpermeable barrier (i.e., sheet-pile wall) be used. This proposal proved to be too costly. Further consideration led to the proposal for a permeable curtain system that used geotextiles that were to be placed around the site. To study the feasiblity of the system, a prototype curtain was designed and constructed.

The design required knowledge of the soil-retention capability and the long-term strength characteristics of the geotextile because it would be exposed to forces caused by tidal action. The tests previously described were used to quantitatively evaluate the various types of geotextiles available. Based on the results of these tests, a more exact specification was developed than previously described for silt fencing.

The prototype curtain was installed in fall 1981 and remained in place until spring 1982. Monitoring and inspection over this period indicated that the curtain performed satisfactorily.

DESIGN GUIDELINES

The experiences previously described have shown that, to achieve an economical design, there is a constant trade-off of desirable characteristics to achieve the best solution for a particular application. The characteristics of flow capacity, soil retention, strength, ultraviolet stability, and friction have to be constantly balanced by the design engineer. These characteristics are rated in the order of significance in Table 1, with 1 being the most significant and 10 being the least significant.

Based on the concepts of Table 1, the minimum requirements listed in Table 2 were established for placement of geotextiles on NYSDOT's approved list for 1982.

It is emphasized that the values listed in Table 2 are for nonsevere or general applications, as previously described. Conditions that require specific design considerations are

1. Underdrain, where the soil is a fine to coarse sand (sieve size = No. 10 to No. 100) and there is a constant source of water and potential high flow;
2. Undercut (subgrade stabilization), where a soil has low bearing capacity; and
3. Bedding, where the soil is a coarse sand (sieve size = No. 10 to No. 40) along an ocean front that is subjected to constant erosion due to wave action.

These severe conditions generally occur in approximately 10 percent of NYSDOT's geotextile applications.

SUMMARY

In summary, the establishment of the approved list and general specifications for installation allowed the successful use of geotextiles within New York State.

The Soil Mechanics Bureau has made the following recommendations, which are currently incorporated in the approved list:

1. Only nonwoven geotextiles should be used in drainage applications because they exhibit the best soil-retention characteristics.
2. Soil stabilization requires a geotextile of reasonable strength so as to survive the installation process.
3. Only woven geotextiles should be used for bedding applications.
4. Geotextiles used for slope protection should be needle punched, which will provide frictional resistance between the fabric and native soil.
5. Tests recommended or that are being developed by ASTM should be used.
6. Consideration should be given to the characteristics needed for design, as shown in Table 1. From this, select minimum values for design as shown in Table 2, which have been developed for nonsevere or general applications.
7. For critical or severe applications, special design procedures are required.

GEOTEXTILES IN THE FUTURE

New York has had relative success with the use of

Table 1. Ratings of applications.

Application	Rating by Characteristic[a]				
	Permittivity	Soil Retention	Strength	Ultraviolet Stability	Friction
Underdrain	2	1	5-6	10	10
Undercut	2	3	1	10	10
Bedding	1	3	1	7-8	9
Slope protection	3	2	5-6	7-8	1
Silt fencing	2	1	4	5-6	10

[a]The rating scale is from 1-10, with 1 being the most significant and 10 being the least significant.

Table 2. Minimum requirements for applications.

Application	Permittivity[a] (sec^{-1})	Soil Retention	Minimal Grab Tensile (lb)	Minimum Wide Width Tensile Strength (lb/in.)
Underdrain	0.51	Nonwoven	75	35
Undercut	0.02	Nonwoven and low permittivity	75	35
Bedding	0.41	Woven with EOS between No. 70 and No. 100 sieve sizes	100	60
Slope protection[b]	0.51	Needle punched	80	35
Silt fencing	—	—	—	—

[a]To convert to gallons per minute per square foot of area per foot of head, multiply by 454.
[b]Used in high friction situations.

geotextiles. However, there is much need for improvement (9). As manufacturers develop other materials and processes to produce geotextiles, it will become increasingly important and necessary to be able to objectively evaluate geotextiles for potential end use and to be able to restrict the use of products with questionable properties.

More emphasis should be placed on evaluating field performance for the desired end use. This can be accomplished by field instrumentation development for geotextiles and modeling laboratory tests that will simulate field conditions. This type of work will enable a better understanding of how geotextiles will perform in the field and, it is hoped, will upgrade the empirical rules for design.

Yet all of this design work will be wasted if proper construction procedures are not followed. In addition, any problems involved with construction will never be overcome unless monitored in the field. Other questions that need to be asked are as follows: What type of fabric was used? What was the soil type? What was the condition of the site before construction began? What construction and monitoring procedures were used for the job? These are all important questions that should be addressed in the documentation of a project. It is only through documentation that others may share and learn new ideas that can help further develop the appropriate use of geotextiles. This documentation, along with laboratory testing and field instrumentation, should be an all-inclusive process, because it is vital to the understanding of geotextile behavior.

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