Selecting Standard Test Methods for Experimental Evaluation of Geosynthetic Durability

C. JOEL SPRAGUE AND RICHARD A. GOODRUM

Geosynthetics have evolved from specialty materials considered state of the art in unique geotechnical designs to commonly used construction materials considered state of the practice in many transportation engineering applications. This relatively quick acceptance of geosynthetics can best be explained by their proven track record. Geosynthetics have generally performed as expected, though relatively few installations have yet reached their designed service lives. The term "durability" refers to the ability of geosynthetics to maintain satisfactory performance over time. Durability can be thought of as relating to changes over time of both the polymer microstructure and the geosynthetic macrostructure. The former involves molecular polymer changes and the latter assesses geosynthetic bulk property changes. Definitions of associated terminology, the identification of potential degradation processes, and the systematic selection of standard tests to evaluate both micro- and macrostructure components of durability as they relate to the use of geosynthetics in various transportation engineering applications are examined.

In 1987 the leadership of the ASTM Committee D35 on Geosynthetics recognized that confusion existed throughout the engineering community concerning the durability of geosynthetics. Yet the available standard test methods did not sufficiently address the question of geosynthetic durability. In fact the question itself appeared to require further definition before additional appropriate test methods could be developed. Therefore the Committee D35 leadership established a task group on durability with the following goals:

- Agree on terms and definitions,
- Perform a literature search,
- Identify potential degradation processes,
- Relate degradation processes to geosynthetic function,
- Identify existing test methods and parameters and propose new test methods, and
- Prepare a standard guide for selecting test methods for the experimental evaluation of geosynthetic durability.

All of these goals have been partially or completely satisfied, and a draft standard is in the balloting stage. It is through participation on this task group that the authors developed the basis for this paper.

OVERVIEW OF GEOSYNTHETIC DURABILITY

History

Since the late 1960s planar materials constructed of synthetic polymers have been used in the construction of impoundments, roads, drainage systems, earth structures, and other civil engineering projects. These materials have become known as geosynthetics because they are synthetic materials used in conjunction with the ground. Geosynthetics are designed to perform a function or combination of functions within the soil/geosynthetic system. Such functions as filtration, separation, planar flow, reinforcement, or fluid barrier, as well as others, are expected to be performed over the life of the installation, which is often 50 to 100 years or more.

Geosynthetics are common materials and like all other materials they have limitations. Geosynthetics are made of polymers that can degrade in certain environments. For example, polyolefins such as polypropylene and polyethylene undergo oxidative degradation, whereas polyester (PET) can be hydrolyzed and polyamides degrade by both hydrolysis and oxidation. Also these degradative processes may be accelerated by exposure to, for example, transition metals in the case of oxidations and extreme pH conditions in the case of hydrolysis. It must be emphasized, however, that these reactions are usually slow and can be further retarded by the use of suitable additives (*1*).

Polymer Degradation

For geosynthetics, oxidation and hydrolysis are the most common forms of chemical degradation. Processes that involve solvents are also common. Generally chemical degradation is accelerated at elevated temperatures because the activation energy for these processes is commonly high. The moderate temperatures associated with most installation environments are therefore not expected to promote excessive degradation within the usual service lifetimes of most transportation engineering systems. Additionally most synthetic polymers are rather inert toward biological enzymatic attack. Yet prudent attention should always be given to unique environments to assess their potential for causing polymer degradation (*2*).

Because many users of geosynthetics are not familiar with polymer chemistry it is useful to assess geosynthetic performance on a functional basis and reserve polymer chemistry for interpreting unsatisfactory test results or performing forensic studies, if necessary.

C. J. Sprague, Sprague & Sprague Consulting Engineers, P.O. Box 9192, Greenville, S.C. 29604-9192. R. A. Goodrum, Hoechst Celanese Corporation, Spunbound Business Unit, P.O. Box 5650, Spartanburg, S.C. 29304-5650.

Geosynthetic Performance

Geosynthetic performance is obvious to the geosynthetic user. Table 1 gives several geosynthetic failure mechanisms that result in unsatisfactory performance. In general long-term piping and clogging resistance and tensile and compression creep resistance are the most common properties related to durability in geotextiles, geogrids, geonets, and geocomposites. With geomembranes, development of openings that lead to leakage is a common concern.

Geosynthetic performance is dependent on the environment to which the geosynthetic is exposed. Therefore an understanding of the exposure environment is necessary before the user can select appropriate test methods to best simulate the aging of the geosynthetic.

Resistance to Aging

The exposure environment will generally be characterized by complex air, soil, and water chemistry as well as unique radiation, hydraulic, and stress-state conditions. The effect of this combination of exposures, over time, is called aging. Aging therefore includes both polymer degradation and reduced geosynthetic performance and is dependent on the specific exposure environment. Durability refers to a geosynthetic's resistance to aging—resistance to both polymer degradation and reduced geosynthetic performance.

Resistance to Polymer Degradation

A 1986 study by the U.S. Army Engineer Waterways Experiment Station found no reported cases of geotextile failure because of attack from chemicals present in a natural soil environment (*3*). However in cases of geosynthetic burial in soils having a very low or very high pH, consideration should be given to the composition of the geosynthetic selected. This should be a rare occurrence because most soils have a pH in the range of 3 to 10 (*4*). Geosynthetic composition should also be considered in cases of complex chemical exposures (e.g., leachate), burial in metal-rich soils, and extended exposure to sunlight. In order to evaluate these unique exposure conditions, tests are recommended that simulate actual exposure conditions on the geosynthetic selected. Accelerated tests should have a generally accepted relationship to real conditions.

Resistance to Reduced Geosynthetic Performance

Geosynthetics almost always encounter soil conditions that can cause reductions in geosynthetic performance. Such conditions may include gap-graded soil, which could lead to clogging of a

TABLE 1 Geosynthetic Failure Mechanisms

Function	Failure Mode	Possible Cause
Separation /Filtration	Piping of soils through the geotextile	Openings in geotextile are incompatible with retained soil. Openings may be enlarged as result of in-situ stress or mechanical damage.
Filtration	Clogging of the geotextile	Permittivity of the geotextile is reduced as a result of particle buildup on the surface of or within the geotextile. Openings may have been compressed as a result of long-term loading.
Reinforcement	Reduced tensile resisting force.	Excessive tensile stress/ relaxation of the geosynthetic.
Reinforcement	Unacceptable deformation of the soil/geosynthetic structure	Excessive tensile creep of the the geosynthetic.
Planar-Flow	Reduced in-plane flow capacity	Excessive compression creep of of the geosynthetic.
Protection	Reduced resis- tance to puncture	Excessive compression creep of the geosynthetic.
Fluid Barrier	Leakage through the Membrane	Openings are found in the geomembrane as a result of puncture or seam failure.

These failure mechanisms do not include polymer microstructure degradation mechanisms or installation damage and the resulting synergistic effects that may arise.

geotextile, or large embankment loads that must be resisted with little geosynthetic creep. Geosynthetic properties can be selected to protect against excessive reductions in performance, and prudent factors of safety can be used in designs incorporating geosynthetics.

Applications, Uses, and Primary Functions

In order to properly assess the effects of any given exposure environment on the performance life of the geosynthetic, a clear understanding of how the geosynthetic is to be used is required. For any given use there will be one or more primary functions that the geosynthetic will be expected to perform during its design life. Accurate identification of the application and the geosynthetic function is essential. Table 2 presents and defines primary geosynthetic functions, and Table 3 relates these functions to transportation engineering applications. It is the ability of the geosynthetic to perform satisfactorily the required primary functions during the design life that constitutes acceptable geosynthetic durability. The approach is consistent with "design by function" engineering, which is the preferred design approach for geosynthetics.

TABLE 2 Primary Geosynthetic Functions

Function	Definition
Erosion Control Device (ECD)	Restricts movement and prevents dispersion of soil particles subjected to erosion actions for an indefinite period of time.
Filter (F)	When placed in contact with a soil, allows liquid seeping from the soil to pass through while preventing most soil particles from being carried away by fluid flow.
Fluid barrier (FB)	Substantially prevents the migration of fluids through it.
Fluid transmission medium (FTM)	Collects a liquid or a gas and conveys it toward an outlet.
Permeable container (PC)	Encapsulates materials such as sand, rocks, and fresh concrete while allowing fluids to enter and escape. (During the placement of fresh concrete in a geotextile flexible form, the geosynthetic functions temporarily as a filter to allow excess water to escape.)
Protection layer (PL)	When placed between two materials, alleviates or distributes stresses and strains transmitted to the material to be protected.
Reinforcement (R)	Improves the mechanical stability of an earth structure through its tensile strength and physical interaction with soil.
Screen (Scr)	When placed across the path of a flowing fluid (groundwater, surface water, wind) carrying particles in suspension, retains some or all fine soil particles while allowing the fluid to pass through. After some period of time, particles accumulate against the screen, which requires that the screen be able to withstand pressures generated by the accumulated particles and the increasing fluid pressure.
Separator (S)	When placed between a fine and coarser material, prevents the fine soil and the coarser material from mixing.
Surface stabilization medium (SSM)	When placed on an incline, restricts movement and prevents dispersion of surface soil particles subjected to erosion actions (rain, wind), often while allowing or promoting vegetative growth.
Vegetative reinforcement medium (VRM)	Indefinitely extends the erosion control limits and performance of vegetation.

TERMS AND DEFINITIONS

Exposure Environment

The exposure environment in which a geosynthetic is placed can be characterized by the following environmental elements:

- *Air chemistry* includes the identification of the following characteristics of the gases expected to be present or created: oxygen content, gaseous pollution (e.g., NO_x, SO_2), ozone, organics (e.g., methane).
- *Fluid content* is a measure of the amount of liquid, vapor, or both in the environment immediately surrounding the geosynthetic.
- *Geometry of exposure* is described by the angle of exposure and the degree of exposure (i.e., surface versus complete).
- *Liquid chemistry* includes the identification of the following characteristics of the groundwater or leachate: pH, electrolytic conditions, dissolved and suspended minerals, chemicals, biochemical oxygen demand, chemical oxygen demand, and dissolved oxygen.
- *Macroorganisms* that are or could be present in the environment shall be identified. Macroorganisms such as insects, rodents, and other higher life forms shall be considered.
- *Microorganisms* that are or could be present in the environment shall be identified. Possible microorganisms include bacteria, fungi, algae, and yeast.
- *Radiation* shall be considered to include ultraviolet radiation, ionizing radiation, and infrared and visible radiation.
- *Soil chemistry* shall include the identification of the following characteristics of the soil or waste: transition metals, soluble minerals, polarizability, and clay mineralogy.
- *Stress* shall be focused on mechanical forces applied externally to the geosynthetic/soil system, resulting in tensile stresses, compressive stresses, shear stresses, or all three on the geosynthetic. Stresses on the geosynthetic shall be described by normal stresses, planar stresses, surface stresses, intensity of stresses, variance of stresses with time (static, dynamic, periodic), and distribution of stresses over the geosynthetic.
- *Temperature of exposure* shall be defined as the temperature of the geosynthetic, which is not necessarily that of the surrounding medium.
- *Time of exposure* shall be defined by the duration of exposure to any specific set of environmental elements.

Degradation Processes

The effects of the exposure environment are characterized by the following degradation processes:

- *Chemical degradation* is the reaction between a chemical or chemicals and a specific chemical structure within a polymer resulting in chain scission, and a reduction in molecular weight and physical properties.
- *Chemical dissolution* is the physical interaction between a solvent and polymer whereby the polymer absorbs the solvent, swells, and eventually dissolves.

TABLE 3 Applications, End Uses, and Primary Functions of Geosynthetics Used in Geotechnical and Transportation Engineering

GEOTECHNICAL/TRANSPORTATION ENGINEERING		
Application	Use	Primary Function(s)
Embankments	Horizontal drain between saturated soil and embankment, filter during consolidation.	F,FTM
	Separation of soft soil and embankment materials.	S
	Reinforcement to improve embankment stability.	R
	Tensioned membrane to bridge soft soils.	R
Slope Stabilization and Protection	Filter between earth embankment and slope protection.	F
	Placed over slopes to prevent erosion.	VRM
	Reinforcement of slopes.	R
Soil Retaining Structures	Reinforced soil walls.	R
	Retained and protected slopes.	R
	Wall waterproofing systems	FB,PL
Roads on Expansive Soils, Soft Soils, or Peat	Reinforcement of soft subgrades, bridging of soft mat'ls.	R
	Separation of pavement material from soft soils.	S
	Horizontal filters, drainage of saturated subgrade.	F,FTM
	Control of expansive soils	FB,PL
	Prevention of frost heave	FB,FTM,PL
	Prevention of enlargement of karst sinkholes	FB,PL
	Protecting frost sensitive soils by encapsulation	FB
Pavement	Placed between pavement layers to act as moisture barrier	FB
	Placed between pavement layers to deter reflective crack'g	R
Railroad Tracks	To separate ballast from embankment.	S
	Moistureproofing railroad subgrades.	FB,PL
	To reinforce track systems and distribute loads.	R
	To prevent upward groundwater movement in a railroad cut	FB,PL
	To prevent contamination in railroad refueling areas	FB,PL
Tunnel Lining	To prevent puncturing of geomembrane lining	PL
	To provide drainage of seepage waters.	FTM
	To prevent migration of seepage through the tunnel lining	FB,PL
Drainage	Filter to wrap gravel drains and pipes.	F
	Drainage medium to collect and transport groundwater	FTM
	Pipeline trench base reinforcement	R

- *Clogging* is the collection of soil particles, microbiological growth, precipitates, or combination thereof on or within the geosynthetic altering its initial hydraulic properties.
- *Creep* is the time-dependent part of a strain resulting from an applied stress.
- *Environmental stress cracking* is the development of external or internal cracks in a geosynthetic that are caused by tensile stresses less than the short-time mechanical strength and are accelerated by the exposure environment.
- *Hydrolysis* is the degradative chemical reaction between a specific chemical group within a polymer and absorbed water causing chain scission and reduction in molecular weight.
- *Macrobiological degradation* is the attack and physical destruction of a geosynthetic by macroorganisms leading to a reduction in physical properties.
- *Microbiological degradation* is the chemical attack of a polymer by enzymes or other chemical excreted by microorganisms resulting in a reduction of molecular weight and changes in physical properties.
- *Mechanical damage* is the localized degradation of the in-service geosynthetic as a result of externally applied load; abrasion, impact loads, and vandalism are examples. (Installation damage is excluded, but it is an important consideration in geosynthetic selection.)
- *Oxidation* is the chemical reaction between oxygen and a specific chemical group within a polymer converting the group into a radical complex that ultimately leads to molecular chain scission or cross linking, thus changing the chemical structure, physical properties, and sometimes the appearance of the polymer.
- *Photo degradation* is the change in chemical structure resulting in deleterious changes to physical properties and sometimes to the appearance of the polymer as a result of the irradiation of the polymer by exposure to light (primarily ultraviolet).
- *Plasticization* is the physical process of increasing the molecular mobility of a polymer by absorption or incorporation of materials of lower molecular weight. The effects are usually reversible when the materials are removed.
- *Stress relaxation* is the decrease in stress, at constant strain, with time.
- *Temperature instability* is the change in appearance, weight, dimension, or other property of the geosynthetic as a result of low, high, or cyclic temperature exposure.

TABLE 4 Degradation Concerns Relating to Geosynthetic Functions

FUNCTION	POTENTIAL DEGRADATION PROCESS														EXPLANATIONS OF PRIMARY LONG-TERM CONCERNS
	Abbreviation	Biological Degradation	Chemical Degradation	Chemical Dissolution	Clogging/Piping	Creep	Environmental Stress Cracking	Hydrolysis	Mechanical Damage	Photo-Oxidation	Plasticization	Stress Relaxation	Temperature Instability	Thermal-Oxidation	
Erosion Control Device	ECD	P[1,2]	S[3]	S[3]	N	N	N	S[4]	S[5]	S[6]	N	N	N	S[7]	Resist Erosive Forces
Filter	F	P[1,2]	S[3]	S[3]	A[8]	S[9]	N	S[4]	S[5]	S[6]	N	S[9]	N	S[7]	Maintain design filtration & resist deformation & intrusion
Fluid Barrier	FB	P[1,2]	S[3]	S[3]	N	S[16]	A[11,20]	S[4]	S[5]	S[6]	N	S[16]	S[12]	S[7]	Maintain intended level of impermeability
Fluid Transmission Medium	FTM	P[1,2]	S[3]	S[3]	A[13]	A[14]	A[20]	S[4]	S[5]	S[6]	N	A[14]	N	S[7]	Maintain flow under compressive loads
Permeable Container	PC	P[1,2]	S[3]	S[3]	S[15]	S[16]	N	S[4]	S[5]	S[6]	N	S[16]	N	S[7]	Remain intact & maintain filtration performance
Protective Layer	PL	P[1,2]	S[3]	S[3]	N	S[17]	N	S[4]	N	S[6]	N	S[17]	N	S[7]	Maintain protective performance
Reinforcement	R	P[1,2]	S[3]	S[3] P[18]	N	A[19]	P[20]	S[4]	P[18]	S[6]	P[21]	S[19]	S[19]	S[7]	Provide necessary strength, stiffness & soil interaction
Screen	Scr	P[1,2]	S[3]	S[3]	S[22]	N	N	S[4]	S[5]	S[6]	N	N	N	S[7]	Maintain filtration performance & resist deformation
Separator	S	P[1,2]	S[3]	S[3]	N	N	N	S[4]	P[23]	S[6]	N	N	N	S[7]	Remain intact
Surface Stabilization Medium	SSM	P[1,2]	S[3]	S[3]	N	N	N	S[4]	A[10]	A[10]	N	N	N	S[7]	Remain intact to resist erosive forces until vegetation is established
Vegetative Reinforcement Medium	VRM	P[1,2]	S[3]	S[3]	N	N	N	S[4]	A[10]	A[10]	N	N	N	S[7]	Remain intact throughout vegetation

KEY: N = Not a generally recognized concern; S = Sometimes a concern; A = Almost always a concern; P = Potential concern being researched

[1] Microorganisms have been known to attack and digest additives (plasticizers, lubricants, emulsifiers) used to plasticize a base polymer. Study is needed to determine relevance to polymers incorporated into geosynthetic products. Embrittlement of geosynthetic surfaces may influence interaction properties.

[2] Microbial enzymes have been known to initiate and propagate reactions deteriorative to base polymers. Study is needed to determine relevance to polymers used in geosynthetic products.

[3] Chemical degradation and/or dissolution, including the leaching of plasticizers or additives from the polymer structure, may be a concern for geosynthetics exposed to liquids containing unusually high concentrations of metals, salts, or chemicals, especially at elevated temperatures.

[4] Hydrolysis may be a concern for PET and PA geosynthetics exposed to extreme pH conditions, especially at elevated temperatures.

[5] When subject to rocking (abrasion), puncture (floating or airborne debris), or cutting (equipment or vandalism).

[6] When permanently exposed or during extended construction (>2-4 weeks) and in wrap-around construction, photo degradation may be a concern for exposed geosynthetics.

[7] Geosynthetics in applications such as dam facings and floating covers that result in exposure to temperatures at or above ambient must be stabilized to resist thermal oxidation.

[8] Clogging resistance of geotextiles can be assessed only by testing with site–specific soil and (sometimes) liquid.

[9] If a filter geotextile is used with a geonet, it is important to assess short–term extrusion and long–term intrusion into the net.

[10] Always exposed therefore resistance to photo oxidation and mechanical damage must be determined.

[11] Residual stresses and surface damage may produce synergistic effects with other degradation processes.

[12] Excessive expansion and contraction resulting from temperature changes may be a concern for geosynthetics without fabric reinforcement.

[13] Composite drains must resist clogging due to soil retention problems and intrusion of filter medium.

[14] Geosynthetics relying on a three-dimensional structure to facilitate flow must demonstrate resistance to compression creep.

[15] If select fill is not available, then a clogging resistance test should be performed with the job–specific soil.

[16] Geosynthetics in containment structures that require long-term strength characteristics should be designed using appropriate creep and stress relaxation criteria.

[17] Sufficient thickness must be maintained by a protective layer over an extended period of time.

[18] Chemical dissolution of or mechanical damage to geosynthetic coatings may affect their interaction properties (i.e., lead to surface or joint slippage).

[19] Geosynthetics creep and stress relax at different rates depending mainly on manufacturing process, polymer type, load levels, temperature, and application.

[20] Polyethylene geosynthetics may experience slow crack growth under long-term loading conditions in certain environmental conditions.

[21] Plasticization may be a concern for PET geosynthetics exposed to humidity or polypropylene and polyethylene geosynthetics exposed to hydrocarbons while under stress.

[22] If the screen is expected to operate indefinitely, then clogging should be assessed often. Commonly, screens are considered temporary.

[23] Holes resulting from mechanical damage may alter the effectiveness of separators.

- *Thermal degradation* is the change in chemical structure resulting in changes in physical properties and sometimes in the appearance of a polymer caused by exposure to heat alone.

SELECTING TESTS TO EVALUATE DURABILITY

Scope

This selection guide defines those factors of the appropriate exposure environment that may affect the post-construction service life of the geosynthetic. Test methods are recommended to facilitate an experimental evaluation of the durability of geosynthetics in a specified environment so that durability can be considered in the design process. This does not address manufacturing, handling, transportation, or installation conditions.

Summary of Selection Process

The effects of a given exposure environment on the durability of a geosynthetic must be determined through appropriate testing. Selection of appropriate tests requires a systematic determination of the primary function(s) to be performed and the associated degradation processes that should be considered. This selection guide provides a suitable systematic approach.

Primary functions of geosynthetics are listed and defined in Table 2. With knowledge of the specific geosynthetic application area and end use, the corresponding primary function(s) is identified. (Table 3 lists transportation engineering applications) Table 4 lists degradation concerns as they relate to geosynthetic functions. Table 5 gives the environmental elements that relate to the various degradation processes and the currently available ASTM D35 standard test method for the experimental evaluation of specific types of geosynthetic degradation.

Designers and specifiers of geosynthetics should evaluate geosynthetic durability as an integral part of the geosynthetic specification and selection process. The following procedure is intended to guide a designer or specifier through a systematic determination of degradation concerns based on the intended geosynthetic function. The procedure then provides a guide to selecting available test methods for experimentally evaluating geosynthetic durability and to identifying areas where no suitable test exists.

This guide does not address the evaluation of degradation resulting from manufacturing, handling, transporting, or installing the geosynthetic.

Step-by-Step Procedure

To use a structured procedure for selecting appropriate test methods, the geosynthetic designer or specifier must have knowledge of

- The intended geosynthetic application,
- The end use of the geosynthetic via its primary function(s),
- The specific environment to which the geosynthetic will be exposed,
- The types of geosynthetics that may or will be used, and
- The duration or time of use.

With this knowledge, the designer or specifier follows the following procedure:

1. Identify the primary functions to be performed by the geosynthetic in the specific application and end use intended. Primary functions are defined in Table 2. Table 3 provides guidance in identifying primary functions for transportation applications.
2. Identify in Table 4 the potential degradation processes that are almost always (A) or sometimes (S) concerns when a geosynthetic performs the primary function(s) that were identified in Step 1. Consult the notes for Table 4 to see whether those identified degradation processes that are sometimes a concern apply to the specific application environment expected.
3. Using Table 5, select the standard test method(s) that applies to the potential degradation processes identified in Step 2 as a concern in the specific exposure environment expected.

Guidance is given in Table 5 to identify the most important elements or variables relating to each degradation process.

TEST METHOD SELECTION PROCEDURES: EXAMPLES

Example 1

Select the appropriate standard test methods to assess the durability characteristics of a geotextile to be used to separate an asphalt-surfaced aggregate road structure from underlying soft soils. The design life of the road is 20 years.

Selection Procedure

- Application (see Table 3): road on soft soil.
- End use: separation of road structure from soft subgrade.
- Primary function(s): separator.
- Potential degradation processes (see Table 4)
  - –Biological degradation (potential being researched; not a documented concern at this time);
  - –Chemical degradation and dissolution (only seepage water is expected; therefore, chemical degradation and dissolution are not concerns);
  - –Hydrolysis (extreme pH conditions are not expected; therefore, hydrolysis is not a concern);
  - –Mechanical damage (potential being researched; not a documented concern at this time);
  - –Photo oxidation (extended ultraviolet exposure is not expected; therefore, photo oxidation is not a concern); and
  - –Thermal oxidation (extended exposure is not expected; therefore thermal oxidation is not a concern).

Summary of Required Tests

No durability tests are required.

Example 2

Select the appropriate standard test methods to assess the durability characteristics of a geotextile to be used to wrap aggregate pavement edge drains. The design life is 20 years.

TABLE 5 Environmental Factors and Tests Relating to Geosynthetic Degradation

POTENTIAL DEGRADATION PROCESS	ENVIRONMENTAL ELEMENTS RELATING TO DEGRADATION											STANDARD TEST METHODS IN ASTM D35 COMMITTEE ON GEOSYNTHETICS	
	Air Chemistry	Fluid Content	Geometry of Exposure	Liquid Chemistry	Macro-Organisms	Micro-Organisms	Radiation	Soil Chemistry	Stress	Temperature of Exposure	Time of Exposure		
Biological Degradation	X	X			X	X		X		X	X	None	Microbio. Attack
Chemical Degradation				X				X		X	X	ASTM D5322 ASTM D5496	Chemical Immersion Field Immersion
Chemical Dissolution				X				X		X	X	None	Effect of Solvents
Clogging/Piping				X		X		X			X	ASTM Proposed ASTM D5101 ASTM D1987 None	Hydr. Conduct. Ratio Gradient Ratio Biological Clogging Precipitate Clogging
Creep			X						X	X	X	ASTM Proposed ASTM D5262 ASTM D4716	Compression Tension Transmissivity
Envir. Stress Cracking	X			X				X	X	X	X	ASTM D5397	Stress Cracking
Hydrolysis		X		X				X		X	X	None	Effect of Water
Mechanical Damage			X						X		X	ASTM D4886 None ASTM D4833	Abrasion Fatigue Puncture
Photo-Oxidation	X						X				X	ASTM Proposed ASTM D4355	Outdoor Exposure UV Resistance
Plasticization		X		X						X	X	None	Effect of Liquids
Stress Relaxation			X						X	X	X	ASTM Proposed ASTM Proposed	Compression Tension
Temperature Instability										X	X	ASTM D4594	Temperature Stability
Thermal Oxidation	X						X			X	X	None	Effect of Heat

<u>Note</u>: This table provides the standard test methods current at the time of the writing of this article. ASTM Standards are in constant development, review, revision, and replacement. It is the responsibility of the geosynthetic specifier to identify the most current applicable standard test method.

Selection Procedure

- Application (see Table 3): drainage.
- End use: filter to wrap gravel drains.
- Primary function(s): filter.
- Potential degradation processes (see Table 4)
  - –Biological degradation (potential being researched; not a documented concern at this time.);
  - –Chemical degradation and dissolution (only seepage water is expected; therefore, chemical degradation and dissolution are not concerns);
  - –Clogging (always);
  - –Creep (because the geotextile will be used adjacent to aggregate, no bridging is required; therefore, creep and stress relaxation are not concerns);
  - –Hydrolysis (extreme pH conditions are not expected; therefore, hydrolysis is not a concern);
  - –Mechanical damage (no rocking, impact, or cutting is expected because of complete burial and negligible stress; therefore, mechanical damage is not a concern);
  - –Photo oxidation (extended ultraviolet exposure is not expected; therefore, photo oxidation is not a concern); and
  - –Thermal oxidation (extended exposure is not expected; therefore, thermal oxidation is not a concern).

Summary of Required Tests

- Potential degradation process: clogging, and
- Standard test methods: ASTM D5101 and D1987.

CONCLUSIONS AND RECOMMENDATIONS

Although geosynthetics have generally performed as expected, some uncertainty exists as to how long these materials can be expected to continue to perform; that is, how durable they are. This paper attempts to provide guidance for the experimental evaluation of geosynthetic durability by outlining a procedure for selecting appropriate standard test methods. The selection of appropriate tests has been related to the primary functions that the geosynthetic is expected to perform and to the specific degradation processes that can be expected for the anticipated exposure environment. Detailed associated terminology has been proposed to facilitate continued discussions of geosynthetic durability among design engineers and polymer scientists.

It is hoped that the proposed selection procedure and terminology will assist engineers in including durability in their ''design by function'' use of geosynthetics and also provide a basis for defining the scope of new tests to evaluate specific degradation processes.

ACKNOWLEDGMENTS

The authors would like to express sincere appreciation to all members and friends of ASTM Committee D35 on Geosynthetics who have contributed to the goals of the Task Group on Durability. A special thanks to Don Bright of the Tensar Corporation, Rick Thomas of National Seal Corporation, Bill Hoffman of Union Carbide, and Robert Koerner of the Geosynthetics Research Institute for their continued support and contributions since the task group's inception.

REFERENCES

1. Colin, G., M. T. Mitton, D. J. Carlsson, and D. M. Wiles. The Effect of Soil Burial Exposure on Some Geotextile Fabrics. *Geotextiles and Geomembranes*, Vol. 4, 1986, pp. 1–8.
2. Schnabel, W. *Polymer Degradation: Principles and Practical Applications*. Hanser International, 1981.
3. Horz, R. *Geotextiles for Drainage, Gas Venting, and Erosion Control at Hazardous Waste Sites*. Report EPA/600/2-86/085. U.S. Army Engineer Waterways Experiment Station Vicksburg, Miss., 1986.
4. *Encyclopedia of Chemistry*. Van Nostrand Reinhold, 1984.