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An Introduction to Geotextiles in Erosion Control

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J. Paul Guyer, P.E., R.A.

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(Figures, tables and equations in this publication are at times at times a little difficult to read, but they are the best available. **DO NOT PURCHASE THIS PUBLICATION IF THIS LIMITATION IS UNACCEPTABLE TO YOU.**)

1. INTRODUCTION. Erosion is caused by a group of physical and chemical processes by which the soil or rock material is loosened, detached, and transported from one place to another by running water, waves, wind, moving ice, or other geological sheet and bank erosion agents. Clayey soils are less erodible than fine sands and silts. See figure 1. This discussion covers the use of geotextiles to minimize erosion caused by water.

2. BANK EROSION. Riprap is used as a liner for ditches and channels subjected to high-velocity flow and for lake, reservoir and channel banks subject to wave action. Geotextiles are an effective and economical alternative to conventional graded filters under stone riprap. However, for aesthetic or economic reasons, articulated concrete mattresses, gabions, and precast cellular blocks have also been used to cover the geotextile. The velocity of the current, the height and frequency of waves and the erodibility of the bank determine whether bank protection is needed. The geotextiles used in bank protection serve as a filter.

2.1 SPECIAL DESIGN CONSIDERATIONS.

2.1.1 DURABILITY. The term includes chemical, biological, thermal, and ultraviolet (UV) stability. Streams and runoff may contain materials that can be harmful to the geotextile. When protected from prolonged exposure to UV light, the common synthetic polymers do not deteriorate or rot in prolonged contact with moisture. All geotextile specifications must include a provision for covering the geotextile to limit its UV radiation exposure to 30 days or less.

2.1.2 STRENGTH AND ABRASION RESISTANCE. The required properties will depend on the specific application- the type of the cover material to be used (riprap, sand bags, concrete blocks, etc.), the size, weight, and shape of the armor stone, the handling placement techniques (drop height), and the severity of the conditions (stream velocity, wave height, rapid changes of water level, etc.). Abrasion can result from movement of the cover material as a result of wave action or currents. Strength properties generally considered of primary importance are tensile strength, dimensional stability, tearing, puncture, and burst resistance. Table 1 gives recommended minimum strength values.

2.1.3 COVER MATERIAL. The cover material (gravel, rock fragments, riprap, armor stone, concrete blocks, etc.) is a protective covering over the geotextile that minimizes or dissipates the hydraulic forces, protects the geotextile from extended exposure to UV radiation, and keeps it in intimate contact with the soil. The type, size, and weight of cover material placed over the geotextile depends on the kinetic energy of water. Cover material that is lightweight in comparison with the hydraulic forces acting on it may be moved. By removing the weight holding the geotextile down, the ground-water pressure may be able to separate the geotextile from the soil. When no longer constrained, the soil erodes. The cover material must be at least as permeable as the geotextile. If the cover material is not permeable enough, a layer of fine aggregate (sand, gravel, or crushed stone) should be placed between it and the geotextile. An important consideration in designing cover material is to keep the void area between stones relatively small. If the void area is excessively large, soils may move from areas weighted by stones to unweighted void areas between the stones, causing the geotextile to balloon or eventually rupture. The solution in this case is to place a graded layer of smaller stones below the large stones that will prevent the soil from moving. A layer of aggregate may also be needed if a major part of the geotextile is covered as for example by concrete blocks. The layer will act as a pore water dissipator.

2.1.4 ANCHORAGE. At the toe of the streambank, the geotextile and cover material should be placed along the bank to an elevation below mean low water level to minimize erosion at the toe. Placement to a vertical distance of 3 feet below mean low water level, or to the bottom of the streambed for streams shallower than 3 feet, is recommended. At the top of the bank, the geotextile and cover material should either be placed along the top of the bank or with 2 feet vertical freeboard above expected maximum water stage. If strong water movements are expected, the geotextile needs to be anchored at the crest and toe of the streambank (fig 2).

2.1.5 IF THE GEOTEXTILE must be placed below low water, a material of a density greater than that of water should be selected.

Type Strength	Test Method	Class A [1]	Class B [2]
Grab Tensile	ASTM D 4632	200	90
Elongation (%)	ASTM D 4632	15	15
Puncture	ASTM D 4833	80	40
Tear	ASTM D 4533	50	30
Abrasion	ASTM D 3884	55	25
Seam	ASTM D 4632	180	80
Burst	ASTM D 3786	320	140

[1] Fabrics are used under conditions more severe than Class B such as drop height less than 3 feet and stone weights should not exceed 250 pounds.

Table 1
Recommended Geotextile Mininmum Strength Requirements.

2.2 CONSTRUCTION CONSIDERATIONS.

2.2.1 SITE PREPARATION. The surface should be cleared of vegetation, large stones, limbs, stumps, trees, brush, roots, and other debris and then graded to a relatively smooth plane free of obstructions, depressions, and soft pockets of materials.

2.2.2 PLACEMENT OF GEOTEXTILES. The geotextile is unrolled directly on the smoothly graded soil surface. It should not be left exposed to UV deterioration for more than 1 week in case of untreated geotextiles, and for more than 30 days in case of UV protected and low UV susceptible polymer geotextiles. The geotextile should be loosely laid, free of tension, folds, and wrinkles. When used for streambank protection, where currents acting parallel to the bank are the principal erosion forces, the geotextile should be placed with the longer dimension (machine direction) in the direction of anticipated water flow. The upper strips of the geotextile should overlap the lower strips (fig 3). When used for wave attack or cut and fill slope protection, the geotextile should be placed vertically down the slope (fig 3), and the upslope strips should cover the downslope strips. Stagger the overlaps at the ends of the strips at least 5 feet. The geotextile should be anchored at its terminal ends to prevent uplift or undermining. For this purpose, key trenches and aprons are used at the crest and toe of the slope.

2.2.3 OVERLAPS, SEAMS, SECURING PINS. Adjacent geotextile strips should have a minimum overlap of 12 inches along the edges and at the end of rolls. For underwater placement, minimum overlap should be 3 feet. Specific applications may require additional overlaps. Sewing, stapling, heat

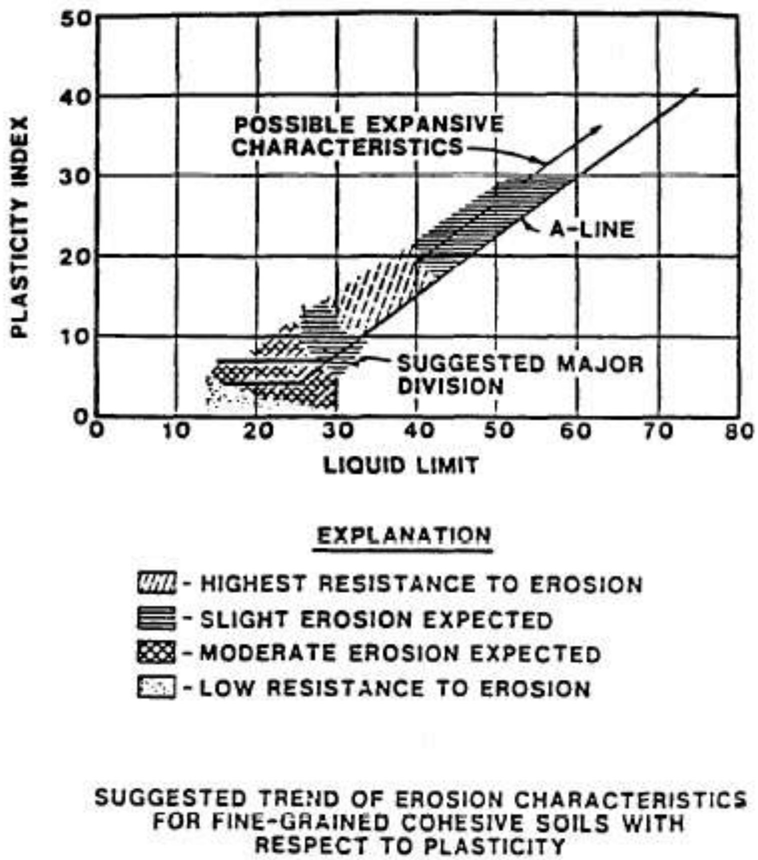

Figure 1

Relationship between Atterberg Limits and Expected Erosion Potential.

Slope	Pin Spacing feet
Steeper than 1V on 3H	2
1V on 3H to 1V on 4H	3
Flatter than 1V on 4H	5

V = vertical; H = horizontal.

Table 2

Pin Spacing Requirements in Erosion Control Applications

welding, or gluing adjacent panels, either in the factory or on site, are preferred to lapping only. Sewing has proved to be the most reliable method of joining adjacent panels. It should be performed using polyester, polypropylene, kevlar or nylon thread. The seam strength for both factory and field seams should not be less than 90 percent of the required tensile strength of the unaged geotextile in any principal direction. Geotextiles may be held in place on the slope with securing pins prior to placing the cover material. These pins with washers should be inserted through both strips of the overlapped geotextile along a line through the midpoint of the overlap. The pin spacing, both along the overlaps or seams, depends on the slope, as specified in table 2. Steel securing pins, 3/16 inch in diameter, 18 inches long, pointed at one end, and fitted with a l.5-inch metal washer on the other have performed well in rather firm soils. Longer pins are advisable for use in loose soils. The maximum slope on which geotextiles may be placed will be determined by the friction angles between the natural-ground and geotextile and cover- material and geotextile. The maximum allowable slope in no case can be greater than the lowest friction angle between these two materials and the geotextile.

2.2.4 PLACEMENT OF COVER MATERIAL ON GEOTEXTILE. For sloped surfaces, placement of the cover stone or riprap should start from the base of the slope moving upward and preferably from the center outward to limit any partial movement of soil because of sliding. In no case should drop heights which damage the geotextile be permitted. Testing may be necessary to establish an acceptable drop height.

3. PRECIPITATION RUNOFF COLLECTION AND DIVERSION DITCHES.

A diversion ditch is an open, artificial, gravity flow channel which intercepts and collects precipitation runoff, diverts it away from vulnerable areas, and directs it toward stabilized outlets. A geotextile or revegetation mat can be used to line the ditch. It will retard erosion in the ditch, while allowing grass or other protective vegetation growth to take place. The mat or geotextile can serve as additional root anchoring for some time after plant cover has established itself if UV resistant geotextiles are specified. Some materials used for this purpose are designed to degrade after grass growth takes place. The geotextile can be selected and specified using physical properties indicated in table 1. Figure 4 shows a typical example.

4. MISCELLANEOUS EROSION CONTROL.

Figures 5 and 6 show examples of geotextile applications in erosion control at drop inlets and culvert outlets and scour protection around bridges, piers, and abutments. Design criteria similar to that used for bank protection should be used for these applications.

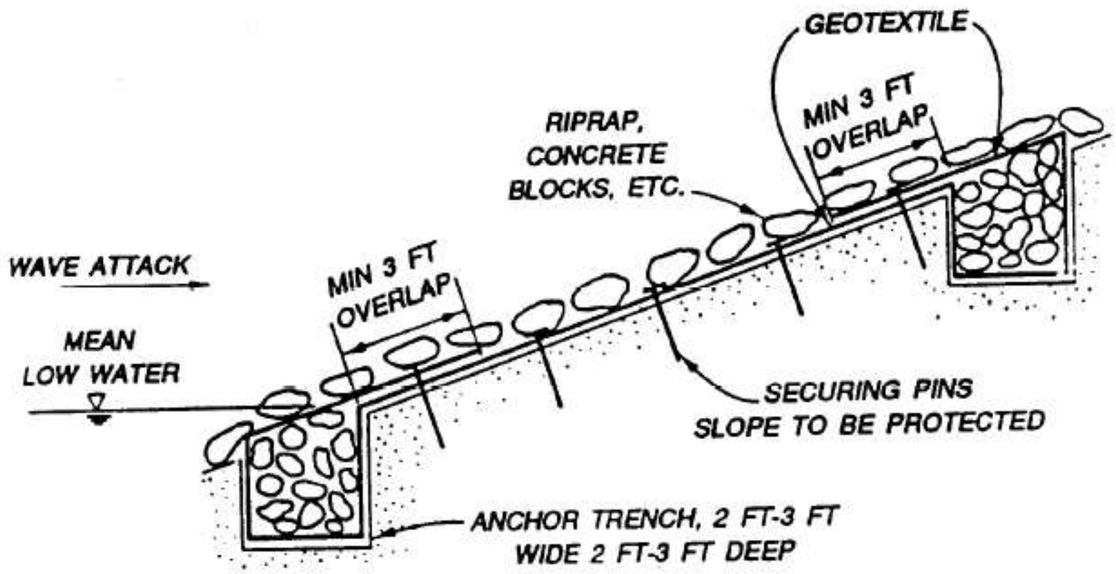

Figure 2

Pin Spacing Requirements in Erosion Control Applications.

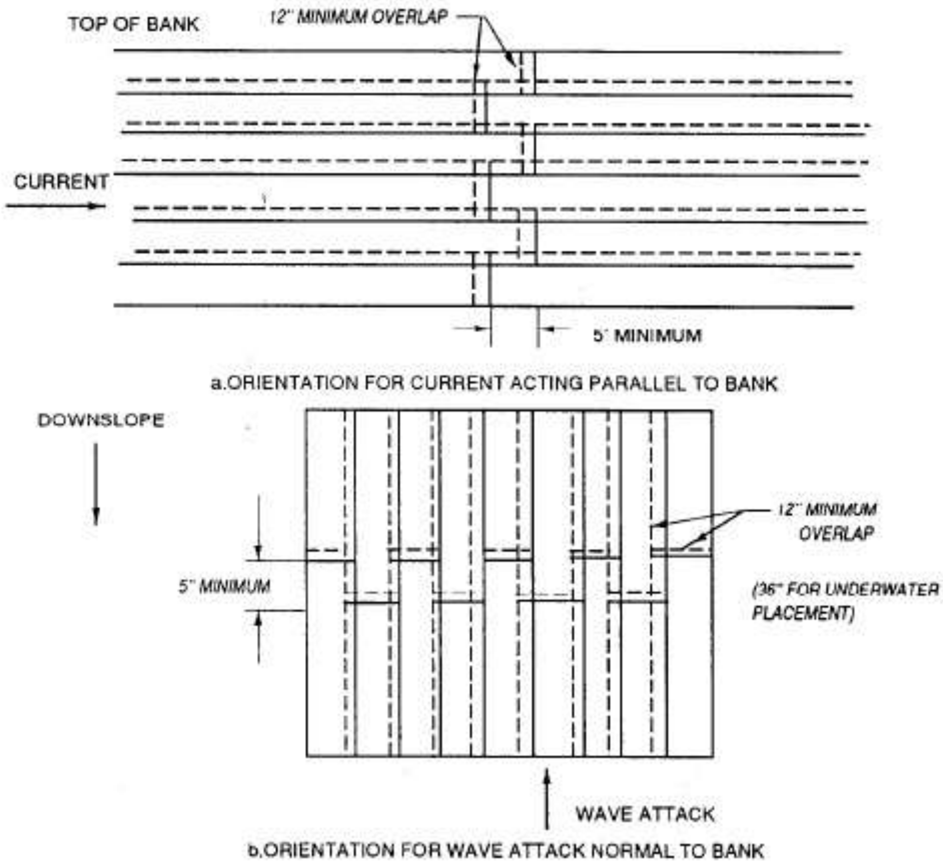

Figure 3

Geotextile Placement for Currents Acting Parallel to Bank

or for Wave Attack on the Bank.

5. SEDIMENT CONTROL. Silt fences and silt curtains are sediment control systems using geotextiles.

5.1 SILT FENCE. A silt fence is a temporary vertical barrier composed of a sheet of geotextile supported by fencing or simply by posts, as illustrated in figure 5. The lower end of the geotextile is buried in a trench cut into the ground so that runoff will not flow beneath the fence. The purpose of the permeable geotextile silt fence is to intercept and detain sediment from unprotected areas before it leaves the construction site. Silt fence are sometimes located around the entire downslope portion or perimeter of urban construction sites. Short fences are often placed across small drainage ditches (permanent or temporary) constructed on the site. Both applications are intended to function for one or two construction seasons or until grass sod is established. The fence reduces water velocity allowing the sediment to settle out of suspension.

5.1.1 DESIGN CONCEPTS. A silt fence consists of a sheet of geotextile and a support component. The support component may be a wire or plastic mesh support fence attached to support posts or in some cases may be support posts only. The designer has to determine the minimum height of silt fences, and consider the geotextile properties (tensile strength, permeability) and external factors (the slope of the surface, the volume of water and suspended particles which are delivered to the silt fence, and the size distribution of the suspended particles). Referring to figure 6-7, the total height of the silt fence must be greater than $h_1 + h_2 + h$; where h_1 the height of geotextile necessary to allow water flowing into the basin to flow through the geotextile, considering the permeability of the geotextile; is the height of water necessary to overcome the threshold gradient of the geotextile and to initiate flow. For most expected conditions, $h_1 + h_2$ is about 6 inches or less. The silt fence accomplishes its purpose by creating a pond of relatively still water which serves as a sedimentation basin and collects the suspended solids from the runoff. The useful life of the silt fence is the time required to fill the triangular area of height

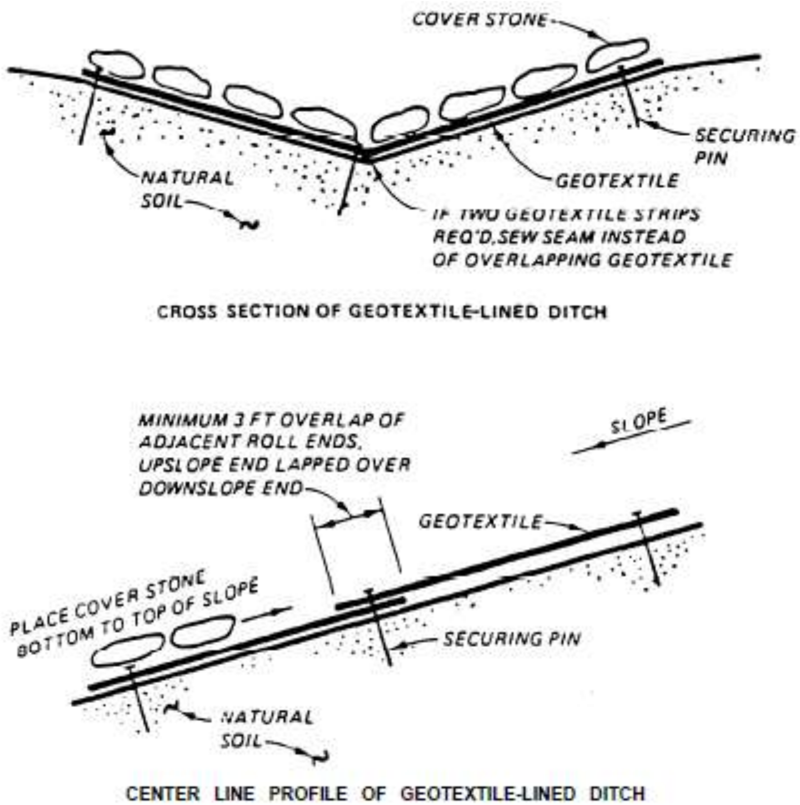

Figure 4

Ditch liners

h (fig 7) behind the silt fence with sediment. The height of the silt fence geotextile should not exceed 3 feet.

5.1.2 DESIGN FOR MAXIMUM PARTICLE RETENTION. Geotextiles selected for use in silt fences should have an AOS that will satisfy the following equation with a limiting value equal to the No. 120 sieve size.

$$\frac{D^{85}\ (\text{mm})\ (\text{soil})}{\text{AOS}\ (\text{mm})\ (\text{geotextile})} \geq 1$$

(Eq 1)

A minimum of 90-pound tensile strength (ASTM D 4632 Grab Test Method) is recommended for use with support posts spaced a maximum of 8 feet apart.

5.1.3 DESIGN FOR FILTRATION EFFICIENCY. The geotextile should be capable of filtering most of the soil particles carried in the runoff from a construction site without unduly impeding the flow. ASTM D 5141 presents the laboratory test used to determine the filtering efficiency and the flow rate of the sediment-filled water through the geotextile.

5.1.4 REQUIRED GEOTEXTILE PROPERTIES. The geotextile used for silt fence must also have:

(a) Reasonable puncture and tear resistance to prevent damage by floating debris and to limit tearing where attached to posts and fence.

(b) Adequate resistance to UV deterioration and biological, chemical, and thermal actions for the desired life of the fence.

5.1.5 CONSTRUCTION CONSIDERATIONS.

(a) Silt fences should be constructed after the cutting of trees but before having any sod disturbing construction activity in the drainage area.

(b) It is a good practice to construct the silt fence across a flat area in the form of a horseshoe. This aids in the ponding of the runoff, and increases the strength of the

fence. Prefabricated silt fence sections containing geotextile and support posts are commercially available. They are generally manufactured in heights of 18 and 36 inches. At the lower portion of the silt fence, the geotextile is extended for burying anchorage.

5.2 SILT CURTAINS. A silt curtain is a floating vertical barrier placed within a stream, lake, or other body of water generally at runoff discharge points. It acts as a temporary dike to arrest and control turbidity. By interrupting the flow of water, it retains suspended particles; by reducing the velocity, it allows sedimentation. A silt curtain is composed of a sheet of geotextile maintained in a vertical position by flotation segments at the top and a ballast chain along the bottom. A tension cable is often built into the curtain immediately above or below the flotation segments to absorb stress imposed by currents and other hydrodynamic forces. Silt curtain sections are usually about 100 feet long and of any required width. An end connector is provided at each end of the section for fastening sections together. Anchor lines hold the curtain in a configuration that is usually U-shaped, circular, or elliptical. The design criteria and properties required for silt fences also apply to silt curtains. Silt curtains should not be used for:

(1) Operations in open ocean.
(2) Operations in currents exceeding 1 knot.
(3) Areas frequently exposed to high winds and large breaking waves.
(4) Around hopper or cutterhead dredges where frequent curtain movement would be necessary.

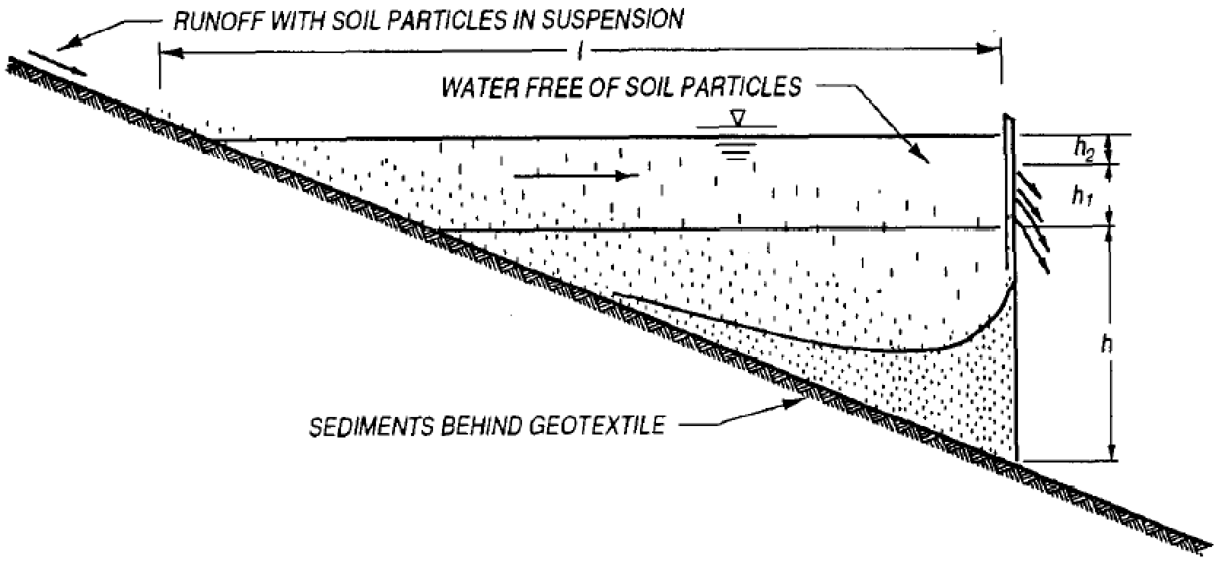

Figure 5

Use of Geotextiles near Small Hydraulic Structures

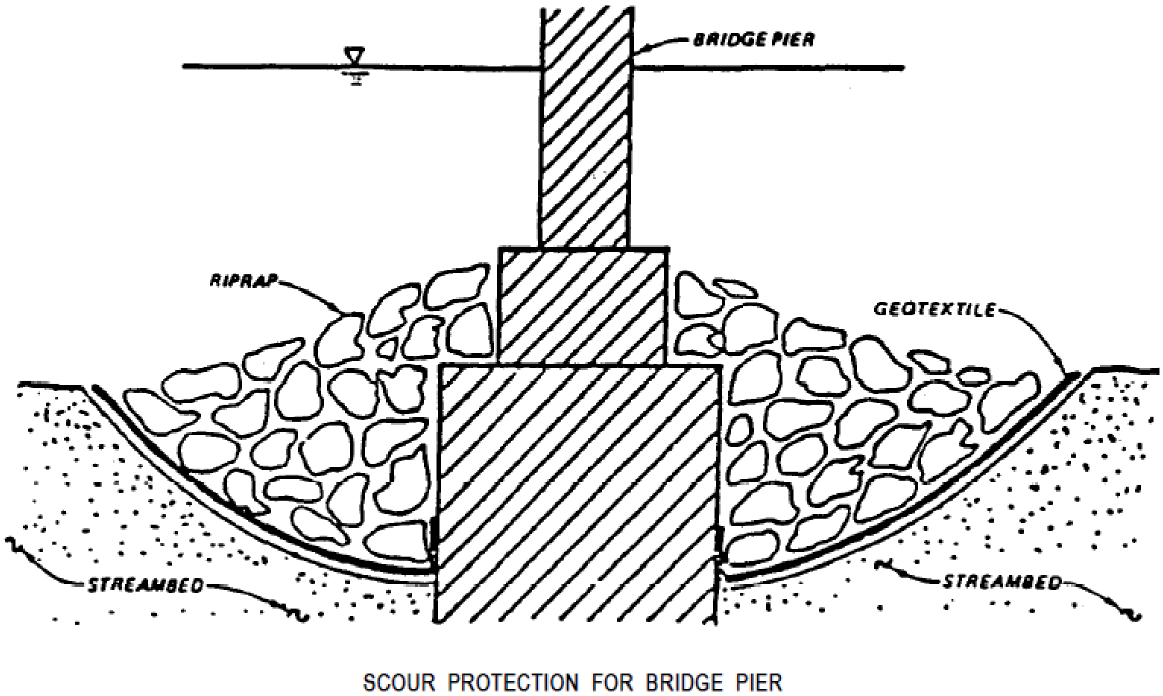

Figure 6

Use of Geotextiles around Piers and Abutments

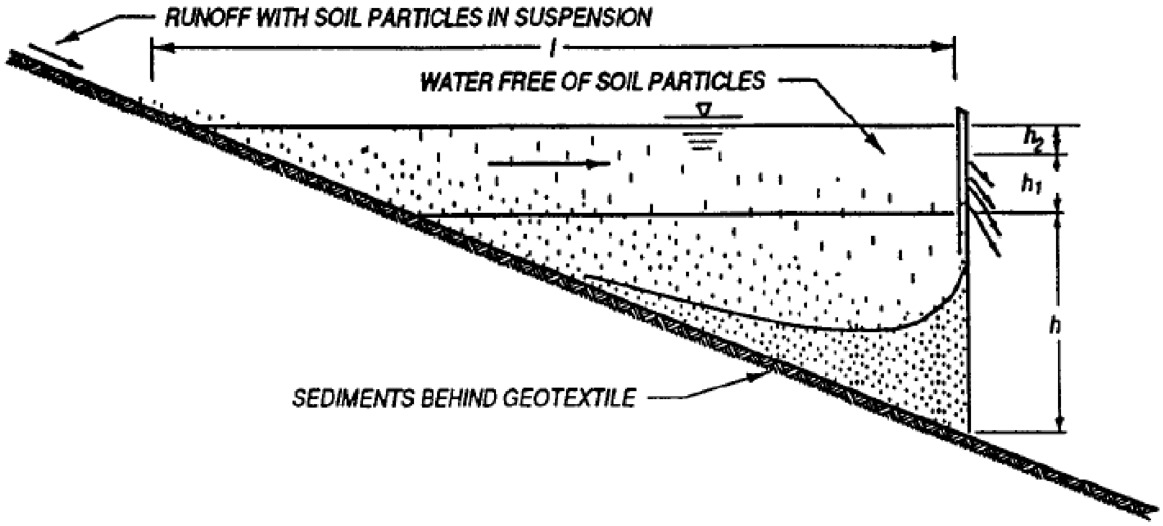

Figure 7

Sedimentation behind Silt Fence.

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