Module 5 Erosion & Sediment Control

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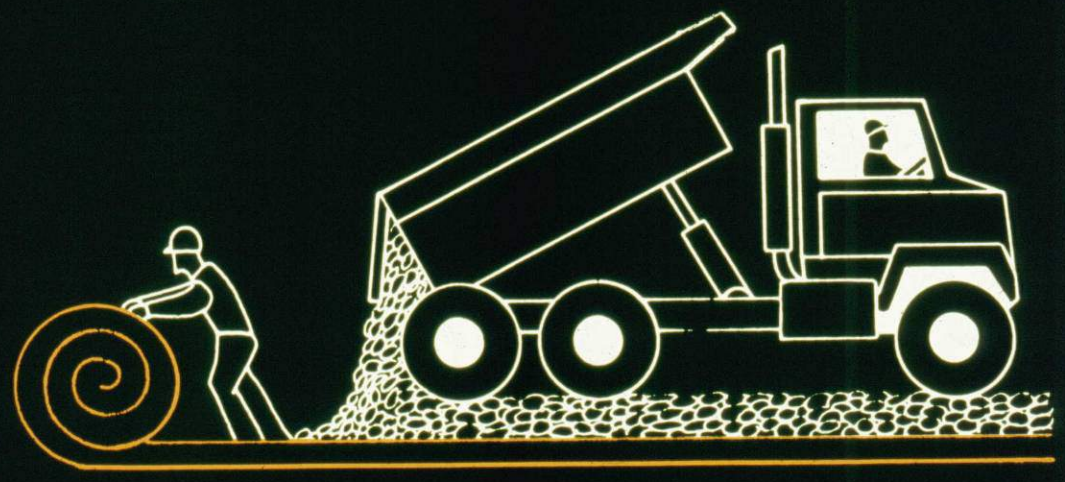
In 2007 Geosynthetics magazine (formerly GFR) enters its 25th year of publication.

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:

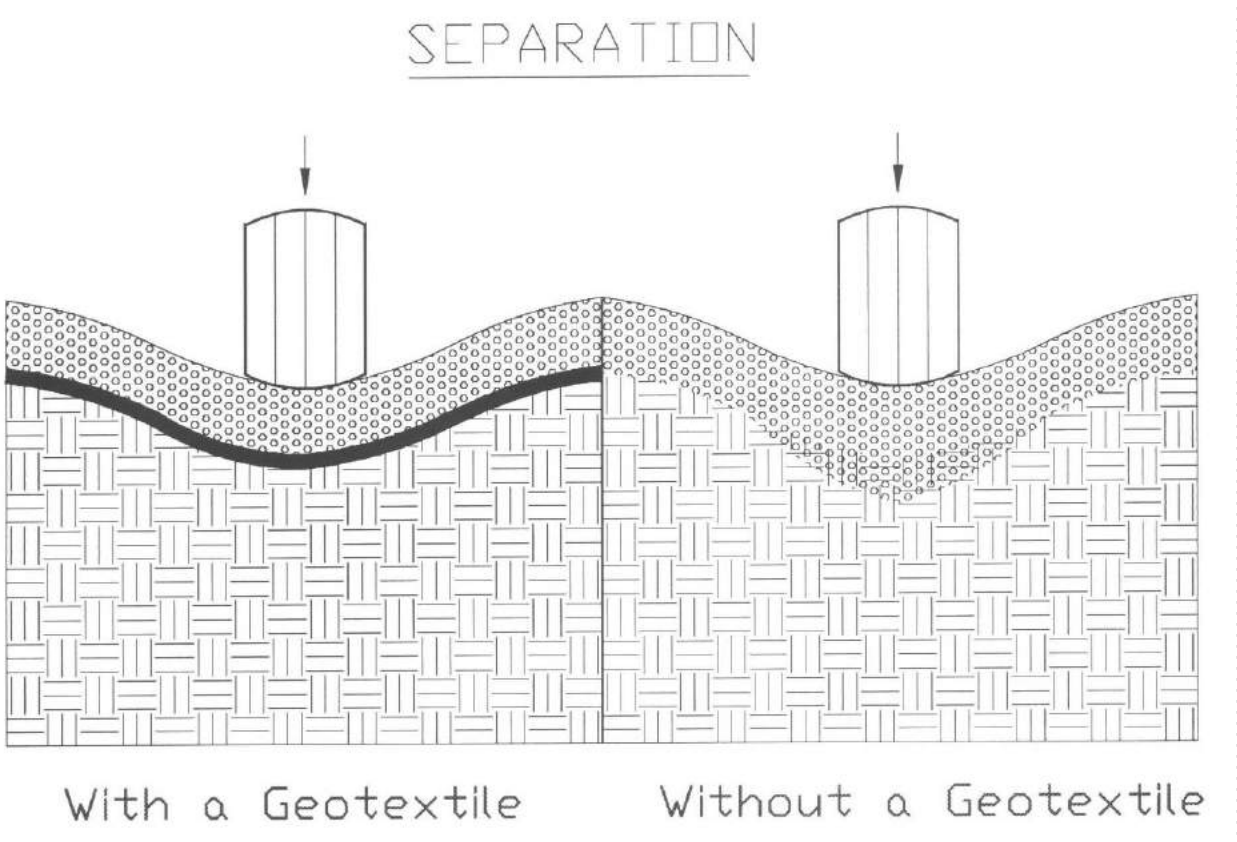
- Geotextiles
- Geomembranes
- Geonets
- Geogrids
- Geocomposites
- Geosynthetic clay liners

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

Geosynthetic Separator

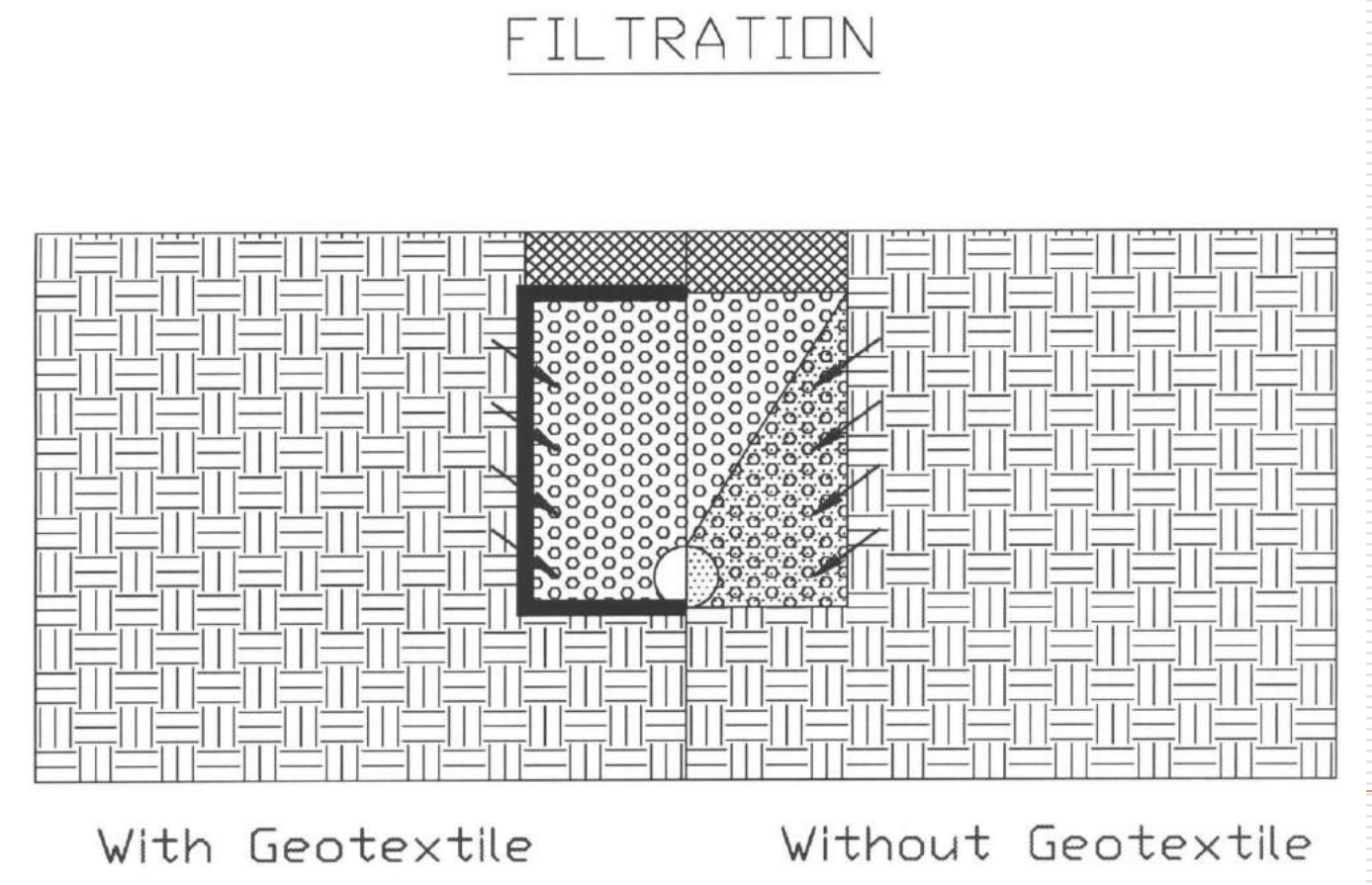
Geosynthetics can perform numerous functions, including the separation function.

In roadways, a separator keeps the base aggregate and the subgrade from mixing.



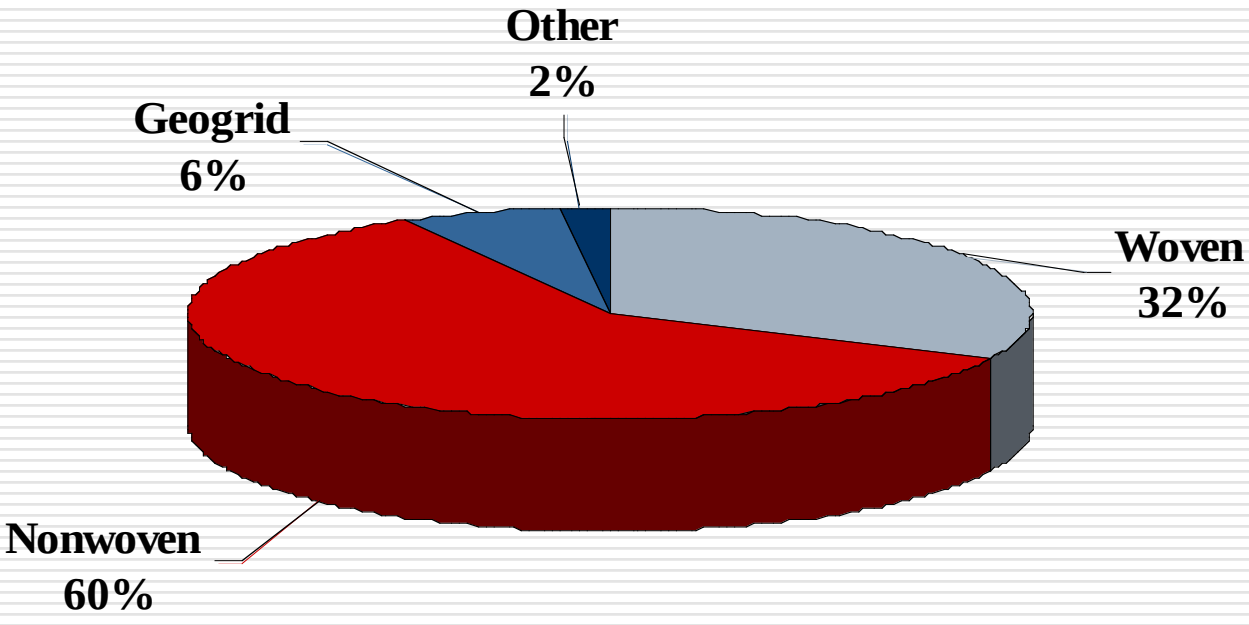
Geosynthetic Filter

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



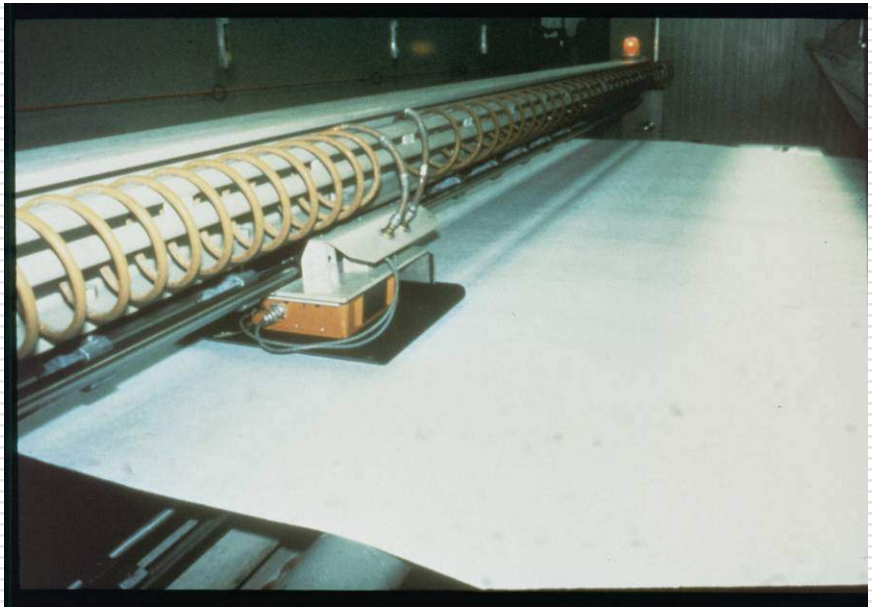
Geosynthetic Categories

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

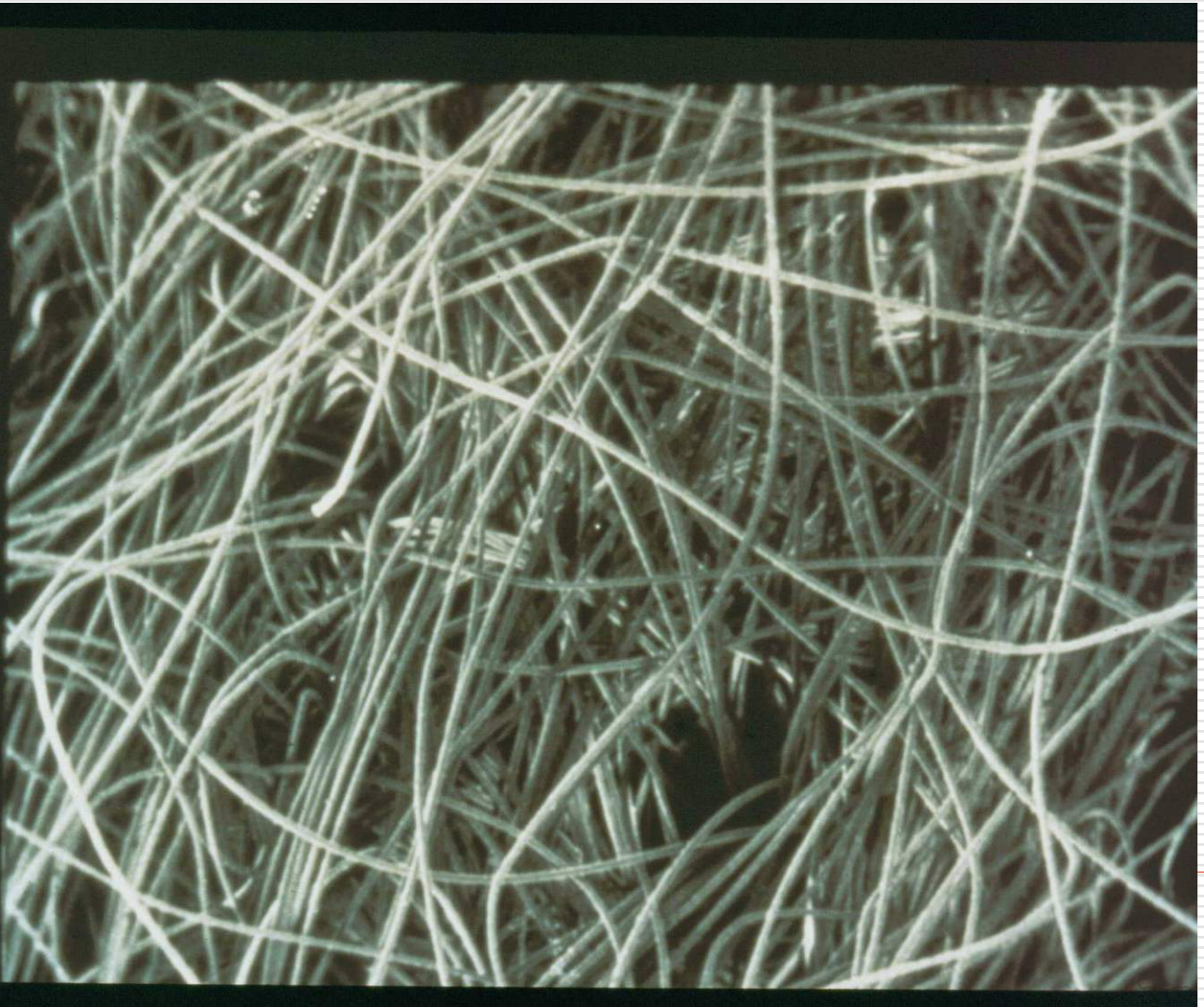
- Nonwoven
- Woven
- Other
  - Knitted
  - Stitch bonded

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.

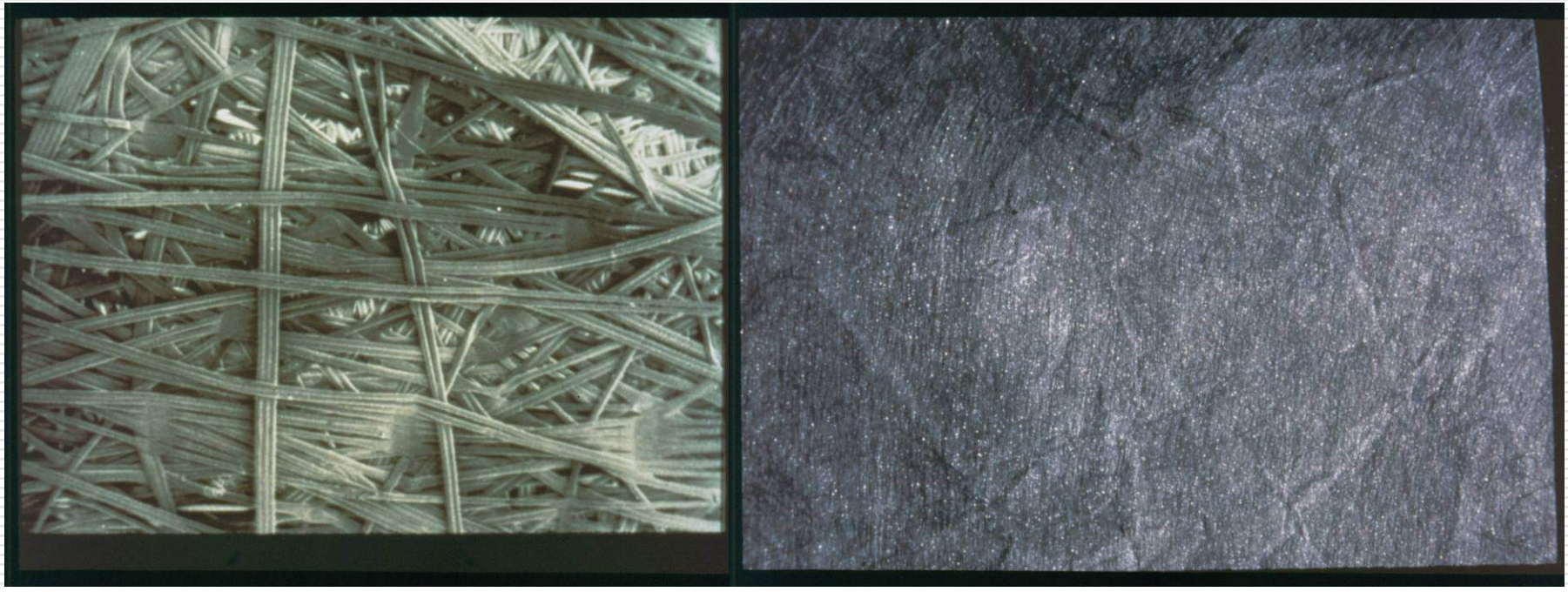
Needle-punched Nonwoven Geotextiles



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

Heatbonded Nonwoven Geotextiles

Heat-bonded nonwovens are thinner and have greater stiffness.

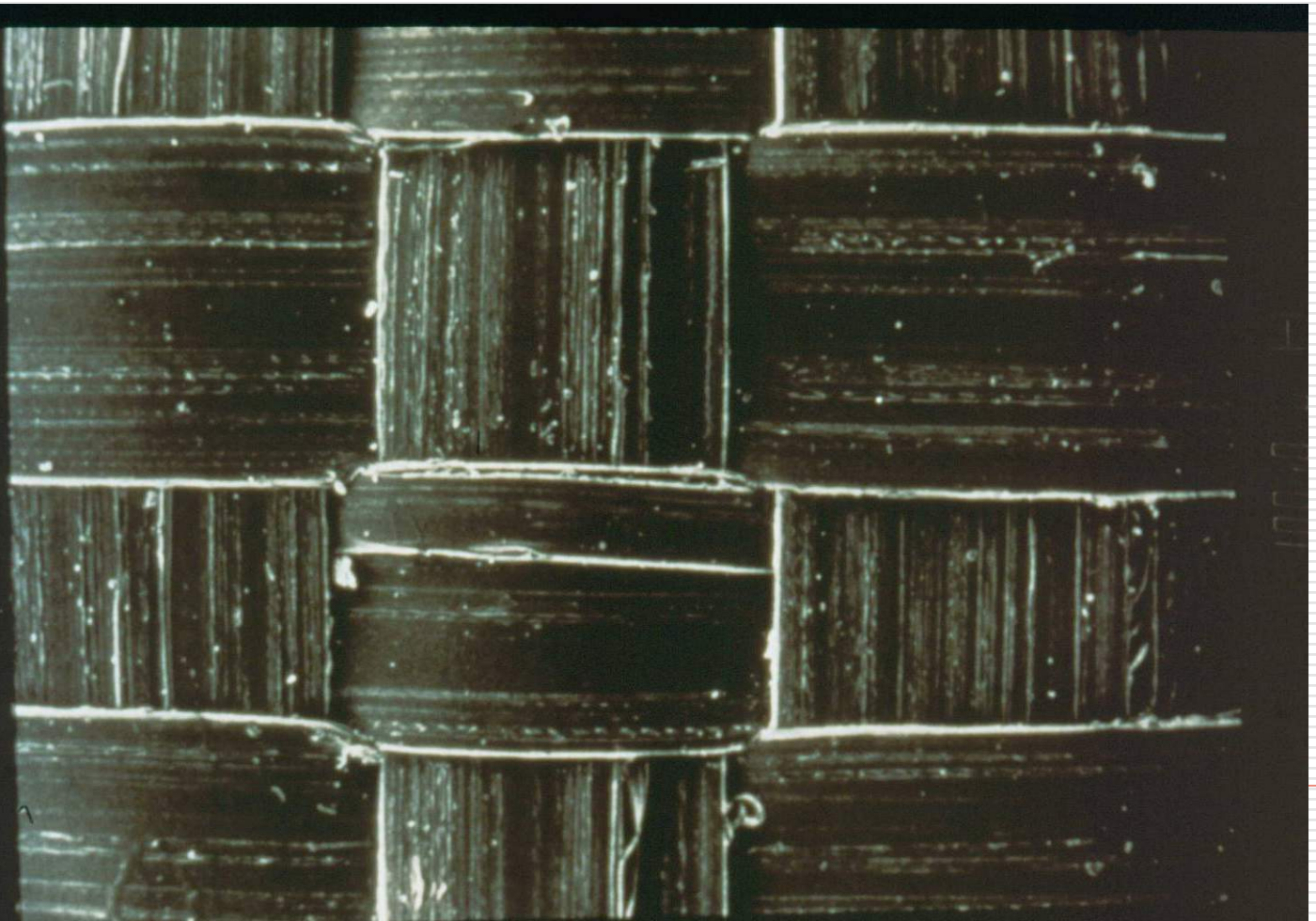


Wovens

- 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



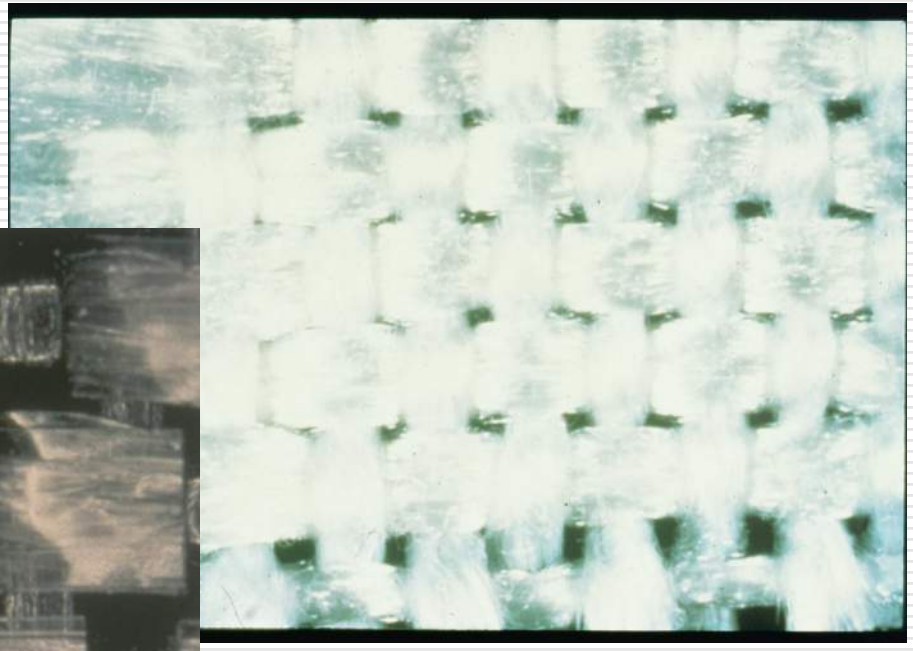
Slit film woven geotextiles provide economical separation of materials.

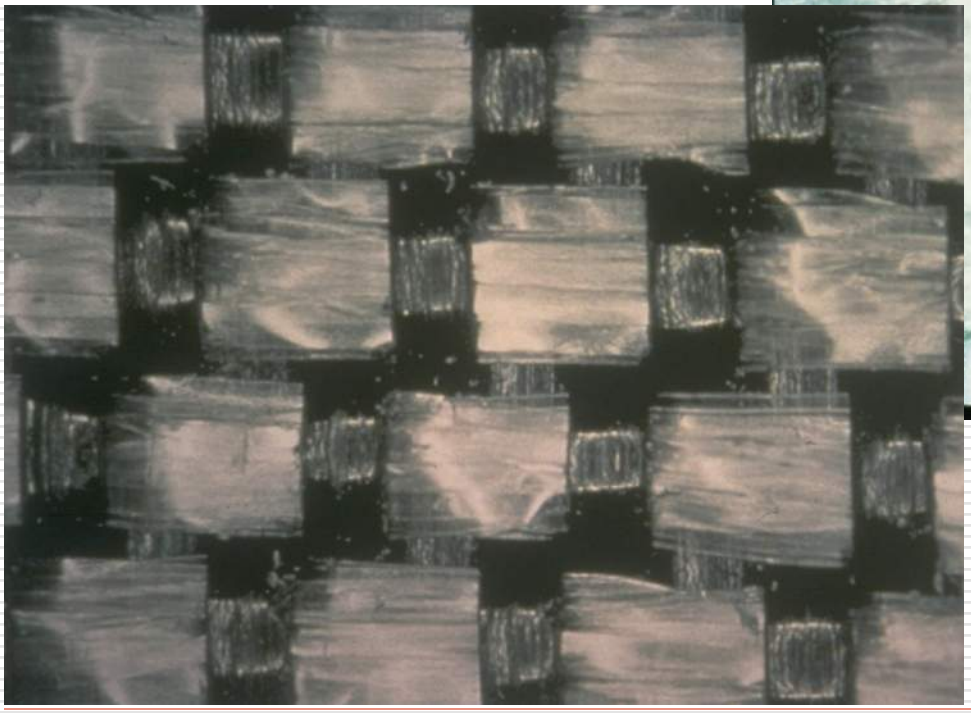
Monofilament Woven Geotextiles

Monofilament woven geotextiles provide enhanced filtration properties.

Fibrillated and Multifilament Woven Geotextiles

Multifilament woven geotextiles provide enhanced tensile strength.





Erosion Control
Nets, Meshes & Blankets

Open weave meshes (left) and blankets (right) can provide dependable, temporary erosion protection while nurturing vegetation establishment.

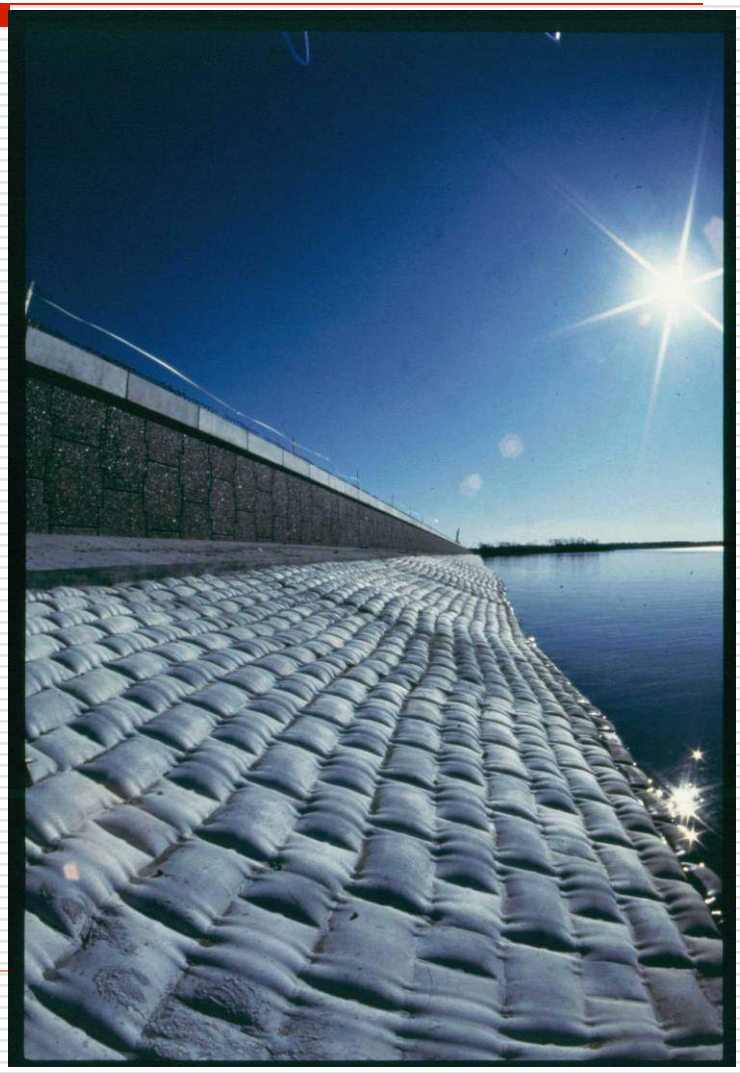
Turf Reinforcement Mats

These flexible, synthetic, 3-dimensional mats are designed to be used in conjunction with topsoil and seed or turf to create strong, durable and continuous soil-root-mat matrices which can provide nearly twice the erosion protection of plain grass alone.

Fabric Formed Revetments

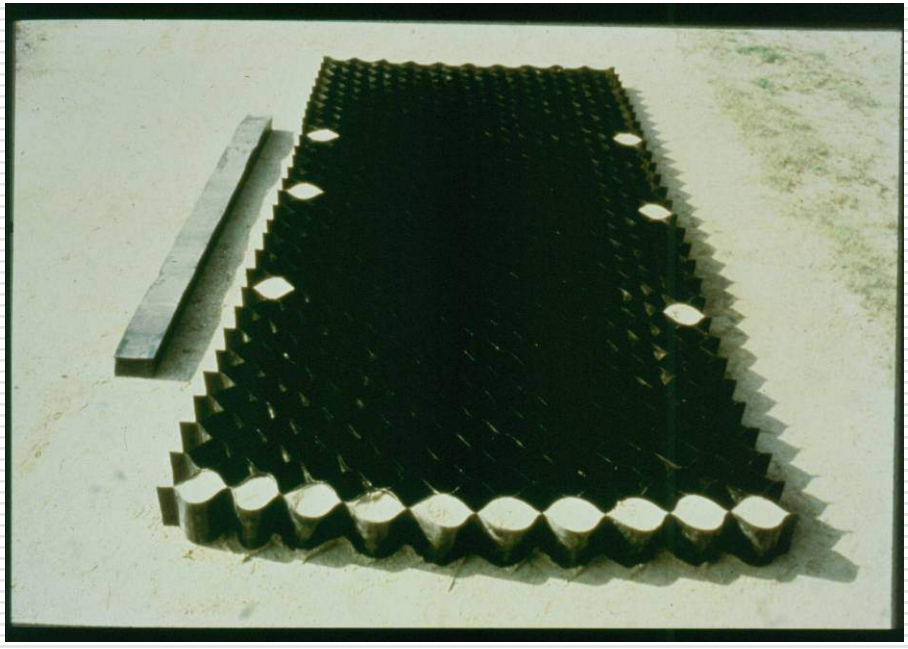
- Fabric formed revetments (FFR) are constructed by pumping a very fluid fine-aggregate grout into a fabric envelope consisting of 2 layers connected by tie-chords or by interweaving.

- FFRs provide the durability of rigid linings, such as cast-in-place concrete.



Geocellular Confinement Systems

Geocellular confinement systems (GCS) are 3-dimensional honeycomb-like structures filled with soil, rock or concrete.



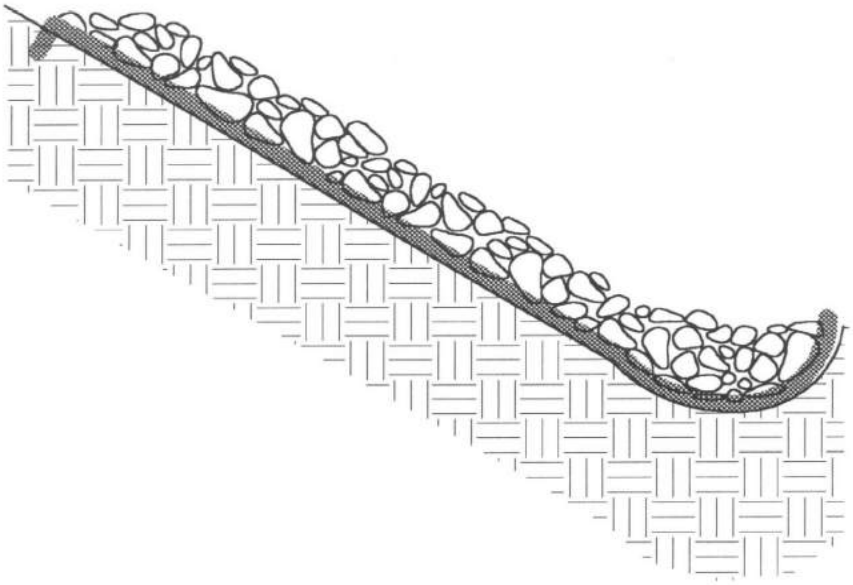
Silt Fence

A well-designed silt fence is made of a durable geotextile attached to support posts with the bottom edge securely buried.

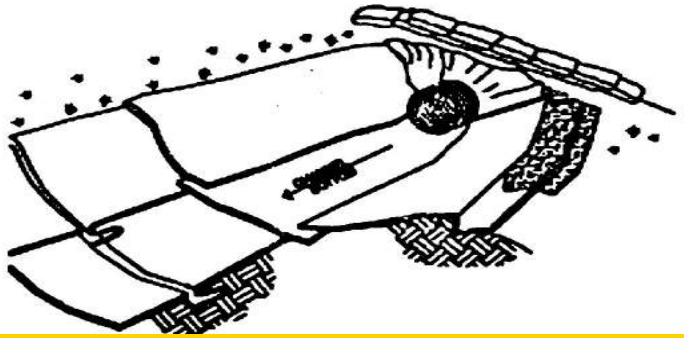
Turbidity Curtains

Reusable floating geosynthetic panels that prevent sediment from shore-side construction or off-shore filling and dredging operations from moving off-site.

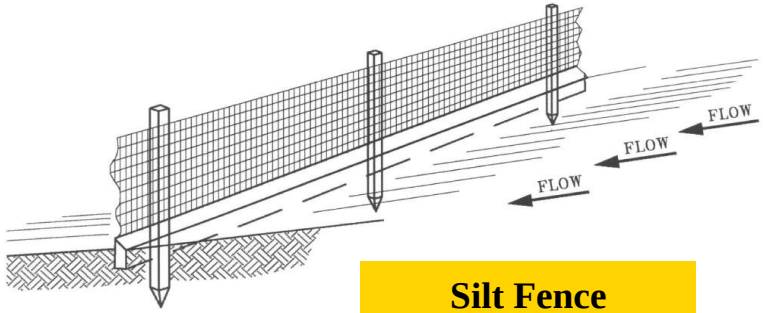
Geosynthetics In Erosion & Sediment Control



Hard Armor Systems



Rolled Erosion Control Products, RECPs

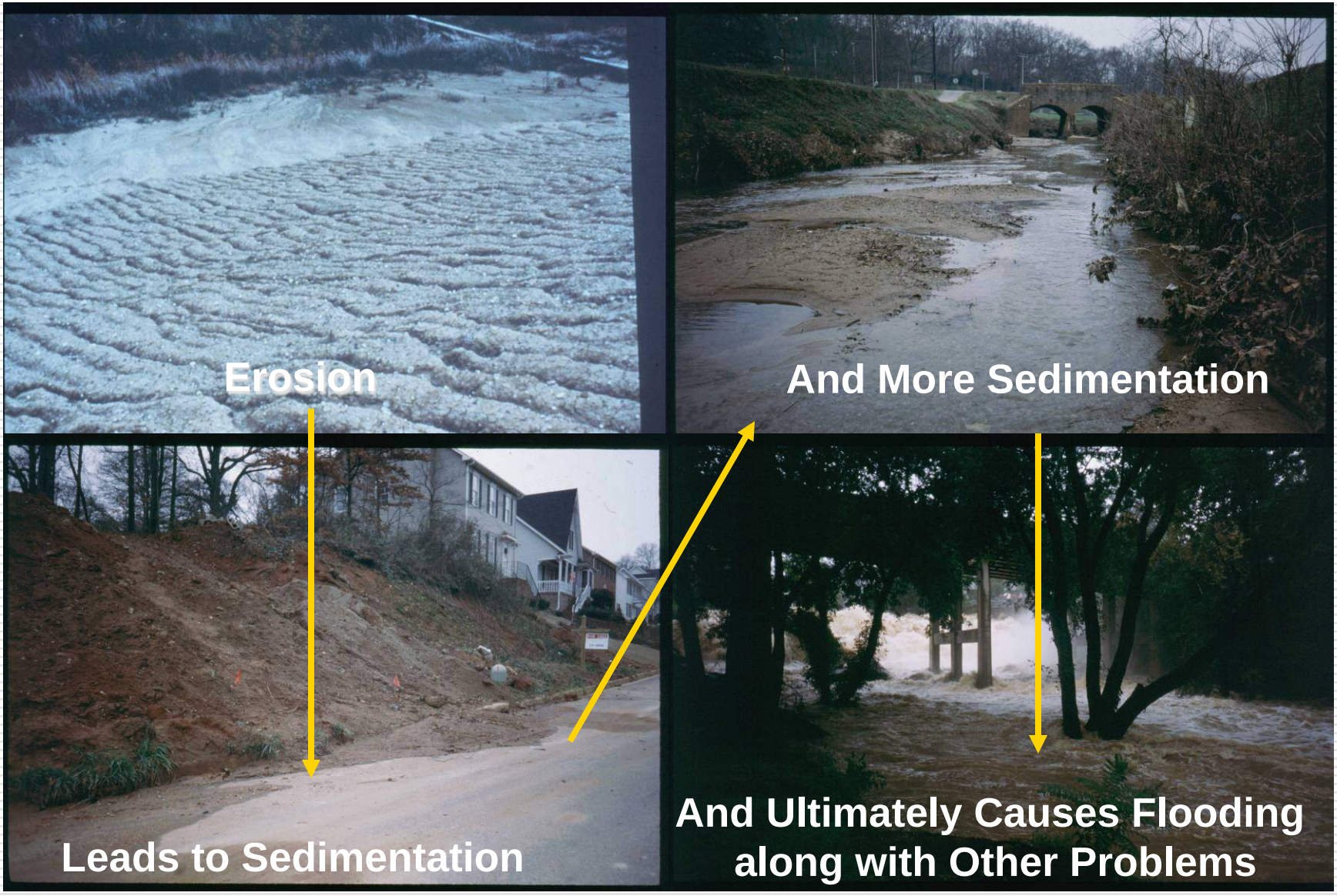


Silt Fence

- **Erosion** occurs when soil particles are displaced due to the impact of raindrops, moving water or wind.

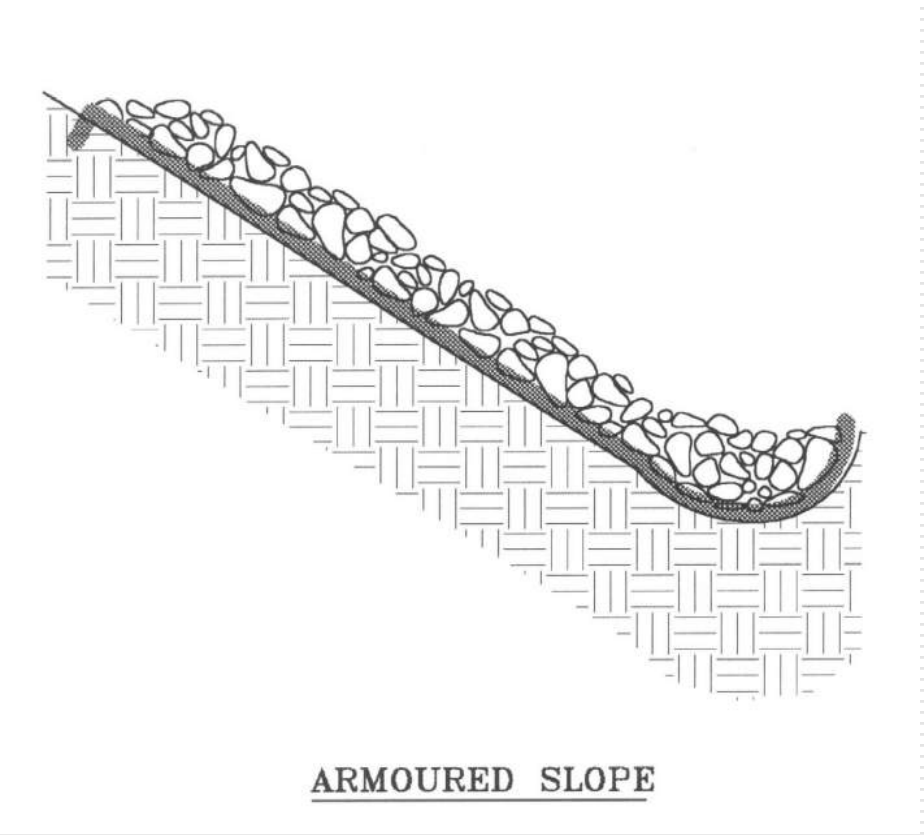
- **Sedimentation** occurs when eroded particles (sediments), carried by water or wind, are deposited in another location where they can cause problems. Thus, erosion and sediment controls are used together to minimize environmental impacts.

Negative Effects Of Erosion



Hard Armor Systems

Soil slopes and channels exposed to constant concentrated flows, currents, or waves cannot support vegetation; so they must be protected from erosion by a properly constructed hard armor systems.



Introduction to the Problem

- When a hard armor system is in place, water can seep in and out of the slope or channel, but the force of the water is resisted by the armor.

- As the water seeps, it can gradually carry soil particles with it. The resulting voids cause armor support to be lost over time.

- This process is called *piping*.

An Undermined Hard Armor System

Typical Problems

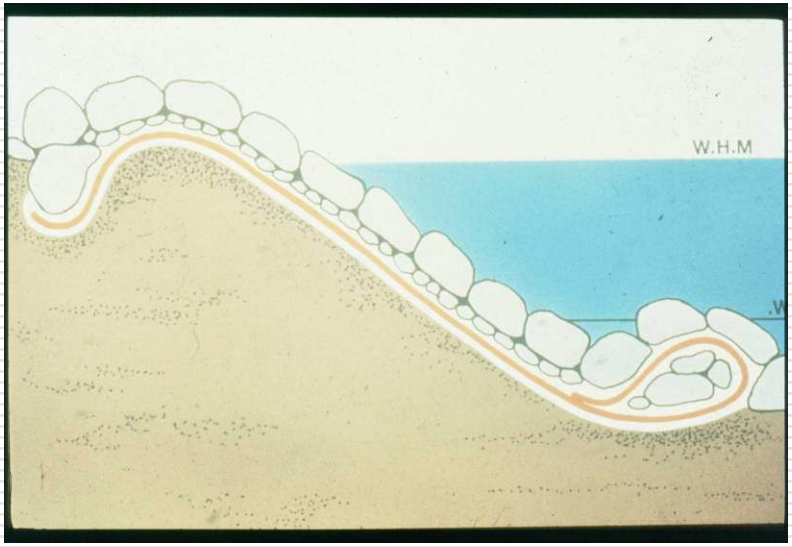
- A properly constructed armor system includes a filter layer placed between the bank soil and the armor to prevent piping.
- Traditional filter layers have been graded sand and aggregate layers. These graded filters are very costly to construct because they are constructed of select graded materials. Also, the filter layer must be a controlled thickness.
- On a steep slope, it can be very difficult to properly construct.
- For these two reasons, filter layers are often – and mistakenly - not included.

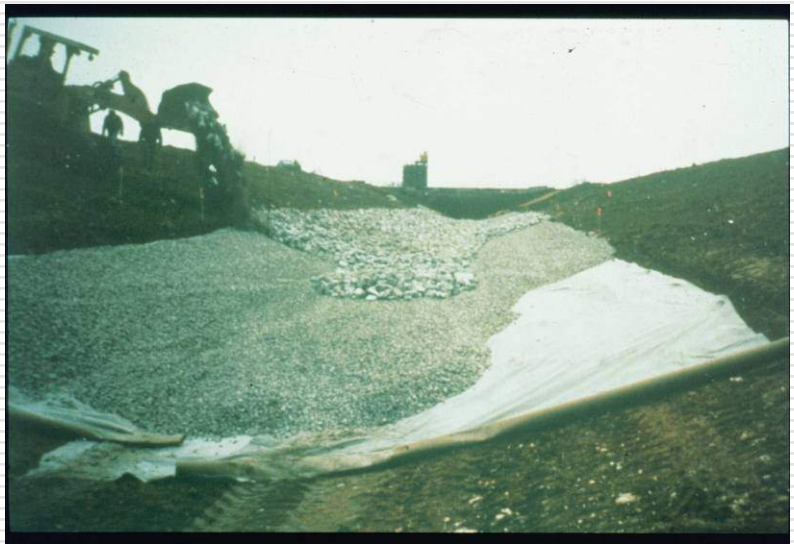
The Solution

- Geotextiles overcome the drawbacks of graded sand and aggregate filters.
- First, they are manufactured with specific hydraulic and soil retention properties, which can be easily selected to complement the soil that needs protection.
- Secondly, they can be installed with ease on slopes – even under water.

The Geotextile Solution

A hard armor system is properly constructed when it includes a filter geotextile.

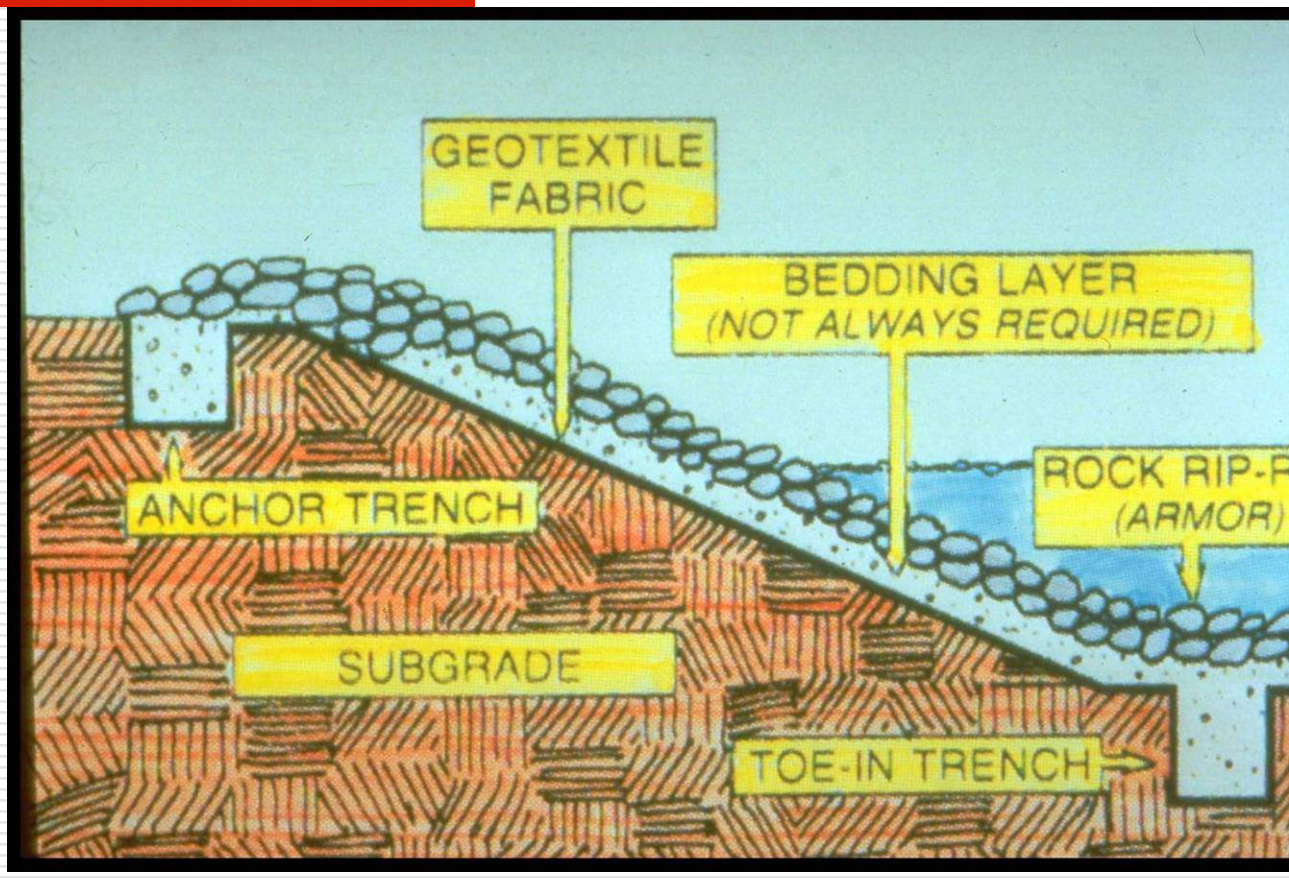




Installation Of Geotextiles Under Hard Armor

Proper hard armor construction includes:

- Site preparation
- Deployment of the geotextile
- Placement of the armor layer



Shoreline Protection - riprap with Geotextile

Site Prep & Geotextile Deployment

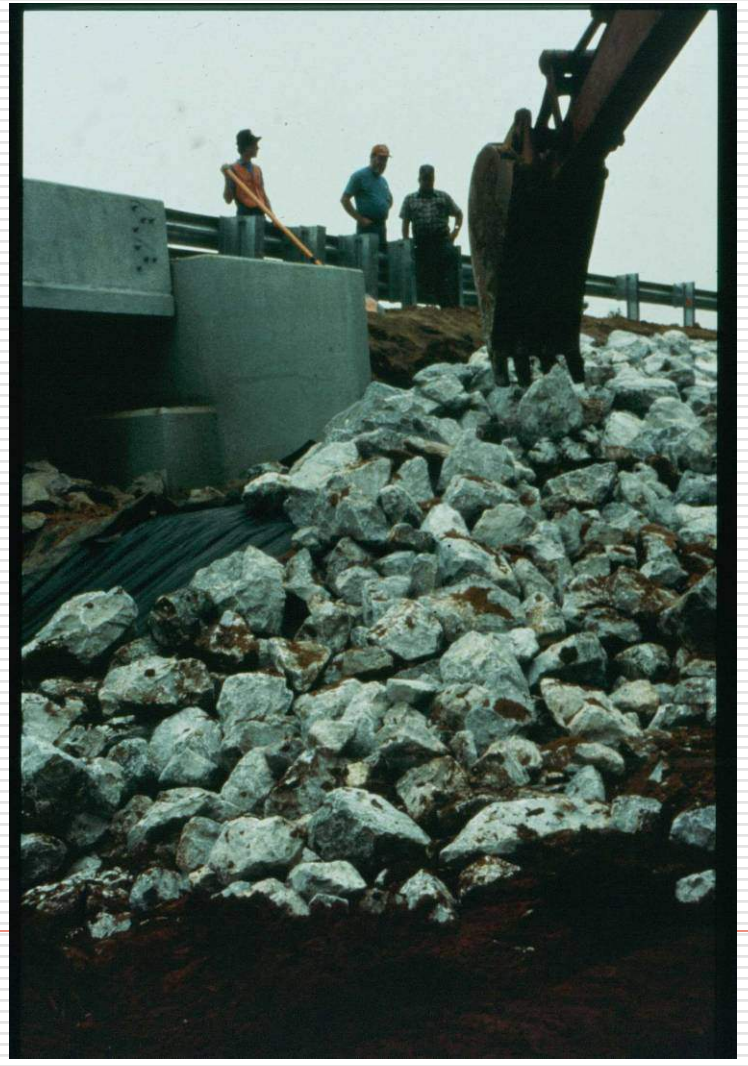
- The slope or channel should be graded smoothly and compacted, if possible.

- Unroll the geotextile on the prepared soil. The geotextile should be placed parallel to small ditch and stream alignments and perpendicular to lake or ocean shores. This alignment minimizes the exposure of the geotextile to current or wave uplift.

- Overlap the geotextile a minimum of 1.5 ft (0.5 m) in order to provide continuous erosion protection. Secure the geotextile in place using 6-18 in (15-45 cm) pins or staples, fill material or rocks.

Placement Of The Armor Layer

The armor, such as riprap or concrete blocks, should be placed in accordance with accepted practices.



Placing armor stone on a woven geotextile.

Placement Of The Armor Layer

Placing armor stone on a nonwoven geotextile

Placement Of The Armor Layer

Concrete block systems must also be protected by a geotextile filter layer.

Placement Of The Armor Layer

- The drop height should be held to a minimum, and care must be exercised to avoid damage to the geotextile.

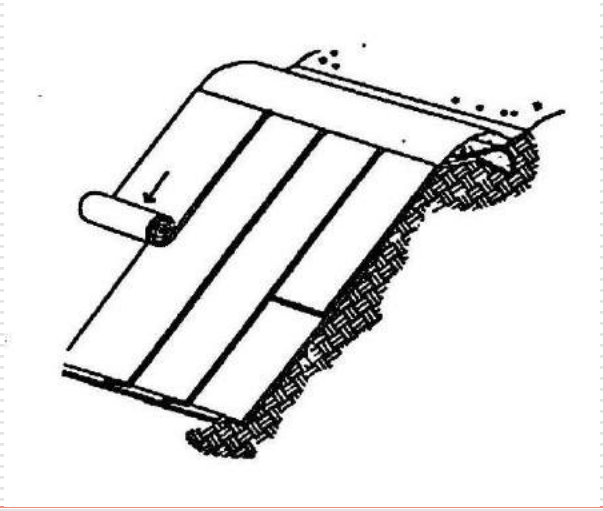
- If a drop height greater than 3 feet is anticipated, a heavier, more durable geotextile will be required.

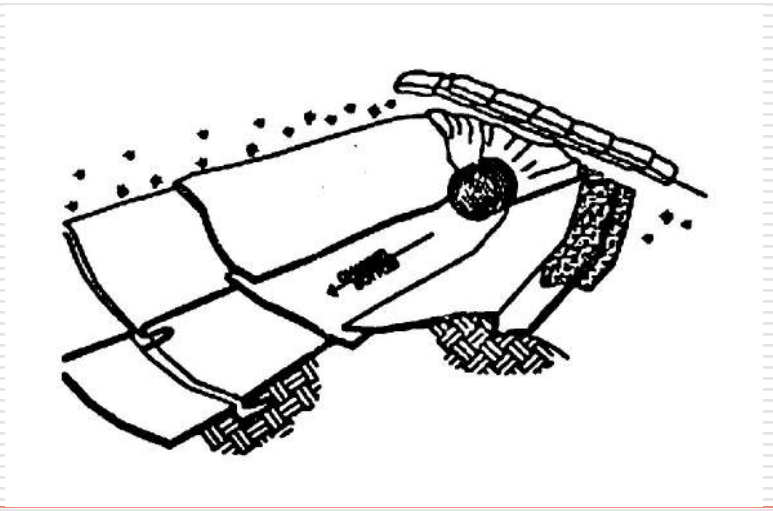
Excessive Drop Height / Damage

Rolled Erosion Control Products (RECPs)

- Temporary, degradable RECPs are used to prevent loss of soil from the seedbed and to enhance the establishment of vegetation where the vegetation alone should provide sufficient site protection once established.

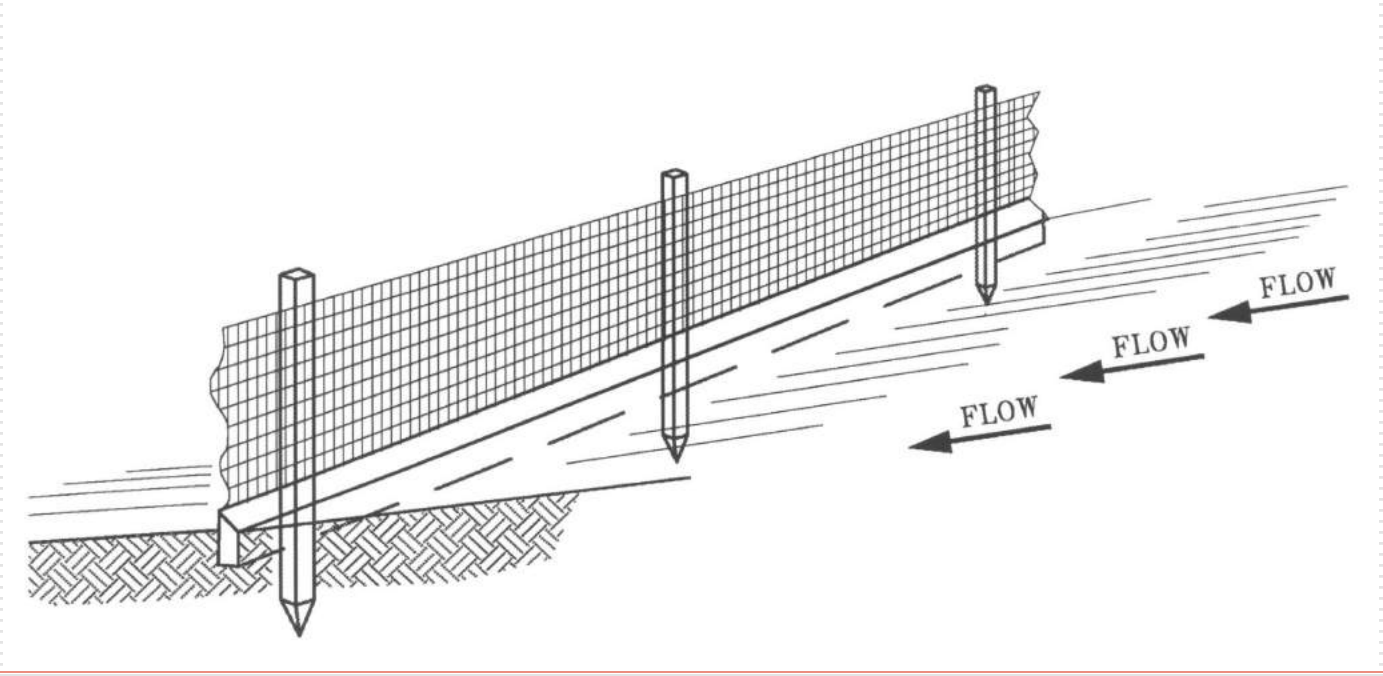
- Long-term, nondegradable RECPs, often called turf reinforcement mats (TRMs), furnish erosion protection and extend the erosion control limits of vegetation, soil, rock, or other materials. More on these materials can be found at **www.ectc.org.**



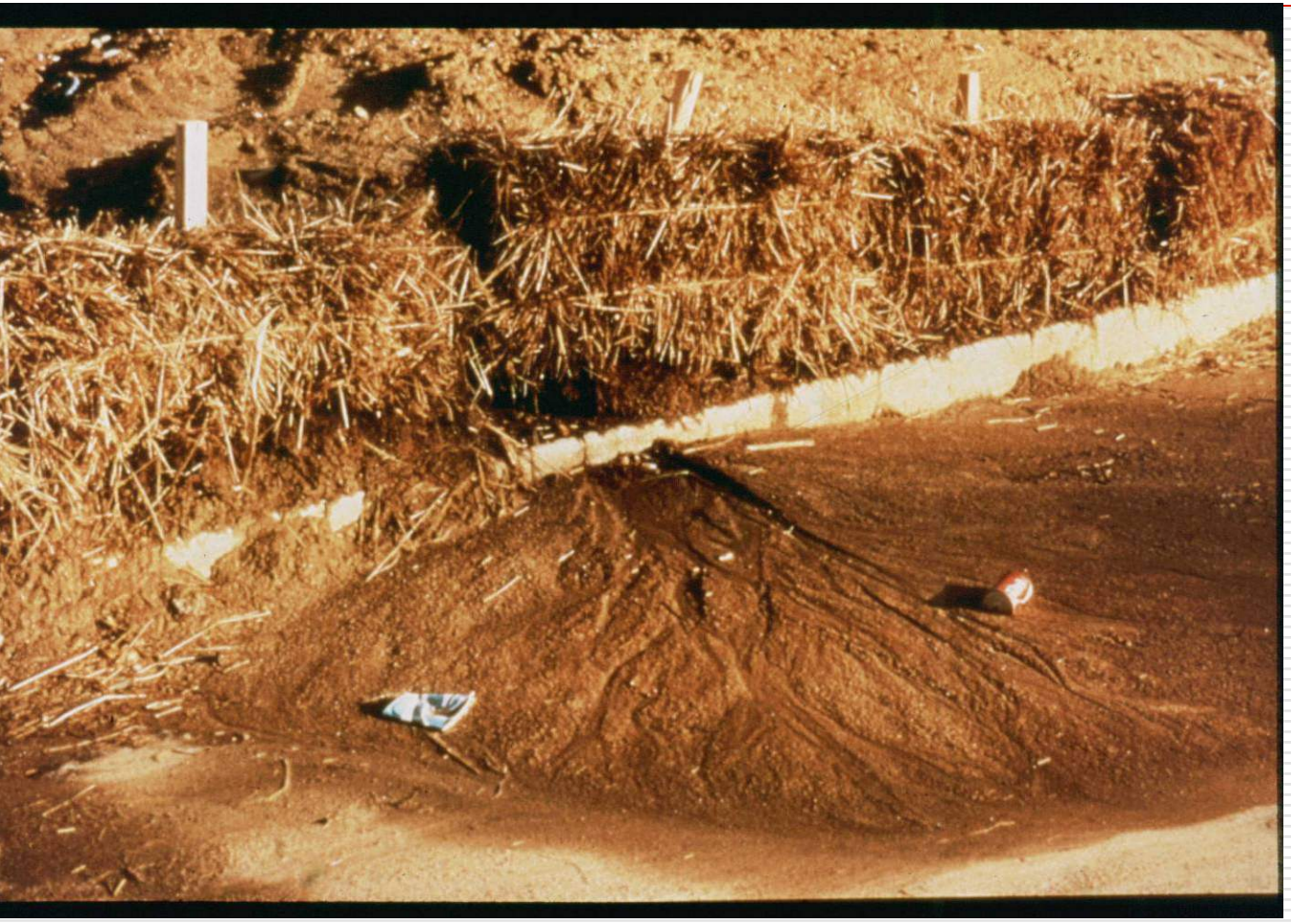


SILT FENCE

- Sediment control barriers, such as silt fence, are needed to prevent construction-generated silt from being carried into nearby waterways or onto adjoining properties.
- These barriers serve (1) to decrease the velocity of moving water, and (2) to trap suspended sediment.



Typical Solutions - Problems



- Improper placement of the traditional barriers, such as straw bales, has allowed undercutting and end flow, which have actually resulted in additions to rather than removal of sediment from runoff waters.

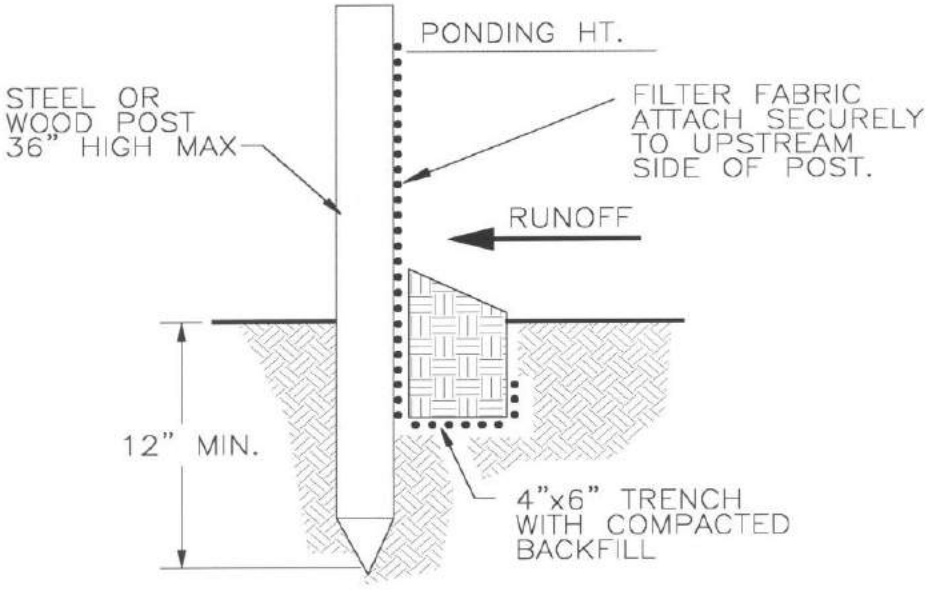
- Inadequate maintenance and cleaning efforts have tended to greatly lower the effectiveness of these barriers.

Typical straw bale installation (failure)

Silt Fence

Silt fences can trap a much higher percentage of the suspended sediments than can straw bales. When properly performing, a well designed silt fence will:

- Initially screen silt and sand particles from runoff.
- Form a soil filter adjacent to the sift fence, reducing the flow of water through the fence.
- Create a pond behind the fence which serves as a sedimentation basin to collect runoff water and retain suspended sediments.



SILT FENCE DETAIL

Silt Fence – The Benefits

Silt fence provides the following benefits over traditional sediment control structures:

- Minimal labor required to install
- Low cost
- Highly efficient in removing sediment
- Very durable and sometimes reusable

Silt Fence Installation - Details

Silt fence must be securely buried in the ground and adequately supported.

Silt Fence Installation - Location

- Unless otherwise specified, silt fence should be placed where it will intercept all runoff from the site.
- Extend the fence far enough uphill to prevent runoff from escaping around the ends.
- When continuing the fence line with a new roll of fencing, install the new fence to prevent silt from passing between the end of the existing fence and the beginning of the new.

Silt Fence Maintenance

- Routine maintenance should be performed on all silt fencing.
- The fence line should be inspected after each significant rain event as well as at specified intervals. If silt buildup is discovered, it should be cleaned from the fabric either by sweeping or by hand shoveling.
- When fabric begins deteriorating either because of U.V. exposure or vandalism/debris, it should be replaced or a new fence should be installed adjacent to the old.

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 714-4
Permanent Erosion Control Geotextile Requirements

	Test Methods	Units	Specifications[1] Type IV-A	Type IV-B	Type IV-C
Grab strength	ASTM D 4632	*N*	1400 / 900	1400 / 900	1400 / 900
Sewn seam strength	ASTM D 4632	*N*	1260 / 810	1260 / 810	1260 / 810
Tear strength	ASTM D 4533	*N*	500 / 350	500 / 350	500 / 350
Puncture strength	ASTM D 4833	*N*	500 / 350	500 / 350	500 / 350
Burst strength	ASTM D 3786	*kPa*	3500 / 1750	3500 / 1750	3500 / 1750
Permittivity	ASTM D 4491	sec^{-1}	0.7	0.2	0.1
Apparent opening size	ASTM D 4751	mm	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% elongation (ASTM D 4632). The second values in a column apply to geotextiles that break at ≥ 50% elongation (ASTM D 4632).
(2) Maximum average roll value.
(3) The minimum average tear strength for woven monofilament geotextile is 245 N.

FP03, Table 714-4 provides both survivability and performance properties for geotextiles used for permanent erosion control. M288 can be used to guide the specification of the appropriate geotextile type. Yellow designates the equivalent of the M288 specification default.

Permanent Erosion Control Geotextile Types

Survivability:

Default geotextile selection is Type IVA, B, or C. As a general guideline, the default geotextile selection is appropriate for conditions of equal or less severity than either of the following:

- Armor layer stone weights do not exceed 100 kg, stone drop height is less than 1 m, and no aggregate bedding layer is required.

- Armor layer stone weighs more than 100 kg, stone drop height is less than 1 m, and the geotextile is protected by a 150-mm thick aggregate bedding layer designed to be compatible with the armor layer. More severe applications require an assessment of geotextile survivability based on a field trial section and may require a geotextile with strength properties.

Permanent Erosion Control Geotextile Types Cont'd

The engineer may specify a Type IVD, E, or F geotextile based on one or more of the following:

- The engineer has found Type IVD, E, or F geotextiles to have sufficient survivability based on field experience.
- The engineer has found Type IVD, 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.
- Armor layer stone weighs less than 100 kg, stone drop height is less than 1 m, and the geotextile is protected by a 150-mm thick aggregate bedding layer designed to be compatible with the armor layer.
- Armor layer stone weights do not exceed 100 kg, and stone is placed with a zero drop height.

Permanent Erosion Control 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 IVA or IVD.
- If the percent passing the 0.075mm sieve is between 15 and 50, use Type IVB or IVE.
- If the percent passing the 0.075mm sieve is > 50, use Type IVC or IVF.

- 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.

FP03, Table 714-5
Temporary Silt Fence Requirements

			Specifications		
	Test Methods	Units	Type V-A	Type V-B[2]	Type V-C[3]
Grab strength - MD	ASTM D 4632	*N*	400	550	550
Grab strength - XD	ASTM D 4632	*N*	400	450	450
Permittivity	ASTM D 4491	sec^{-1}	0.05	0.05	0.05
Apparent opening size	ASTM D 4751	mm	0.60[1]	0.60[1]	0.60[1]
Ultraviolet stability	ASTM D 4355	%	50% retained strength after 500 hours exposure		

- Type V-A: Supported by 14-gage steel wire with a mesh spacing of 150 x 150 mm or polymeric mesh of equivalent strength, and posts at no more than 1.2m spacing.
- Types V-B and –C are unsupported, except for posts spaced at no more than 1.2m and 2.0m, respectively.

FP03, Table 714-5 provides both survivability and performance properties for geotextiles used for silt fence. M288 can be used to guide the specification of the appropriate geotextile type. Yellow designates the equivalent of the M288 specification default.

Questions

THINK

GMAtechline@ifai.com

Thank You!

For more information go to www.gmanow.com