Module 2 – Subsurface Drainage

Introduction To Geosynthetics In Transportation

Prepared by

GMA Geosynthetic Materials Association

July 2007

For the Local Technical Assistance Program

IFAI INDUSTRIAL FABRICS Association International

- **The Geosynthetic Materials Association (GMA)** represents all segments of the geosynthetics industry
  - Manufacturers
  - Companies that test or supply material or services to the industry

- GMA activities further the acceptance and use of geosynthetic materials in a variety of applications.
  - Trade association
  - Bimonthly magazine
  - Conferences and trade show

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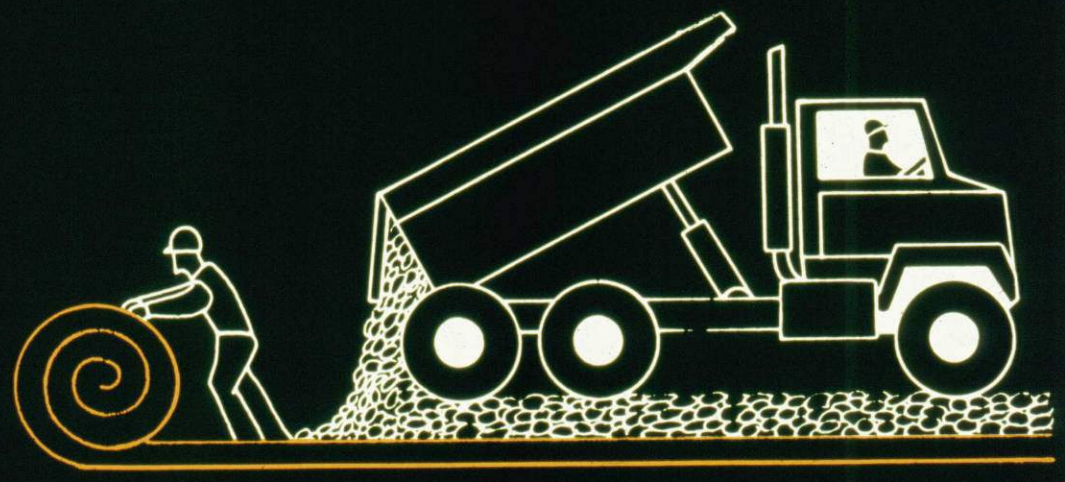
In 2007 Geosynthetics magazine (formerly GFR) enters its 25th year of publication.

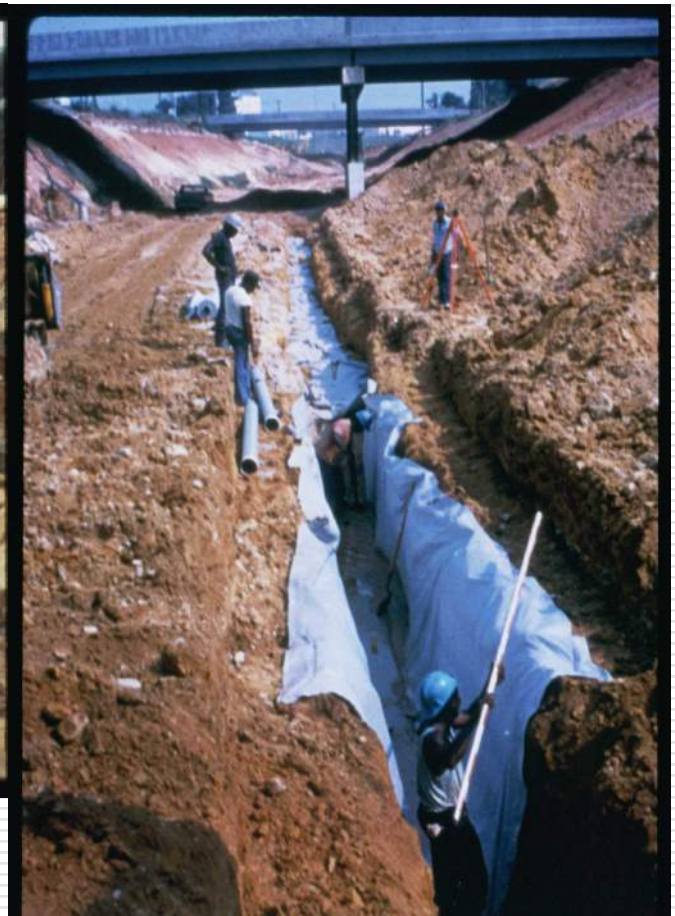
Preface

- This short-course introduces geosynthetics from the perspective of practical application.
- It is intended to serve as a general reference in the field for those who are building structures that include geosynthetics.



Geosynthetics

The most versatile and cost-effective ground modification materials.



Contents

Introduction to Geosynthetics

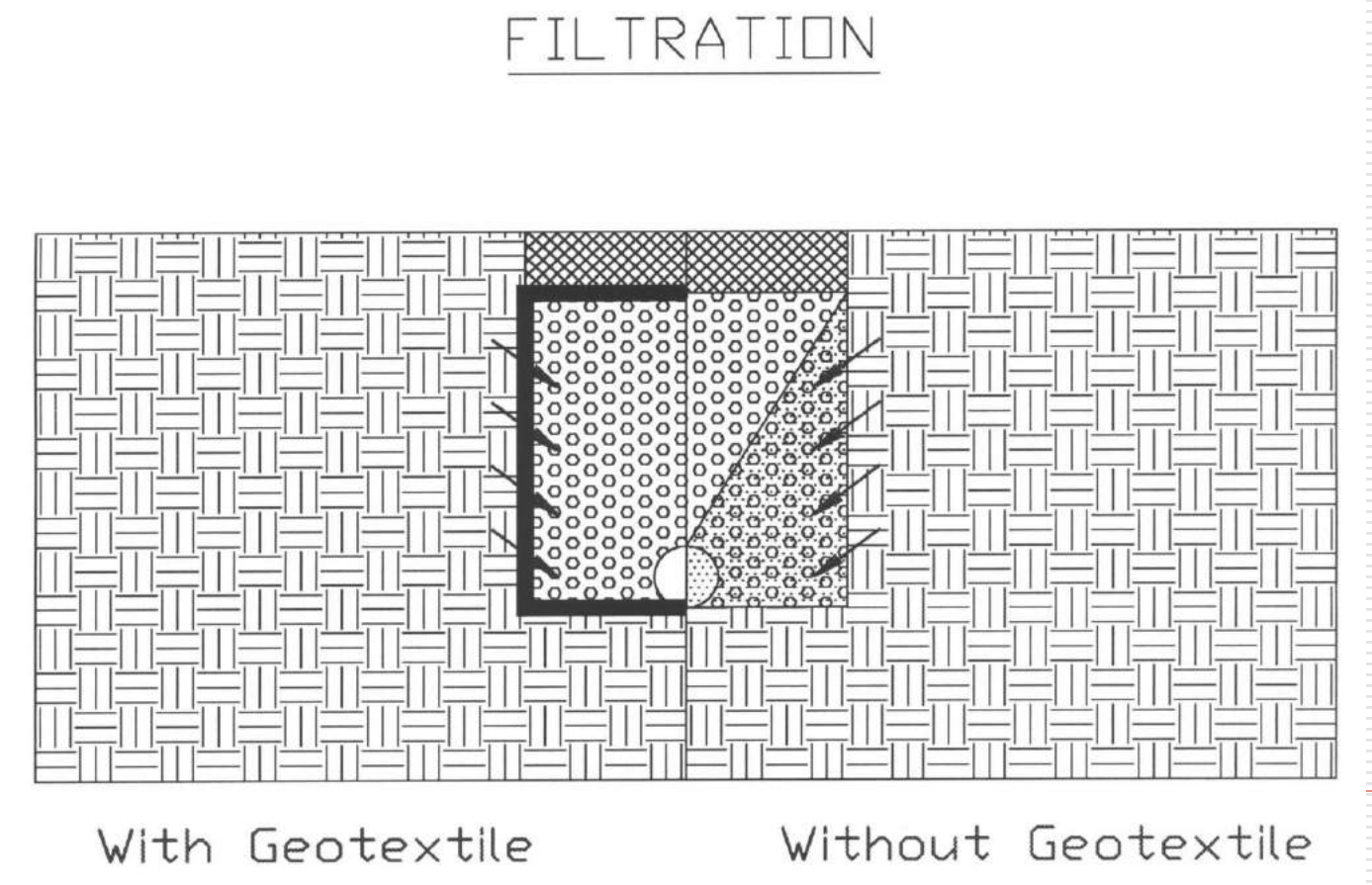
Geosynthetics, including:

- Geotextiles
- Geomembranes
- Geonets
- Geogrids
- Geocomposites
- Geosynthetic clay liners

…Are often used in combination with conventional materials, offer numerous advantages over traditional materials

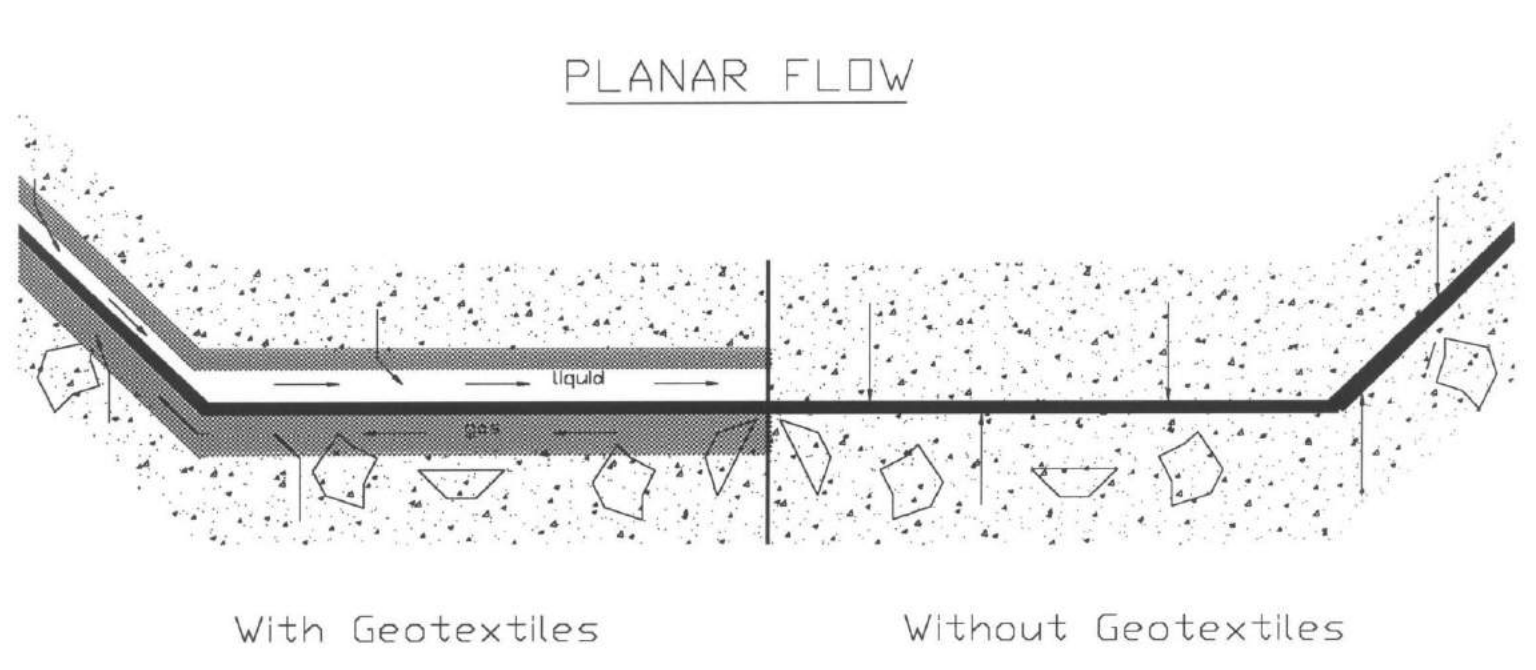
Geosynthetic Filter

A geosynthetic performs the filtration function when it allows water to pass while restricting the movement of soil particles.



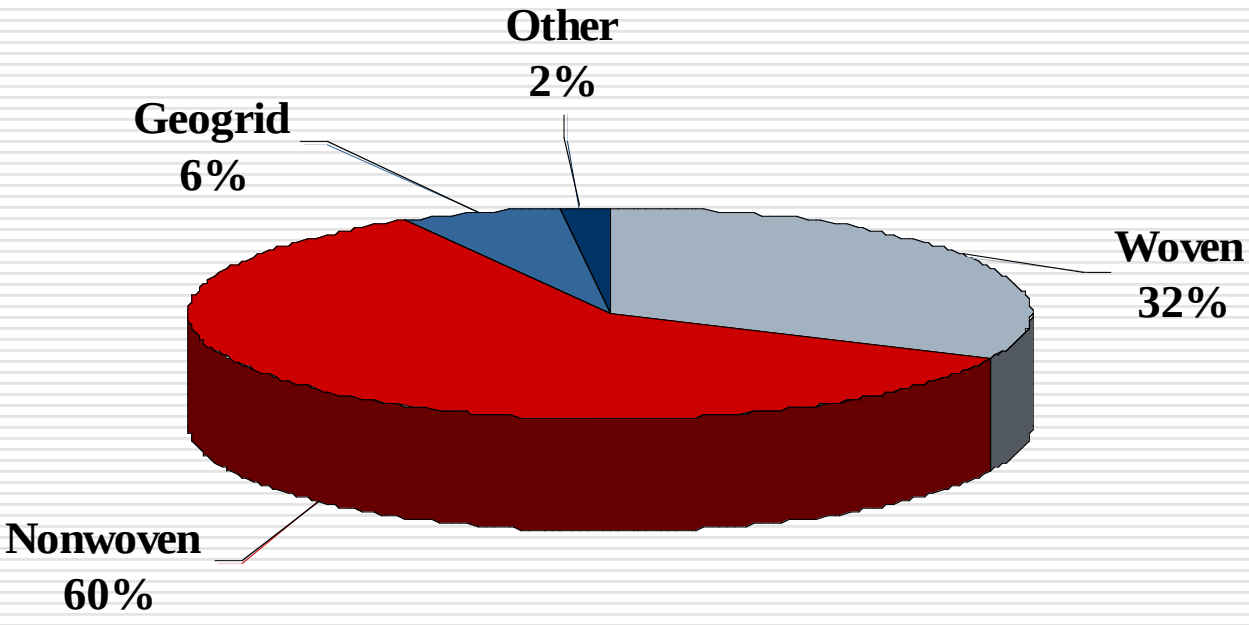
Geosynthetic Planar Drain

A geosynthetic performs the planar drainage function when allows water or gas to pass within the plane of the geosynthetic.



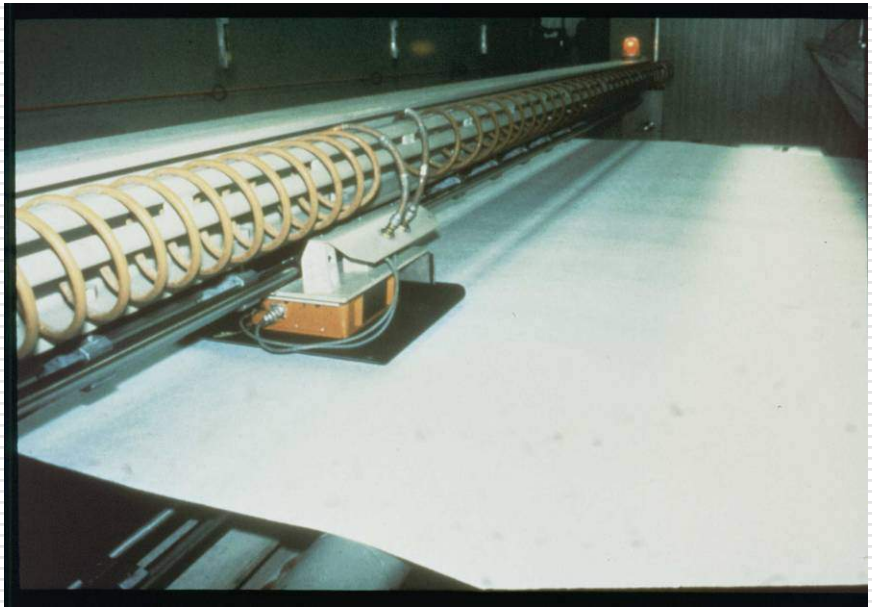
Geosynthetic Categories

Geotextiles – both woven and nonwoven – make up the largest percentage of geosynthetics used in transportation applications.



USA Market

Geotextiles



Geotextiles, like other geosynthetics, are manufactured in state-of-the-art facilities using sophisticated equipment.

Geotextiles

Polymers

- Almost all are polyester or polypropylene.
  - Polypropylene is lighter than water (specific gravity of 0.9), strong and very durable.
  - Polyester is heavier than water, has excellent strength and creep properties, and is compatible with most common soil environments.

Structures

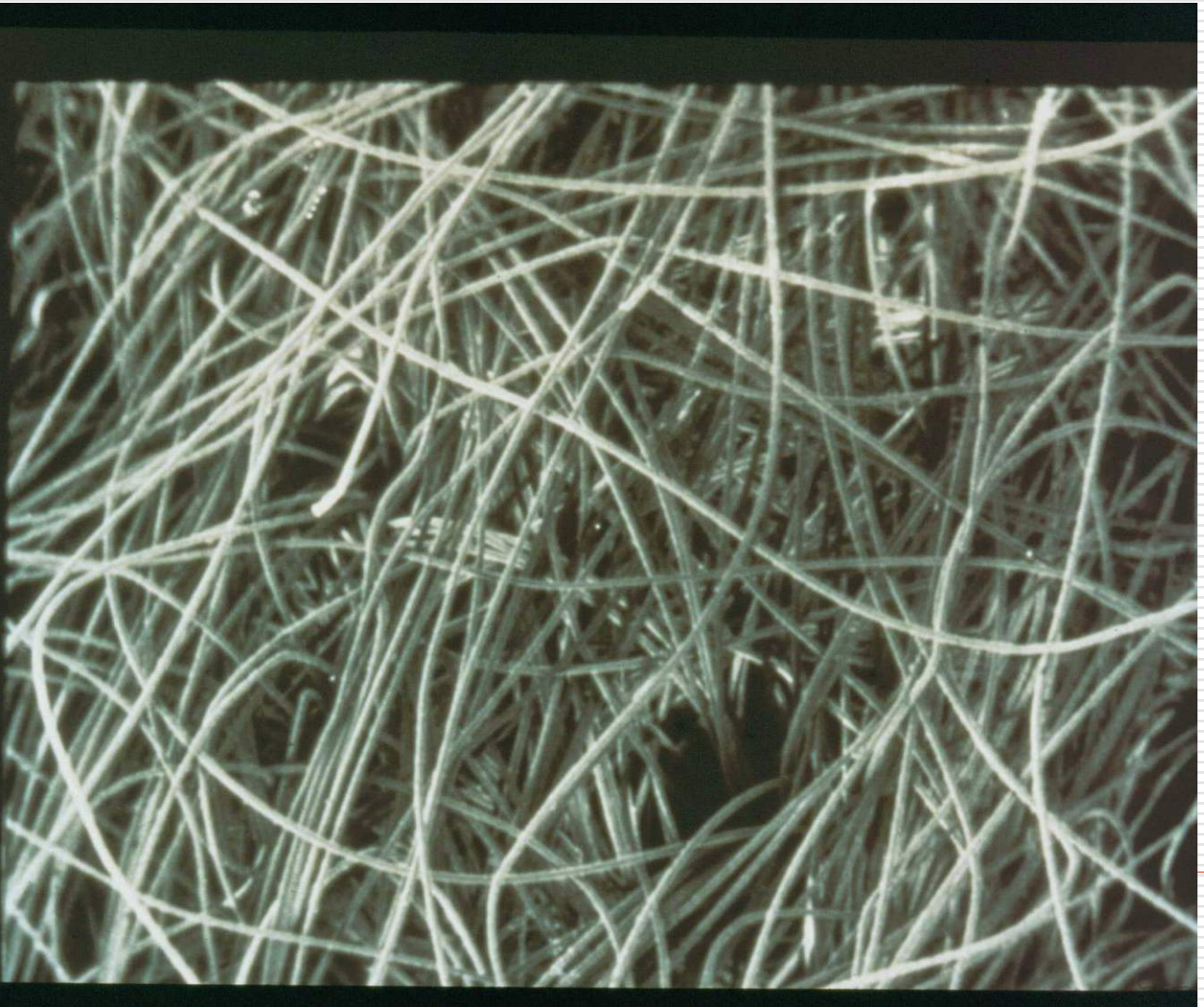
- Nonwoven
- Woven
- Other
  - Knitted
  - Stitch bonded

Nonwovens

- Manufactured from (short) staple fibers or continuous filaments randomly distributed in layers onto a moving belt to form a "web".

- The web then is needled or heat and pressure bonded to interlock the fibers.

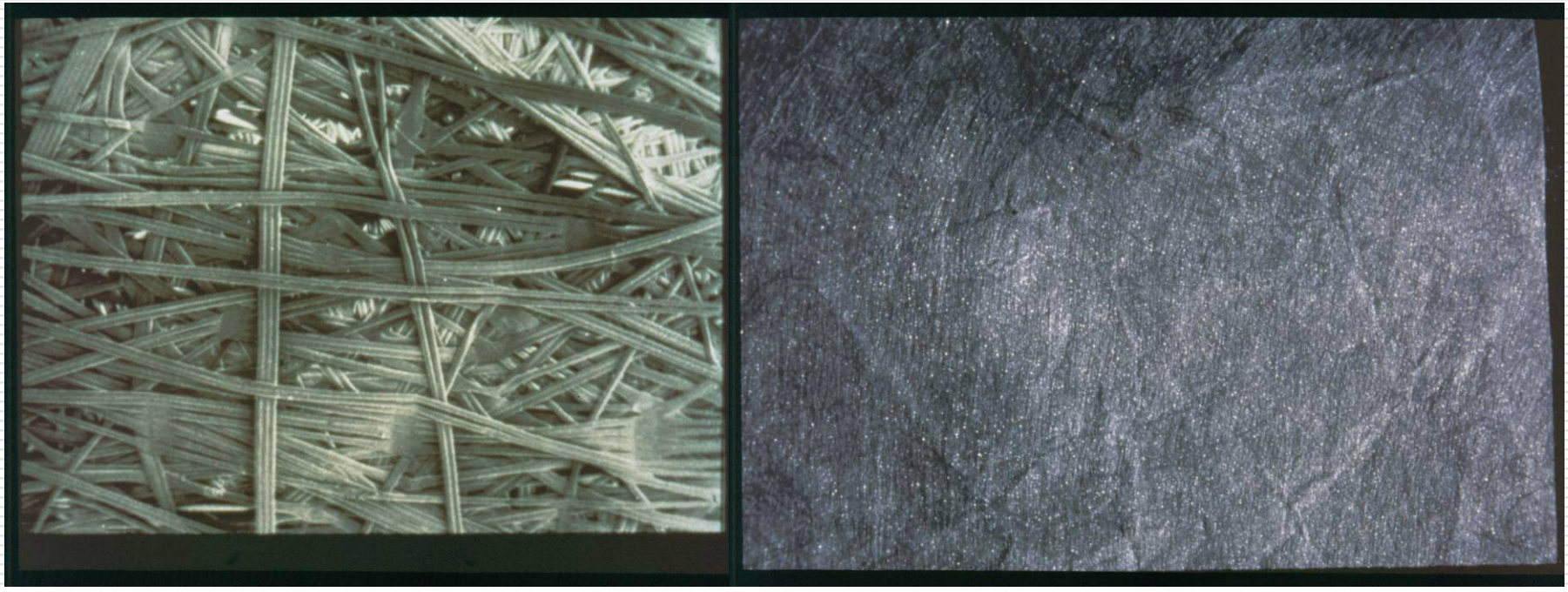
Needle-punched Nonwoven Geotextiles



Needle-punched nonwovens are “felt-like” and very flexible.

Heatbonded Nonwoven Geotextiles

Heat-bonded nonwovens are thinner and have greater stiffness.

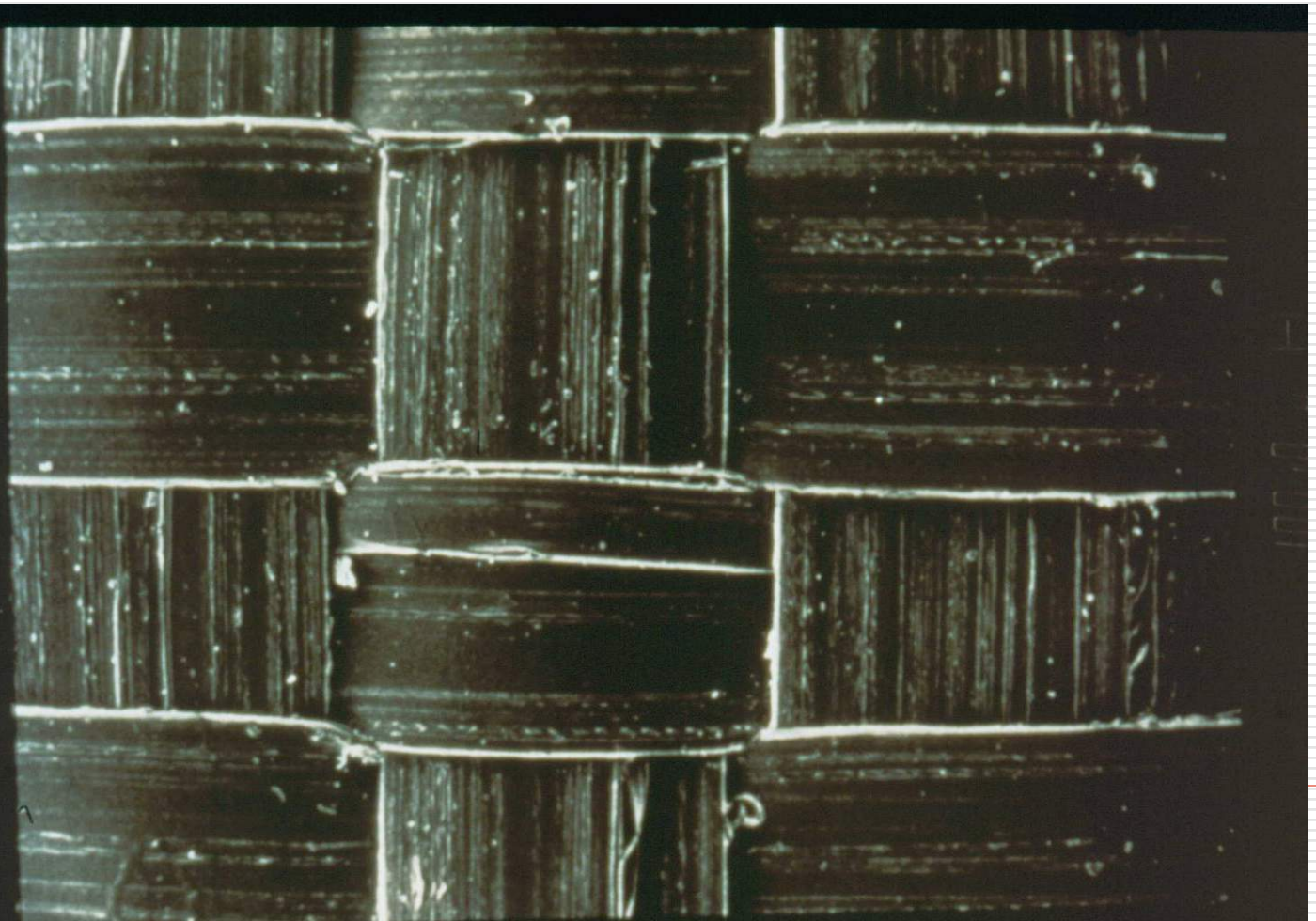


Wovens

- Weaving is a process of interlacing yarns to make a fabric.

- Woven geotextiles are made from weaving slit film, monofilament, or multifilament yarns.

Slit Film Woven Geotextiles



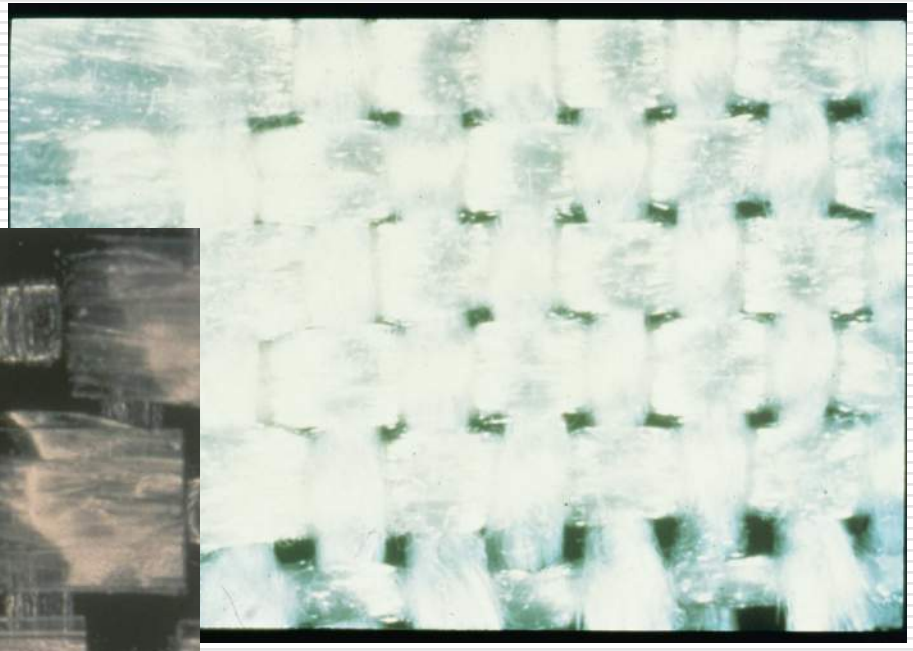
Slit film woven geotextiles provide economical separation of materials.

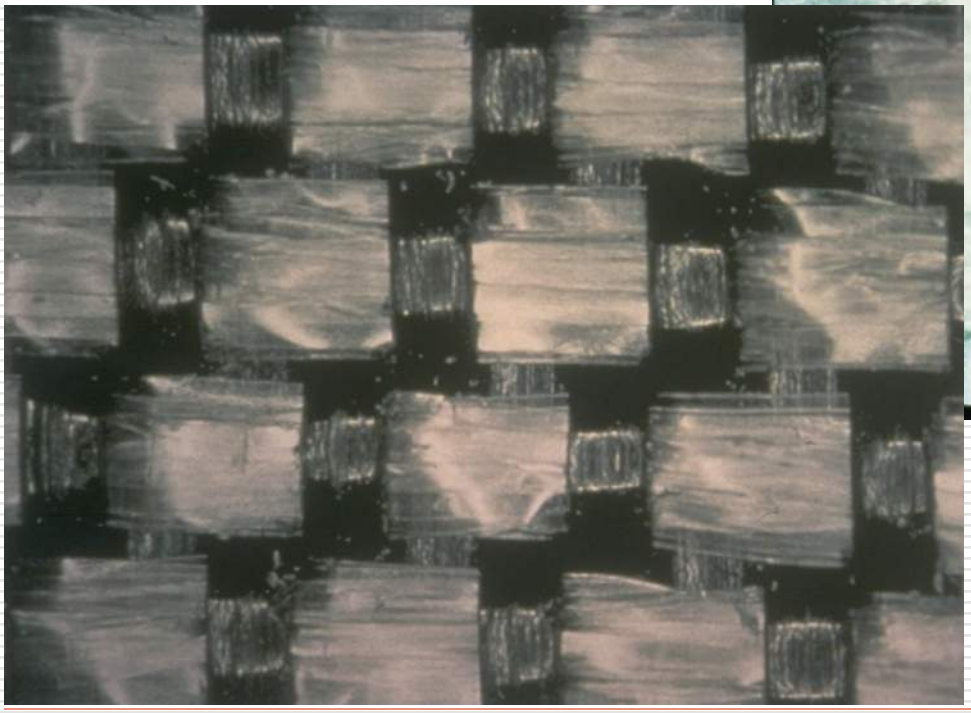
Monofilament Woven Geotextiles

Monofilament woven geotextiles provide enhanced filtration properties.

Fibrillated and Multifilament Woven Geotextiles

Multifilament woven geotextiles provide enhanced tensile strength.

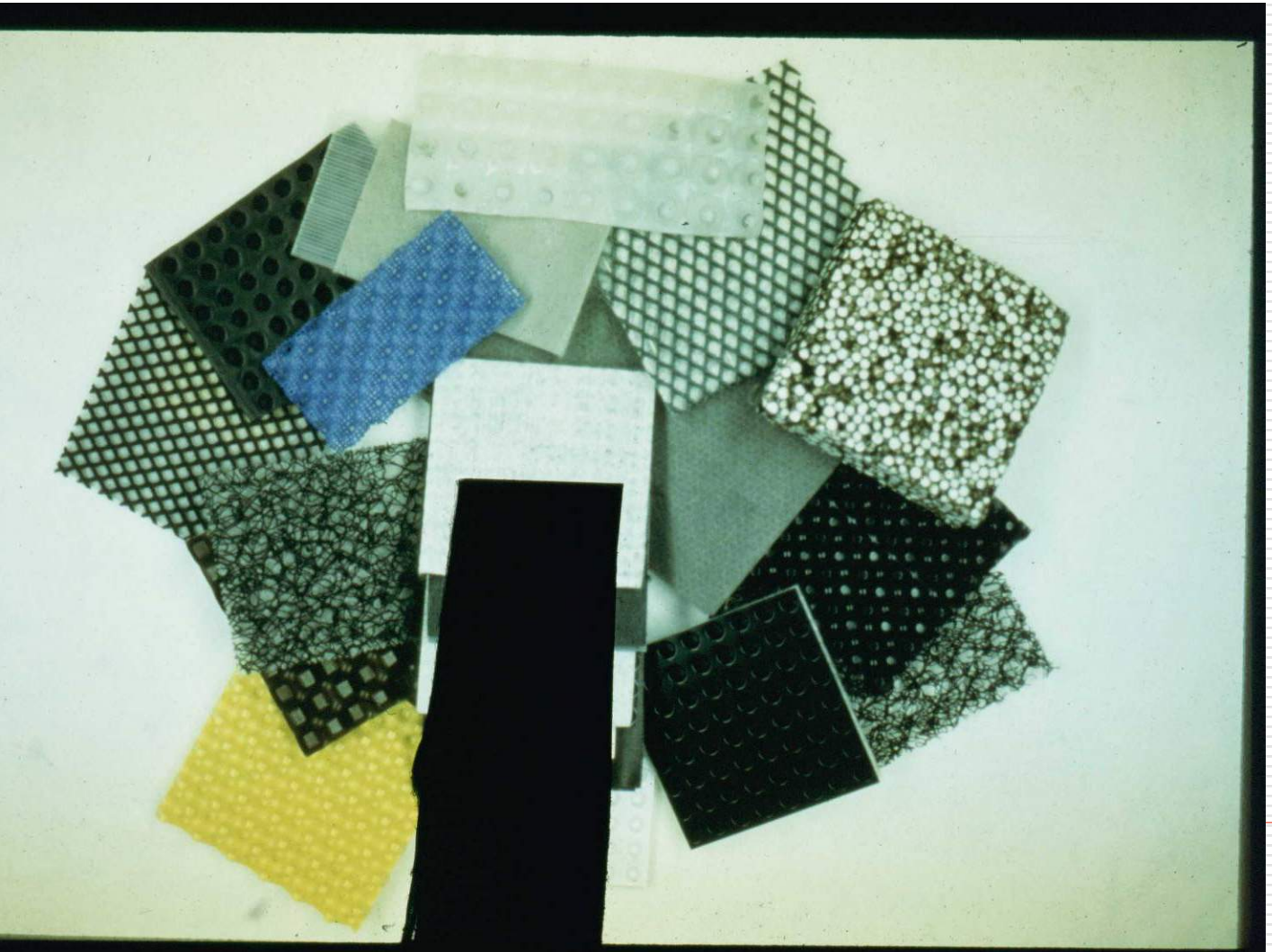




Geonets

Geonets are made of stacked, crisscrossing polymer strands that provide in-plane drainage. Nearly all geonets are made of polyethylene.

Geocomposites



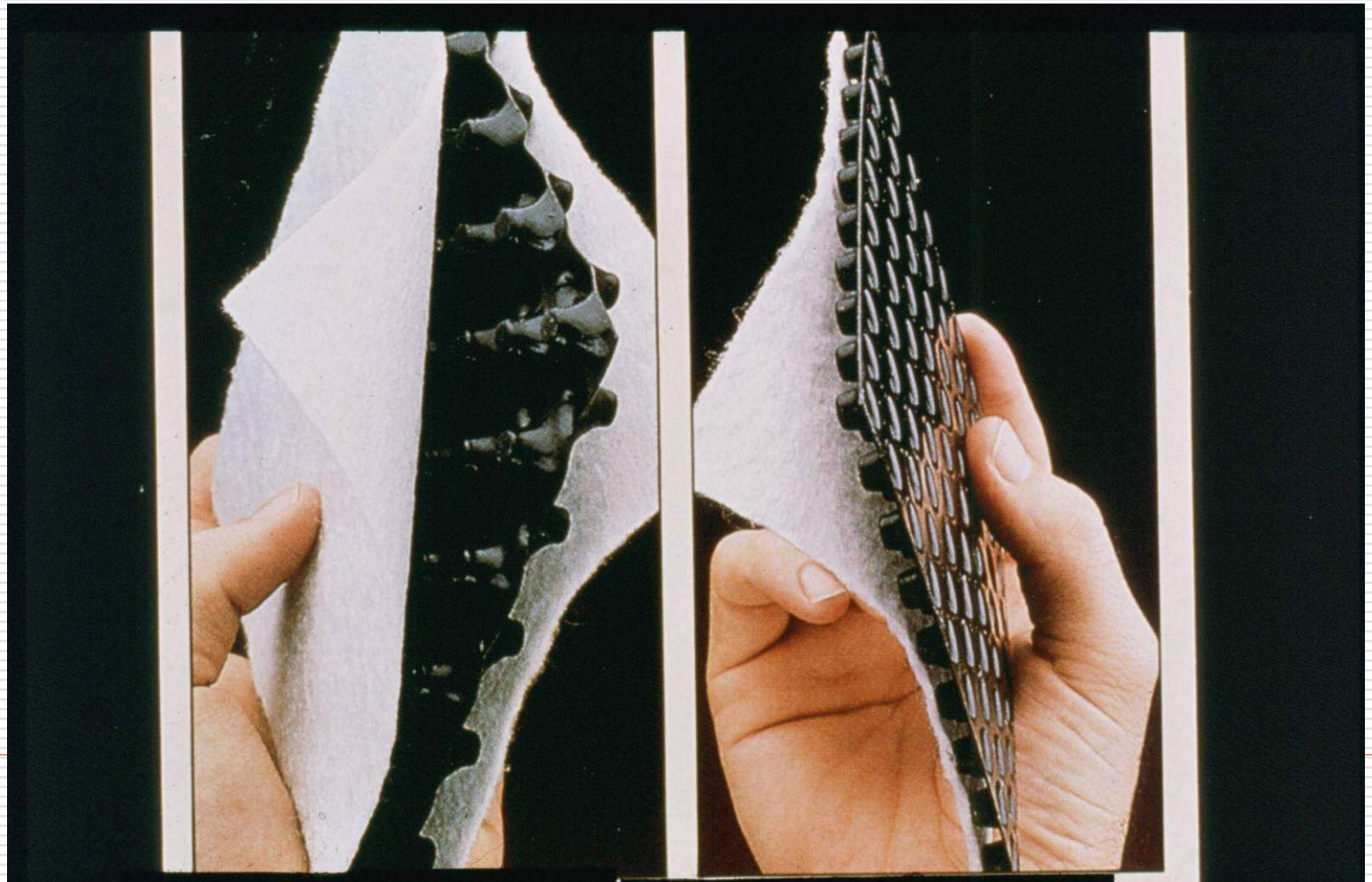
The possibility of combining the superior features of various geosynthetics has rendered a host of so called "geocomposite" materials.

Drainage Geocomposites

- Drainage geocomposites are composed of a geotextile filter surrounding either:
  - A geonet (blanket drain)
  - A thick preformed core (panel or edge drain) or
  - A thin preformed core (wick drain)

- Geocomposites can be either one-sided or two-sided, depending on whether drainage is required on one side only, or on both sides.

Double- and Single-sided Geocomposite Drains



Blanket Drains

Blanket Drains can be used as leachate or infiltration collection and removal layers within landfills or over the roadbed to enhance road base drainage.

Panel Drains

Panel Drains can be placed adjacent to structures to reduce hydrostatic pressures.

Edge Drains

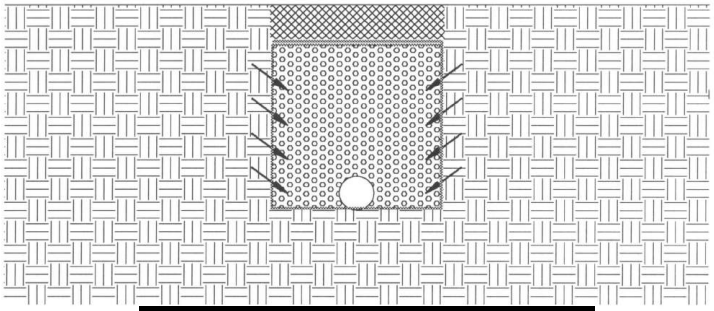
Edge Drains are often used adjacent to pavement structures to collect and remove lateral seepage from the road base.

Wick Drains

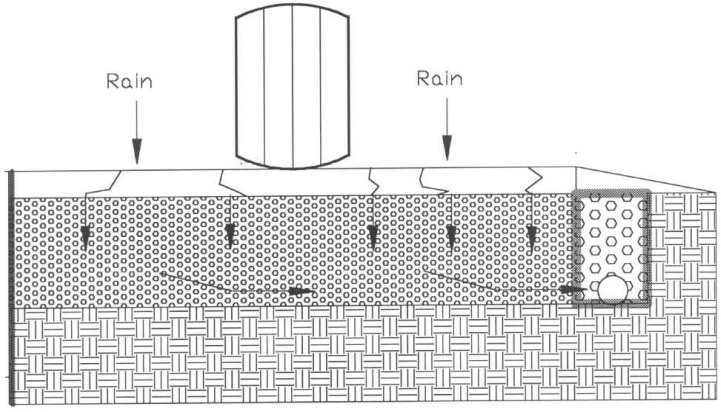
Wick Drains are pushed deep into the ground, providing drainage paths to expedite the consolidation of saturated soils, significantly decreasing the settlement time of embankments over soft soils.

Geosynthetics in Subsurface Drainage

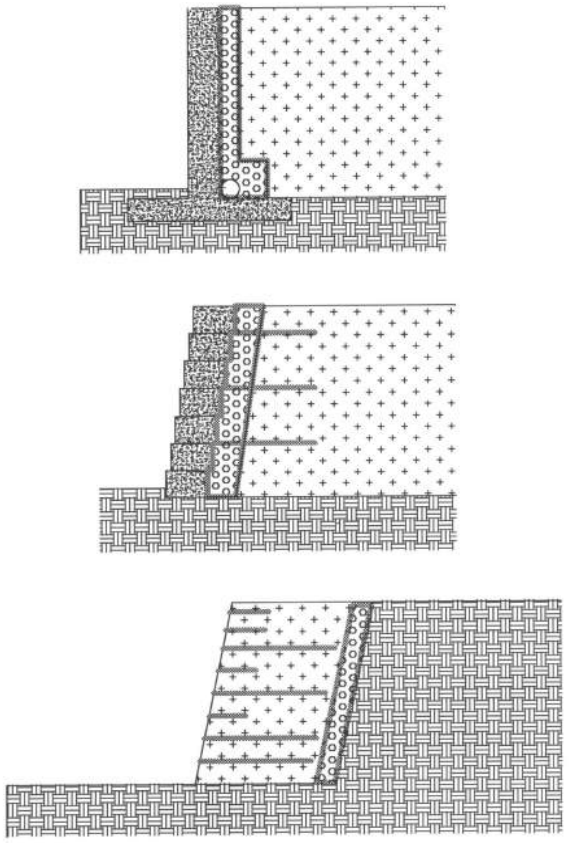
Geosynthetics enhance the performance of all types of subsurface drainage.



Subgrade Dewatering



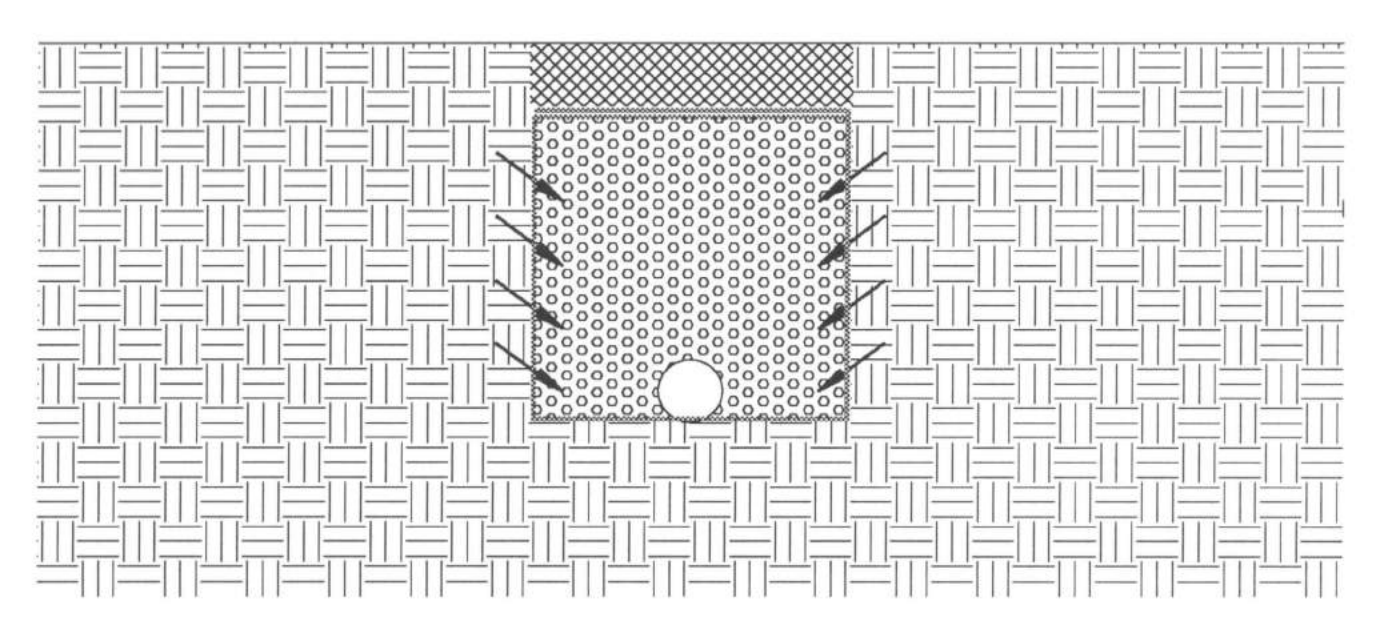
Road Base Drainage



Structure Drainage

Subgrade Dewatering

Effective subgrade dewatering requires a very porous drainage media to accept seepage and a properly graded filter to prevent piping.



Introduction to the Problem

- Many soils are considerably weaker when they have high water contents or have not been drained prior to loading.
- This means that weather-related or seasonal fluctuations in groundwater levels can adversely affect permanent structures founded on undrained soils.
- High groundwater is a threat to any construction project.

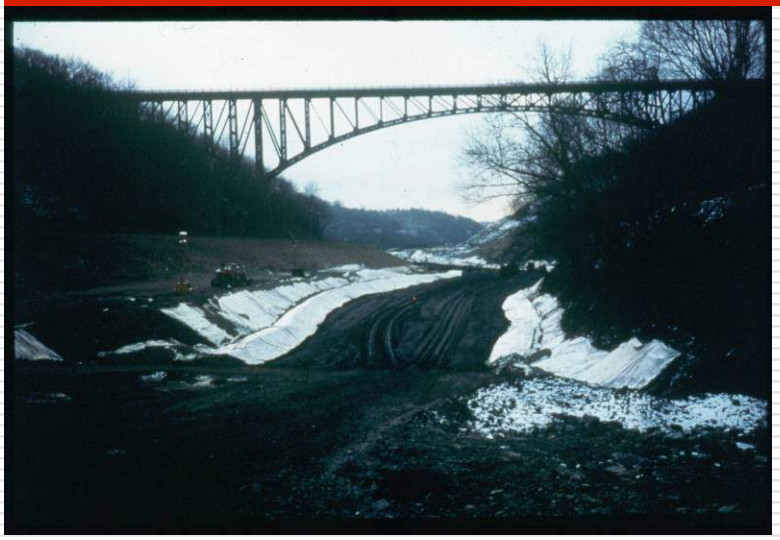
The Geosynthetic Solution

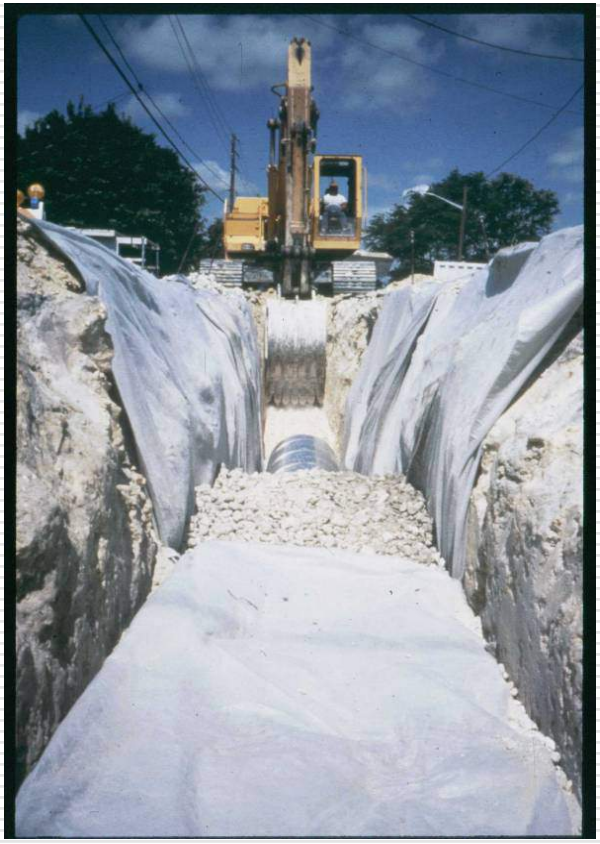
- Geotextiles are being used in lieu of select grades of sand and aggregate because they are less expensive, provide more consistent properties, and are much easier to install.

- The traditional approach to subgrade dewatering is to dig a trench to the depth to which the water table is to be lowered and filling the trench with coarse drainage stone, sometimes including a perforated pipe at the base of the trench to more efficiently transport collected seepage to an outlet.

More and more . . .

The Geosynthetic Solution





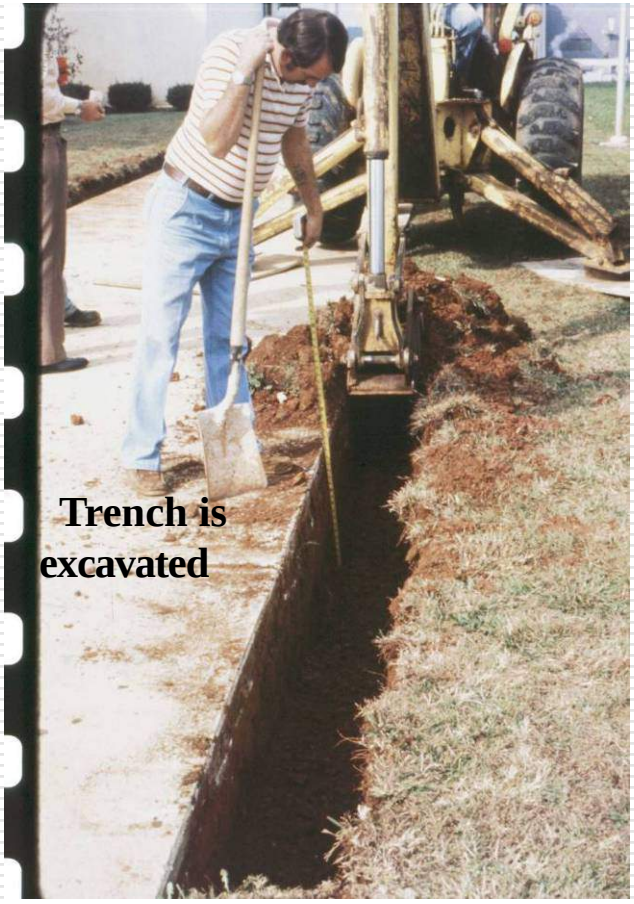
- Coarse aggregate drains must be protected by a geotextile
- A geotextile sandwiched aggregate blanket drain protects this highway fill

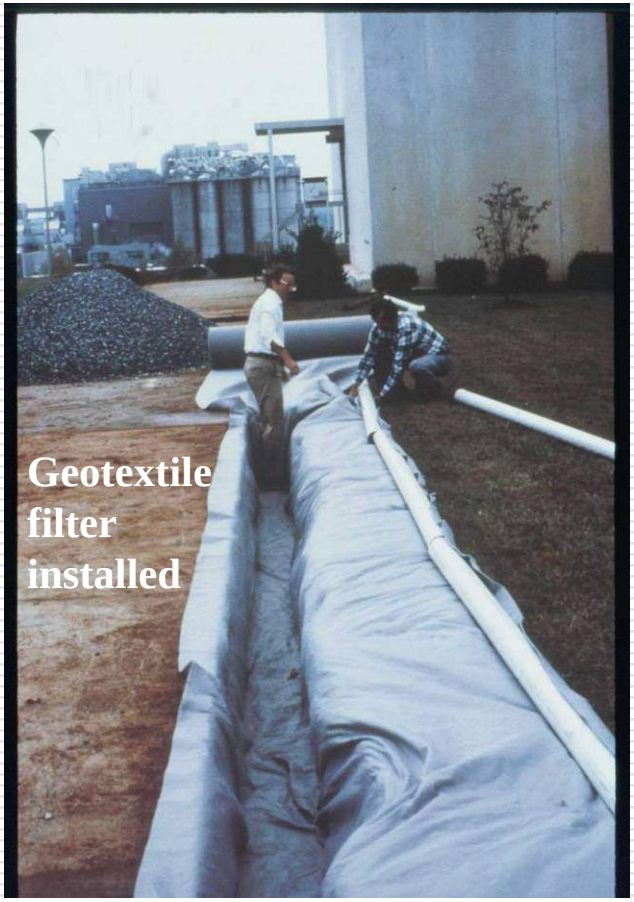
The "Complete" Geosynthetic Solution

- Sands and gravels can be costly, have variable gradations, and be costly and burdensome to install.

- A geocomposite drain incorporating a 3-dimensional plastic drainage core wrapped with a filtration geotextile overcomes all these limitations.

Installation Of Geosynthetics For Subgrade Dewatering





Installation Of Geosynthetics For Subgrade Dewatering

Placement of coarse aggregate and pipe.

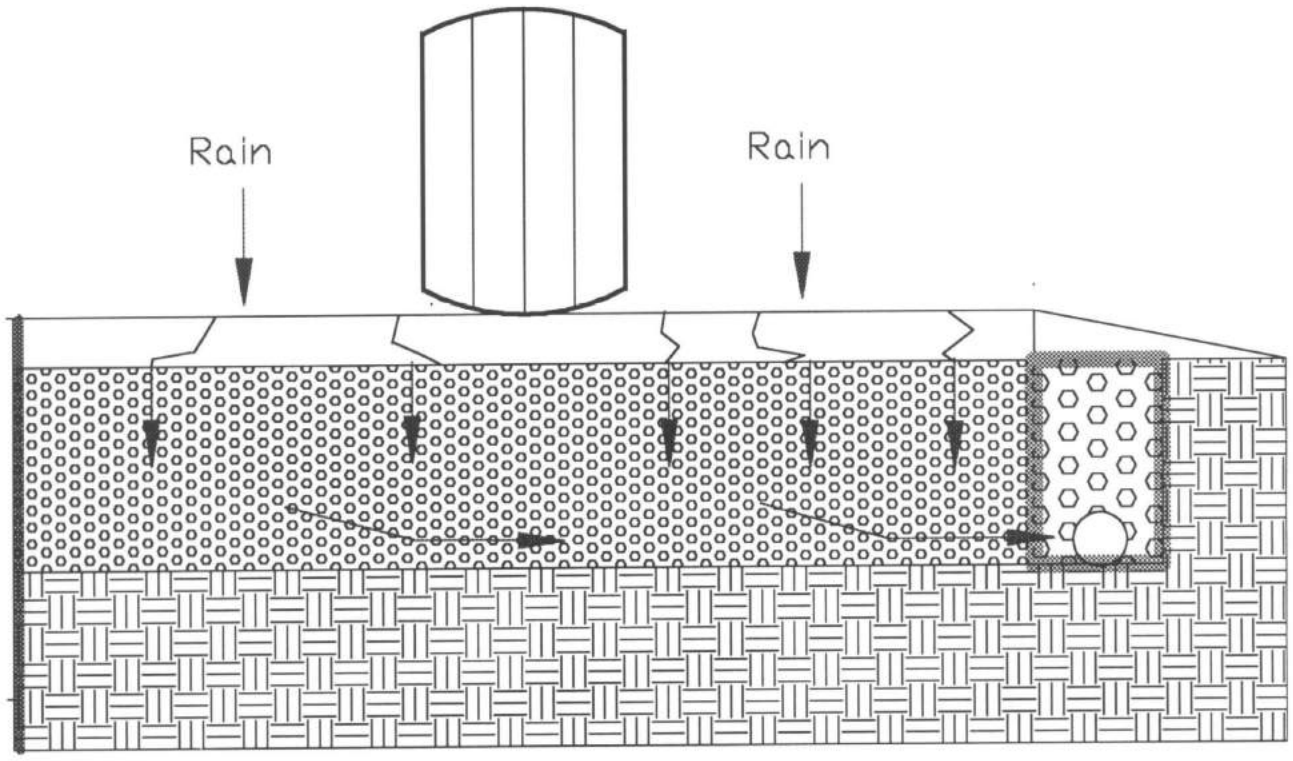
Completion of drain by wrapping the geotextile. Then backfill to grade.

Road Base Drainage

Enhanced performance has been identified for pavements having an efficient functioning edge drain system—

- ***Flexible Pavements:*** 25% increase in service life.

- ***Rigid Pavements***: 50% increase in service life.



The Benefits of Filtration Geotextiles

- Lack of positive, rapid subsurface drainage costs billions of dollars a year due to increased rates of pavement damage caused by poor drainage.

- The excellent filtration and separation characteristics associated with filtration geotextiles permits the use of a single layer of open-graded base or trench aggregate enveloped in a geotextile.

The Geosynthetic Solution

New Construction:

- The open-graded base course (below) ties into an edge drain (right).
- Both are protected by geotextiles.

Installation Of Geotextiles For Roadbase Drainage - Retrofit

The trench is “lined” with the filtration geotextile prior to pipe and aggregate placement.

Installation Of Geocomposite For Roadbase Drainage – Retrofit

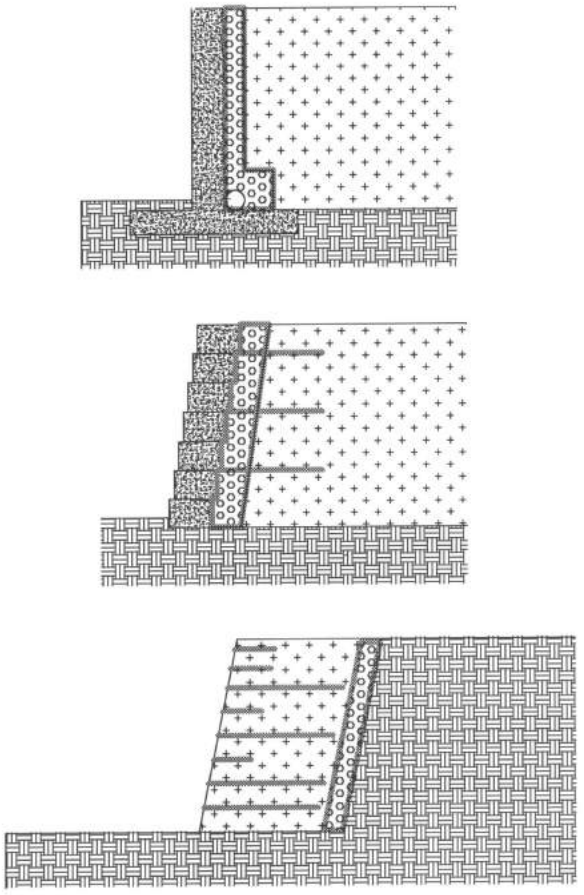
- The geocomposite drain is “inserted” into the narrow trench in a continuous process.
- The trench is completed by backfilling with sand between the geocomposite and the exposed base course.

Structure Drainage

Undrained backfill against structure walls can lead to two damaging conditions:

- Excess uplifting or overturning pressures caused by trapped water.
- Channeling of seepage and piping caused by the presence of permeable discontinuities.

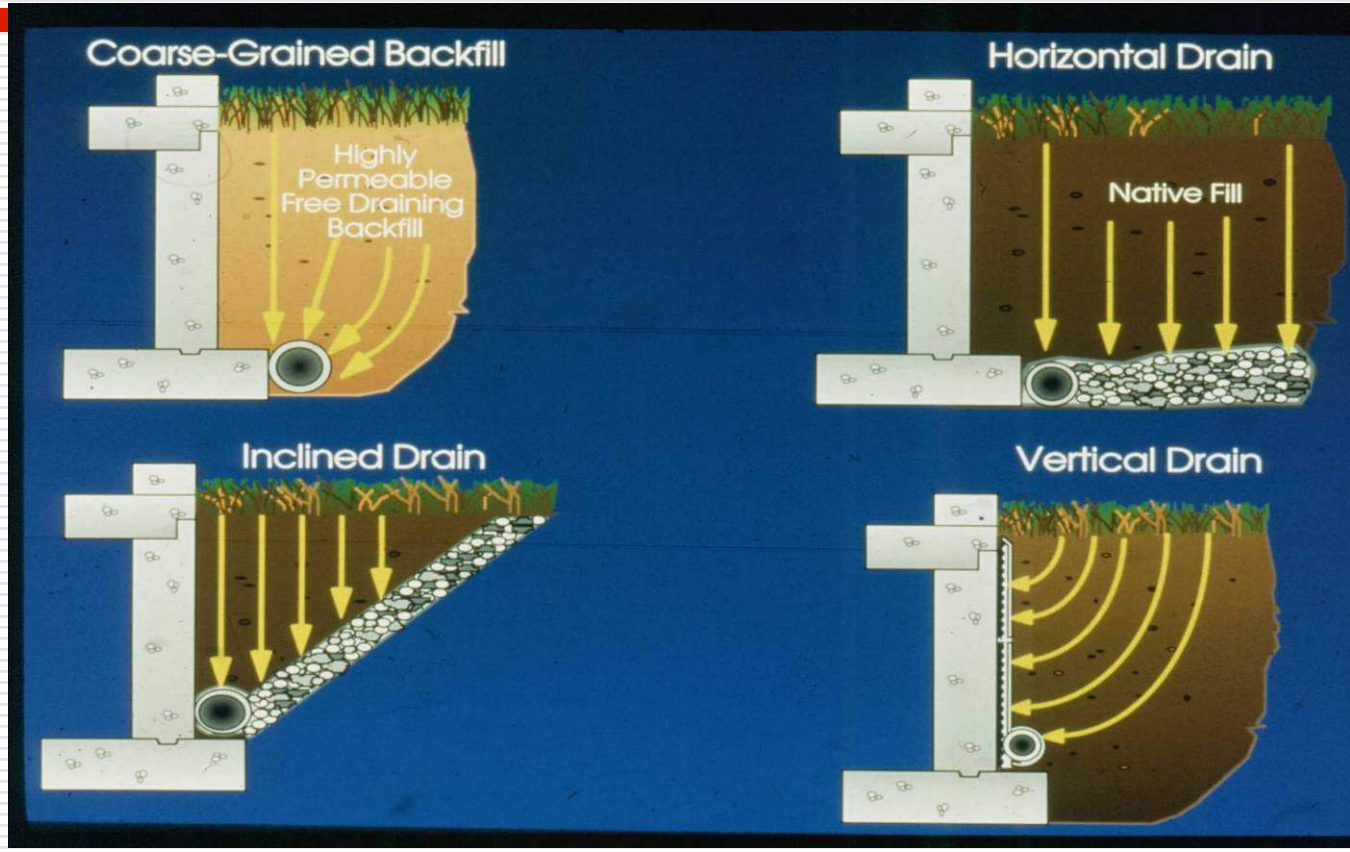
Geosynthetic drainage materials eliminate the difficulties associated with vertical gravel and sand drains and filters.



Wall Drainage Options

- It has been demonstrated that even when the back face of a wall is drained with a vertical blanket significant pore pressures can exist in the earth behind the blanket.

- This leads to increased pressure on the wall. An inclined drainage layer overcomes this deficiency by causing seepage to occur in the vertical direction.

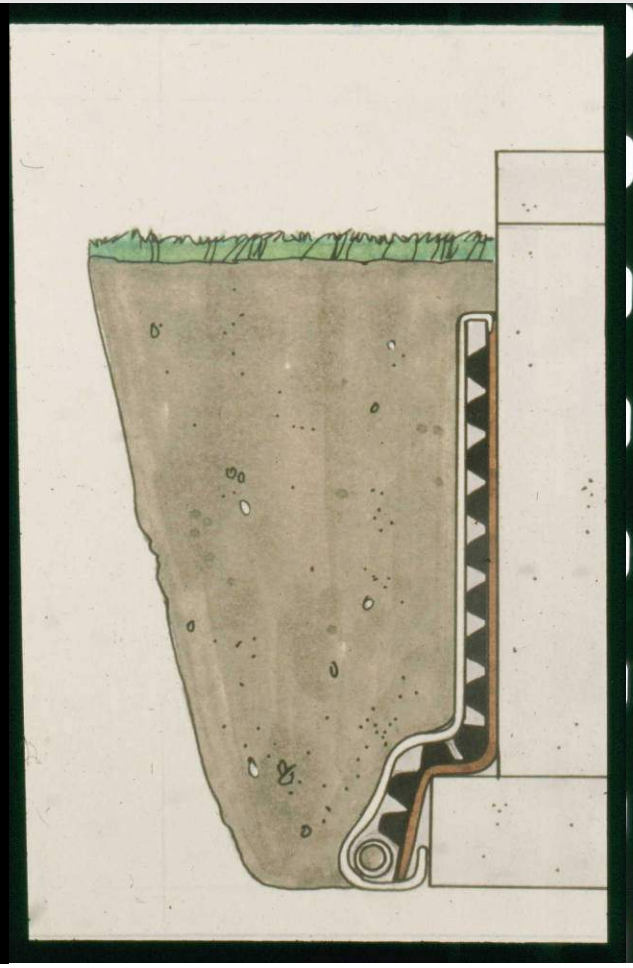


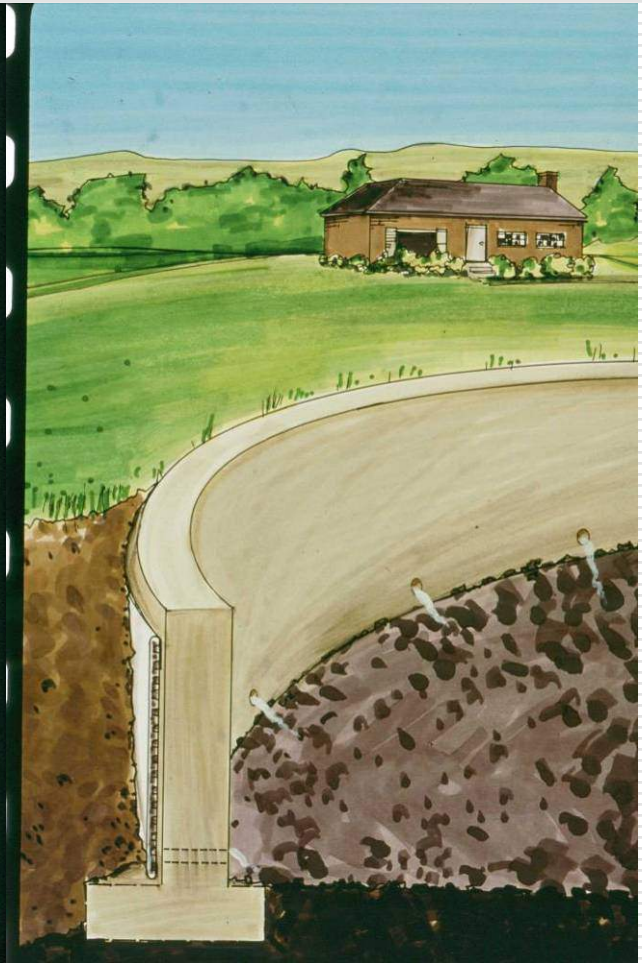
Still, whether vertical or inclined, a drainage layer is difficult to construct using sands and gravels.

The Best Drainage Option: Geocomposite Drain

- A prefabricated geocomposite drain is a complete geosynthetic alternative.

- The geocomposite drain replaces the aggregate with 3-dimensional plastic core and comes to the site already covered with the necessary filtration geotextile.





Installation of "Inclined" Drains Around Structures

- **Aggregate Drain**
  - To assure an effective aggregate drain, place a filtration geotextile on the excavated stable slope in back of the wall
  - Place a few inches of permeable crushed rock ¼ to 1 inch (6-25 mm) in size over the geotextile, and cover the rock with another layer of the filtration geotextile.

- **Geocomposite Drain**
  - Install the 2-sided drain on the excavated stable slope. As additional drain sections are added, insure that there's a positive fabric overlap.
  - Overlap panels in the direction of water flow.

Installation of Geocomposites In Vertical Applications

- In vertical applications, install the drain over the waterproofed wall with the filter fabric side away from the wall surface.
- As additional drain sections are added, insure that there's a positive fabric overlap. Overlap panels in the direction of water flow.
- If a drainpipe discharge system is used, place the bottom of the drain behind the geotextile-covered drain pipe and aggregate.
- Soil should be placed and compacted adjacent to the drain.

Installation of Geocomposites In Horizontal Applications

- In horizontal applications (e.g. plaza decks), lay the initial drain section horizontally, filter fabric side up.
- Make sure that the drain properly attaches to an outflow drain and that additional drain sections properly overlap, insuring a continuous flow path.
- Place temporary ballast atop the drain until the permanent decking is placed.

Simplified Generic Specifications For Routine Applications*

(*The specification of "critical" geosynthetic applications will generally require the input of a qualified engineering professional)

Specification Criteria:

- Construction Survivability
- In-Service Performance

- Geotextiles for routine applications are easily specified by using generic specifications such as AASHTO M288 and FHWA FP-03.
- The specifications use common geotextile properties to specify geotextiles based on empirical evidence of construction survivability and in-service performance over three decades.
- The FP-03 specifications are available for downloading at no charge at **www.wfl.fha.dot.gov/design/specs/fp03.htm.**

Simplified Generic Specifications For Routine Applications – FP03

FP-03 specifications rely on a single table for each application that addresses both survivability-related properties and in-service performance-related properties.

- **Survivability & Performance Properties**
  - **Table 714-1 – Subsurface Drainage**
  - Table 714-2 – Separation
  - Table 714-3 – Stabilization
  - Table 714-4 – Permanent Erosion Control
  - Table 714-5 – Temporary Silt Fence
  - Table 714-6 – Paving Fabric

  (All values in tables, with the exception of AOS, represent minimum average roll values in the weakest principal direction.)

FP03, Table 714-1
Subsurface Drainage Geotextile Requirements

	Test Methods	Units	Specifications[1]					
			Type I-A	Type I-B	Type I-C	Type I-D	Type I-E	Type I-F
Grab strength	ASTM D 4632	*N*	1100 / 700	1100 / 700	1100 / 700	800 / 500	800 / 500	800 / 500
Sewn seam strength	ASTM D 4632	*N*	990 / 630	990 / 630	990 / 630	720 / 450	720 / 450	720 / 450
Tear strength	ASTM D 4533	*N*	400[3] / 250	400[3] / 250	400[3] / 250	300 / 175	300 / 175	300 / 175
Puncture strength	ASTM D 4833	*N*	400 / 250	400 / 250	400 / 250	300 / 175	300 / 175	300 / 175
Burst strength	ASTM D 3786	*kPa*	2750 / 1350	2750 / 1350	2750 / 1350	2100 / 950	2100 / 950	2100 / 950
Permittivity	ASTM D 4491	sec^{-1}	0.5	0.2	0.1	0.5	0.2	0.1
Apparent opening size	ASTM D 4751	mm	0.43[2]	0.25[2]	0.22[2]	0.43[2]	0.25[2]	0.22[2]
Ultraviolet stability	ASTM D 4355	%	50% retained strength after 500 hours exposure					

(1) The first values in a column apply to geotextiles that break at < 50 percent elongation (ASTM D 4632). The second values in a column apply to geotextiles that break at ≥ 50 percent elongation (ASTM D 4632).

(2) Maximum average roll value.

(3) The minimum average tear strength for woven monofilament geotextile is 245 N.

FP03, Table 714-1 provides both survivability and performance properties for geotextiles used in subsurface drainage. M288 can be used to guide the specification of the appropriate geotextile type. Yellow designates the equivalent of the M288 specification selected.

Subsurface Drainage Geotextile Types

Survivability

- Default geotextile selection is Type IA, B, or C. Engineer may specify a Type ID, E or F geotextile based on one or more of the following:
  - Engineer has found Type ID, E, or F geotextiles to have sufficient survivability based on field experience.
  - Engineer has found Type ID, E, or F geotextiles to have sufficient survivability based on laboratory testing and visual inspection of a geotextile sample removed from a field test section constructed under anticipated field conditions.
  - Subsurface drain depth is less than 2 m; drain aggregate diameter is less than 30 mm; and compaction requirement is less than 95% of T 99.

Subsurface Drainage Geotextile Types

In-Service Performance: These default filtration property values are based on grain size analysis of *in situ* soil in accordance with T 88.

- If the percent passing the 0.075mm sieve is < 15, use Type IA or ID.
- If the percent passing the 0.075mm sieve is between 15 and 50, use Type IB or IE.
- If the percent passing the 0.075mm sieve is > 50, use Type IC or IF.

In addition to the default permittivity value, the engineer may require geotextile permeability and/or performance testing based on engineering design for drainage systems in problematic soil environments.

- Site-specific geotextile design should be performed if one or more of the following problematic soil environments are encountered: Unstable or highly erodible soils such as non-cohesive silts; gap graded soils; alternating sand/silt laminated soils; dispersive clays; and/or rock flour.
- For cohesive soils with a plasticity index greater than seven, geotextile maximum average roll value for apparent opening size is 0.30 mm.

Questions

THINK

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Thank You!

For more information go to www.gmanow.com