

# Applications of Geosynthetics in Low-Volume Roads



GEOAMERICAS  
*2008*

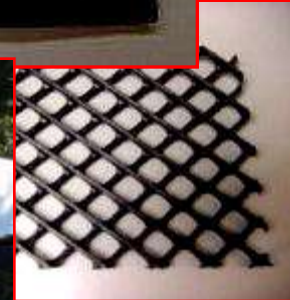
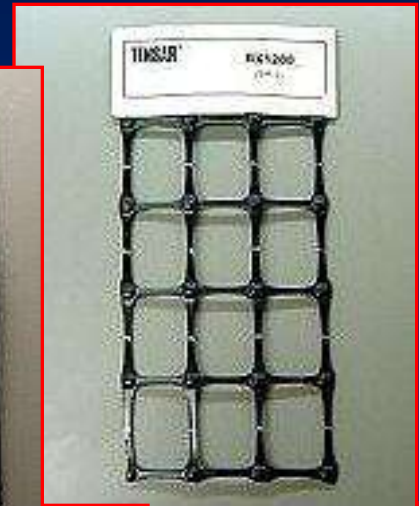
Presented by:  
Gordon Keller, PE  
&  
Jeb Tingle, PE



# What Are Geosynthetics?

## Types

- Geotextiles
- Geogrids
- Geonets
- Geocells
- Geomembranes
- Geosynthetic Clay Liners
- Geopipe
- Geofoam
- Geofibers
- Geocomposites



## Definitions (ASTM)

- **GEOSYNTHETIC:**

- A planar product manufactured from polymeric material used with soil, rock, earth, or any other geotechnical engineering related material as an integral part of a man-made project, structure, or system

D4439





GEOTEXTILES



GEOGRIDS



# GEOCOMPOSITES



# GEONETS



FHWA, R. Koerner



# GEOFOAM



# GEOPIPE

# Basic Functions of Geosynthetics

- **Drainage**
- **Filtration**
- **Separation**
- **Reinforcement**
- **Containment/ Moisture Barriers**

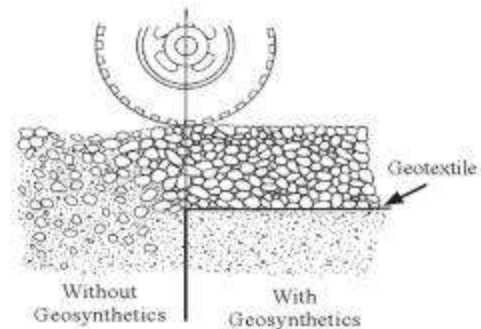


# **Applications of Geosynthetics** **in Low-Volume Roads**

- **Drainage and Filtration**
    - In Underdrains & Filter Blankets
    - Behind Riprap
  - **Base-Subgrade Separation**
  - **Subgrade Reinforcement**
  - **Structure Reinforcement**
    - In Retaining Walls
    - Reinforced Slopes
  - **Erosion Control-Sediment Traps**
  - **Edge Drains, Moisture Barriers**
- 



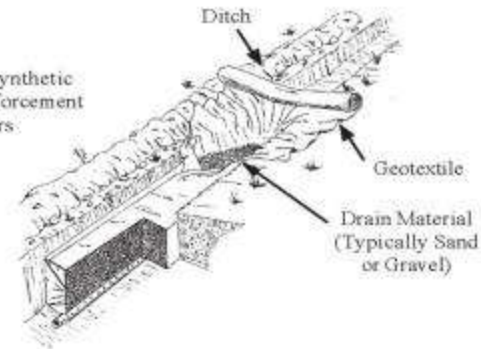
**a. Filter Behind Riprap for Stream Bank Protection.**



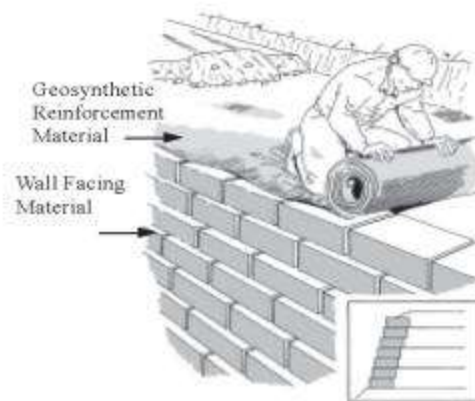
**b. Subgrade Separation and Reinforcement.**



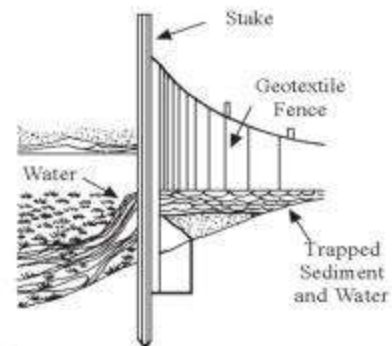
**c. Embankment Reinforcement over Soft Soil Deposits**



**d. Filtration in an Underdrain.**



**e. Reinforced Soil Retaining Structure**



**f. Silt Fence to Trap Sediment.**

**Typical geosynthetics applications for roads.** (Adapted with permission from AMOCO Fibers Corporation.)

# DRAINAGE AND FILTRATION



D. Alzamora

# The Two Basic Functions of Filters:

- 1) Retain or prevent the movement of soil (piping) from behind riprap or gabions into the coarse rock, or into the drain rock.
- 2) Prevent water pressure buildup by allowing groundwater to flow from the soil without building up pressure.

## Types of filters

- Coarse sands and gravels
- Geotextiles



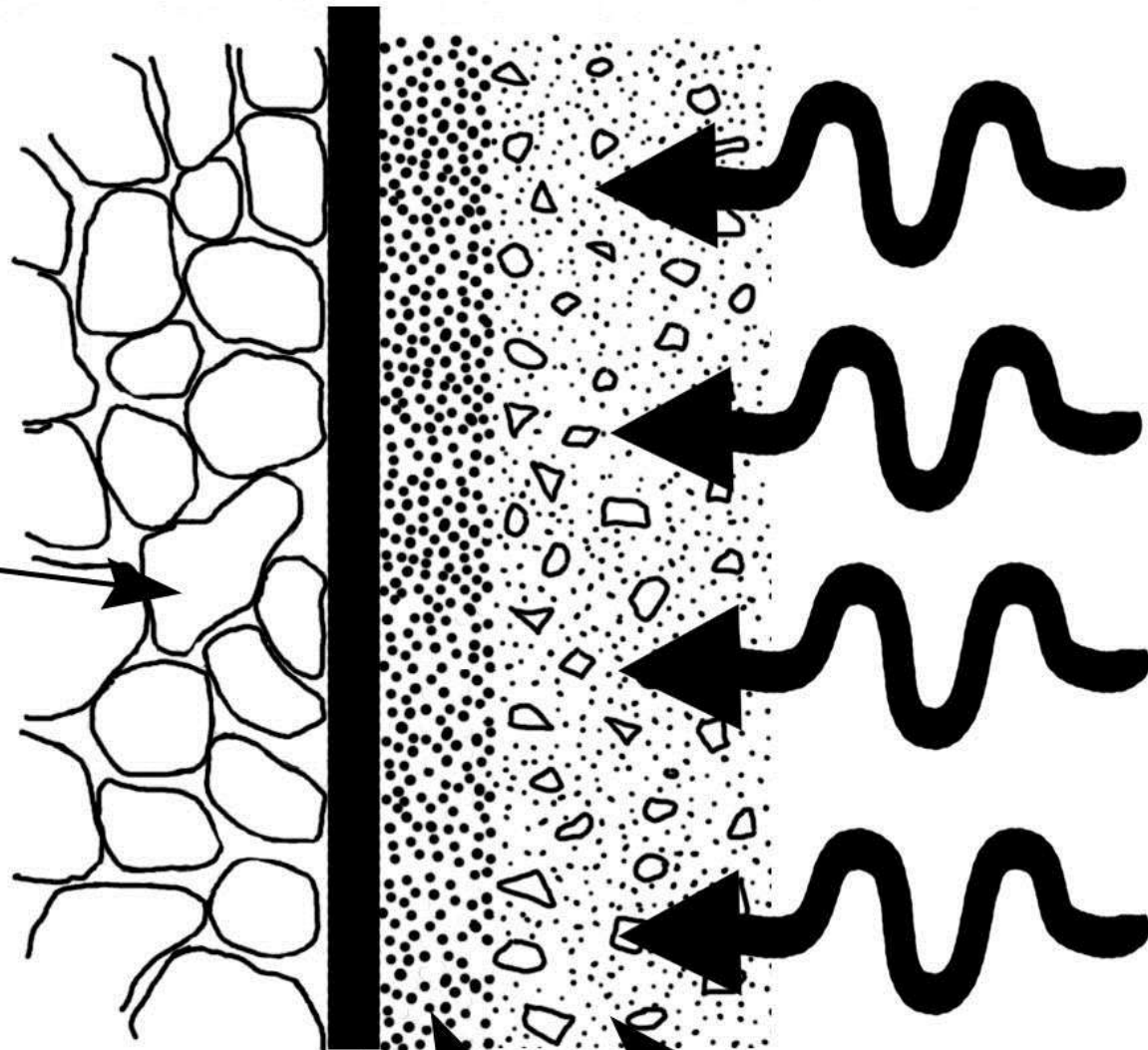
Drainage  
Aggregate

Geotextile

Filter Bridge

Soil

Seepage



# Filter Criteria

<u>Soil -% Minus 200 (passing .075 mm)</u>		
<15%	15-50%	>50%

## For Retention

AOS (mm)	0.43	0.25	0.22
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(For cohesive soil with  $PI > 7$ , maximum AOS = 0.3 mm.)

## For Permittivity

(per second)	0.5	0.2	0.1
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(Permeability of geotextile  $\gg$  permeability of the soil)

## For Clogging Resistance

$O_{95}(\text{geotextile}) \geq 3D_{15}(\text{soil})$

(Where O is the geotextile opening or pore size, like AOS)

# Drainage Design Requirements

- Permittivity/Permeability
- Flow Capacity
- Piping Prevention
- Clogging Resistance
- Strength, Durability, Survivability
  - Grab, Seam and Tear Strength
  - Puncture and Burst Strength
  - UV Resistance



# Specifications

## AASHTO M288-96 Subsurface Drainage

**Description:** This specification is applicable to placing a geotextile against the soil to allow long-term passage of water into a subsurface drain system retaining the in-situ soil. The primary function of the geotextile in subsurface drainage applications is filtration. Geotextile filtration properties are a function of the in-situ soil gradation, plasticity, and hydraulic conditions.

**Geotextile Requirements:** Woven silt film geotextiles (i.e. geotextiles made from yarns of a flat, tape-like character) will not be allowed.

Test	Test Method	Units	Class 2 <sup>2</sup>						Class 3					
			<50%			>50%			<50%			>50%		
Grab Strength	ASTM D-4632	N lbs	1100	248		700	158		800	180		500	113	
Sewn Seam Strength	ASTM D-4884	N lbs	990	223		630	142		720	162		450	101	
Tear Strength	ASTM D-4533	N lbs	400	90*		250	56		300	68		180	41	
Puncture Strength	ASTM D-4833	N lbs	400	90		250	56		300	68		180	41	
Burst Strength	ASTM D-3786	kPa psi	2700	392		1300	189		2100	305		950	138	
UV Resistance	ASTM D-4355	%	50% @ 500 hrs.			50% @ 500 hrs.			50% @ 500 hrs.			50% @ 500 hrs.		
% in-situ soil passing 0.075mm (#200 sieve) <sup>1</sup>			Coarse <15	Medium 15-50	Fine >50	Coarse <15	Medium 15-50	Fine >50	Coarse <15	Medium 15-50	Fine >50	Coarse <15	Medium 15-50	Fine >50
Permittivity <sup>3,4</sup>	ASTM D-4491	sec <sup>-1</sup>	.5	.2	.1	.5	.2	.1	.5	.2	.1	.5	.2	.1
AOS <sup>5,6</sup>	ASTM D-4751	mm	.43	.25	.22 <sup>7</sup>	.43	.25	.22 <sup>7</sup>	.43	.25	.22 <sup>7</sup>	.43	.25	.22 <sup>7</sup>

<sup>1</sup> Based on grain size analysis of in-situ soil in accordance with AASHTO T88.

<sup>2</sup> Default geotextile selection. The Engineer may specify a Class 3 geotextile for trench drain applications based on one or more of the following:

- The Engineer has found Class 3 geotextiles to have sufficient survivability based on field experience.
- The Engineer has found Class 3 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 (6.56 ft), drain aggregate is less than 30 mm (1.18 in) and compaction requirement is equal to or less than 95% of AASHTO T-99.

<sup>3</sup> These default filtration property values are based on the predominate particle sizes of the in-situ soil. 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.

<sup>4</sup> Site specific geotextile design should be performed especially if one or more of the following problematic soil environments are encountered: unstable or highly erodable soils such as non-cohesive silts; gap graded soils; alternating sand/silt laminated soils; dispersive clays; and/or rock flour.

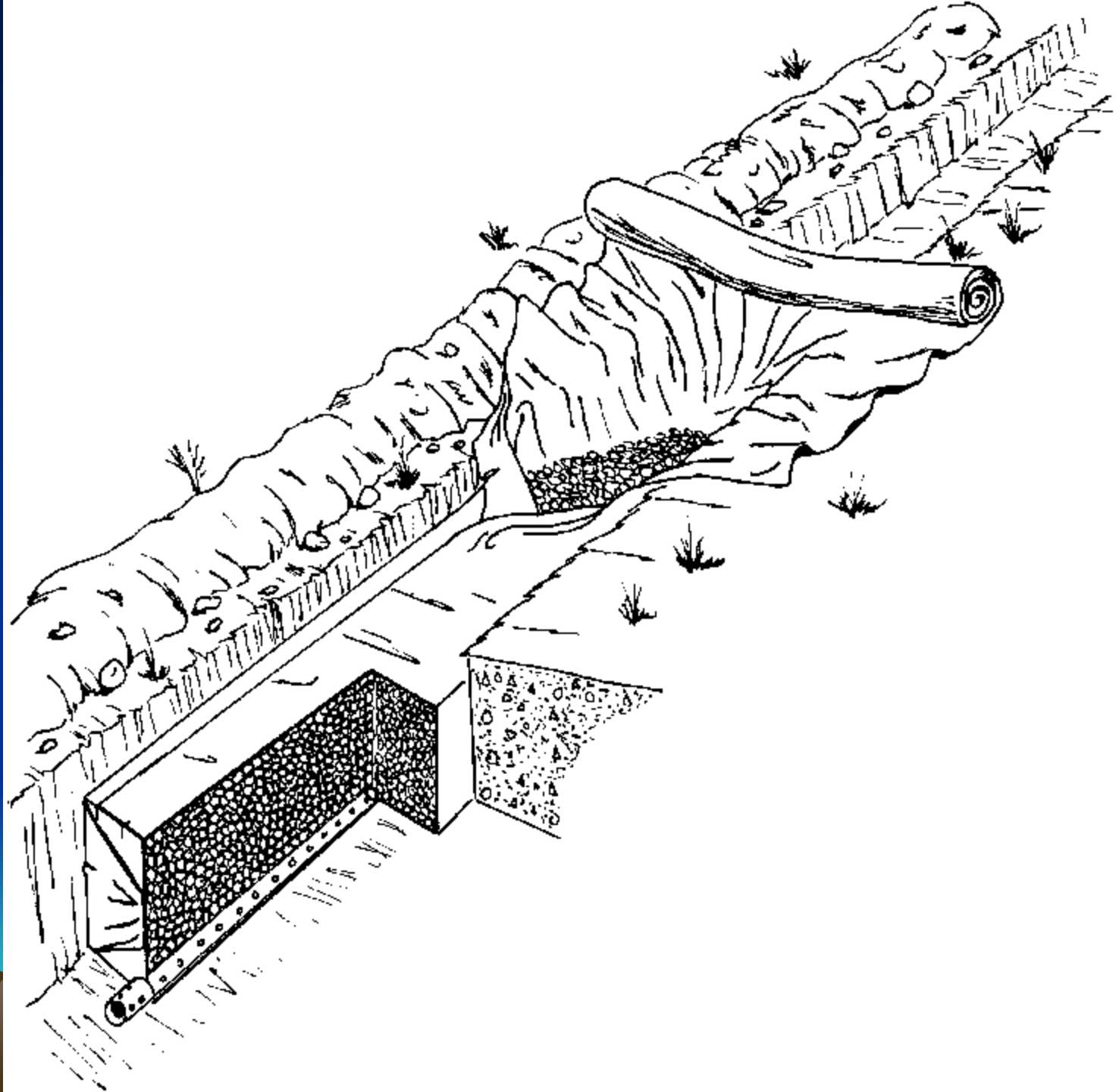
<sup>5</sup> For cohesive soils with a plasticity index greater than 7, geotextile maximum average roll value for apparent opening size is 0.30 mm (#50 sieve).

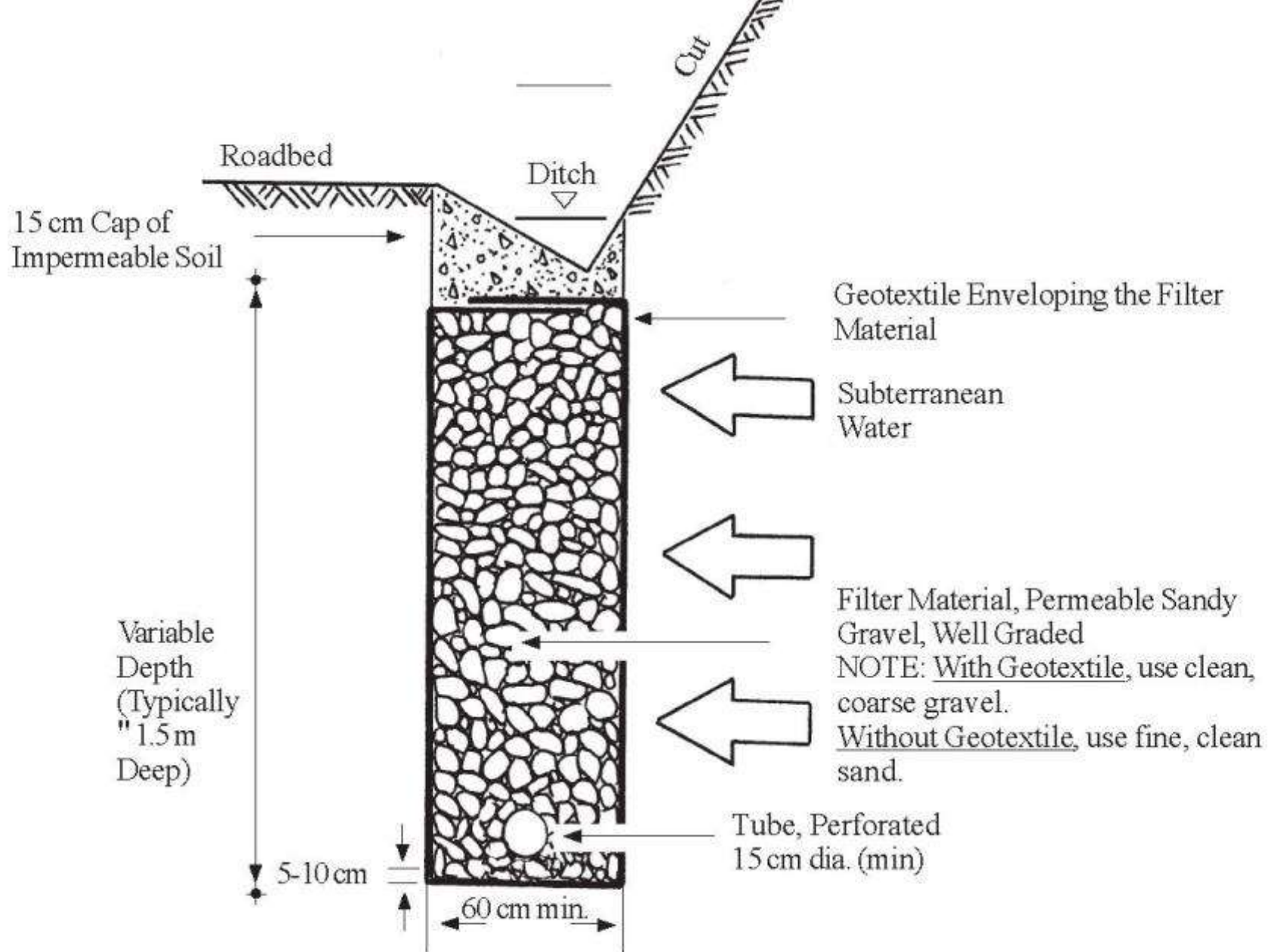
<sup>6</sup> The required MARV tear strength for woven monofilament geotextiles is 250 N (56 lbs).

<sup>7</sup> Maximum Average Roll Value

All other values are Minimum Average Roll Values (MARV)

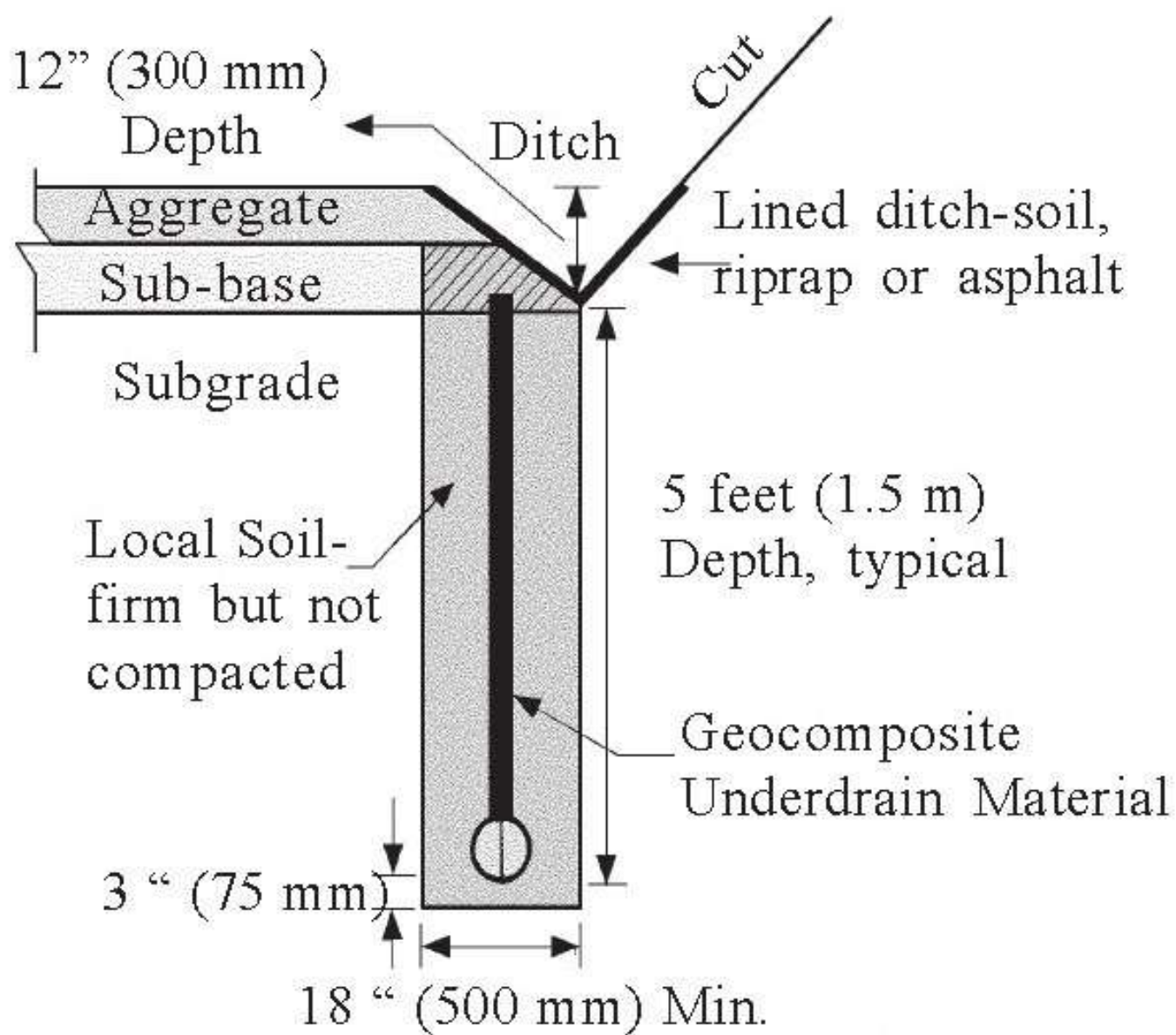
AASHTO M288-96





**Typical gravel underdrain**





## Geocomposite Underdrain





# Filter Blankets



# Behind Riprap











D. Elton





**Filter “Bib”**



# Commonly Used Materials

- Needle Punch Non-Woven Geotextile
  - 6.0 oz/sq. yd. (200 g/sq. m.)
- Woven Monofilament
- Behind Riprap, use strong material
- Don't use slit-film woven geotextiles for filtration /drainage applications



# STRUCTURE REINFORCEMENT



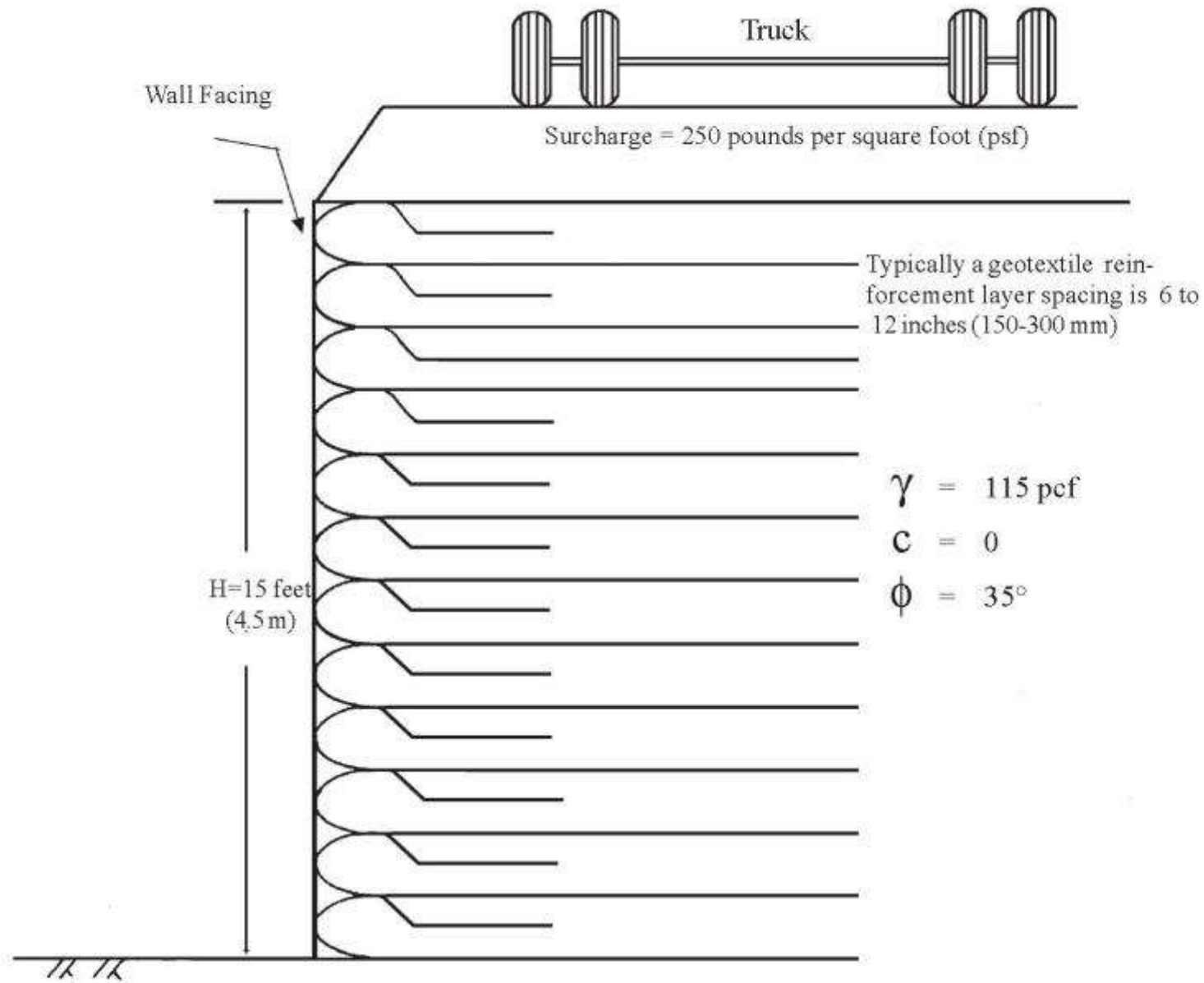
FHWA

# MSE Walls









**Cross-Section of a designed geotextile reinforced soil wall.**





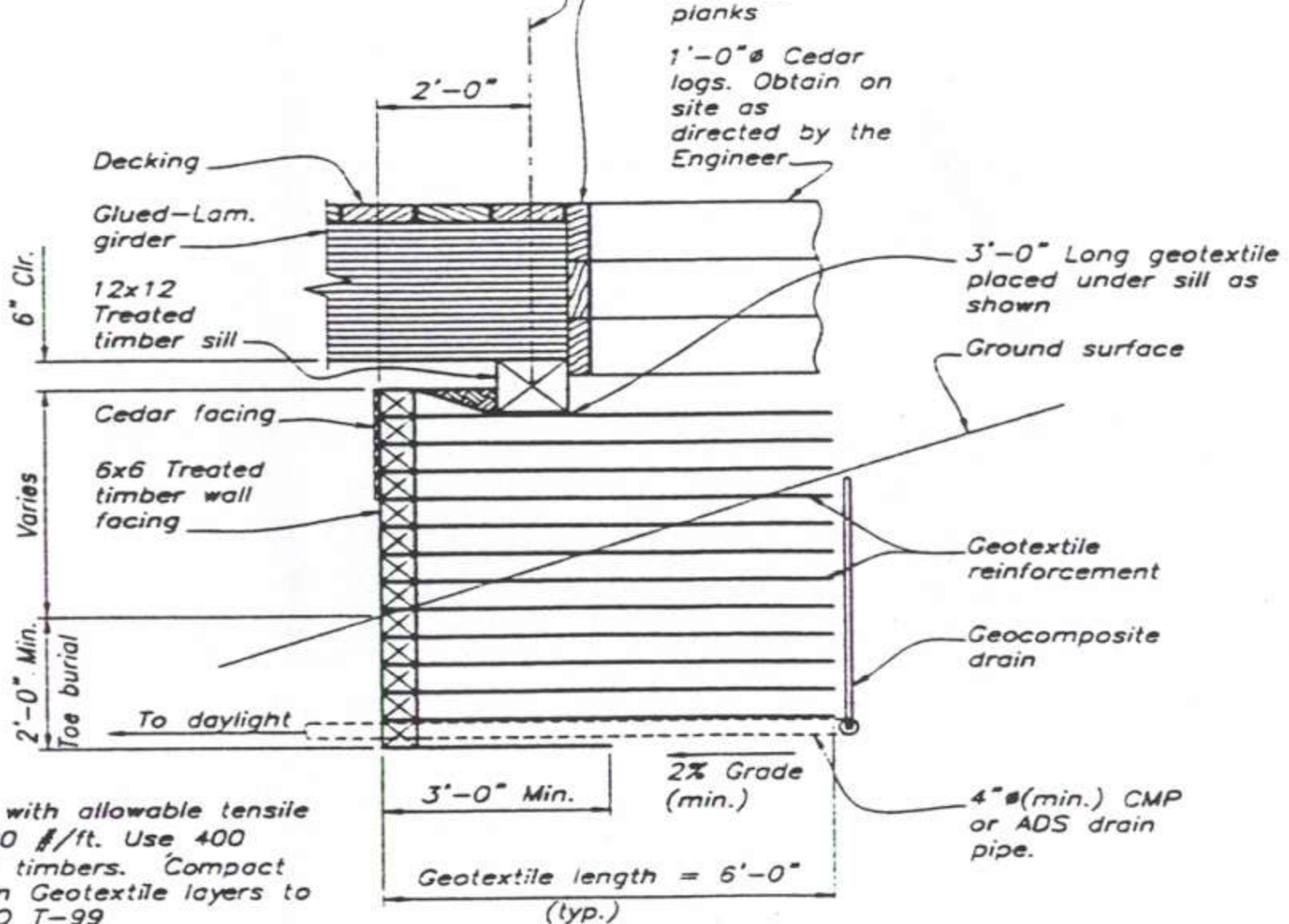
# Key Design Issues

- Facing Materials
- Reinforcement Spacing and Type
- Strength Reduction Factors and Factor of Safety
- Reinforcement Length
- Face Connection Details
- Drainage Requirements
- Foundation and Global Stability



# GRS Bridge Abutments





# MECHANICALLY STABILIZED BACKFILL TIMBER BRIDGE ABUTMENT WALL SECTION

Scale: 1/2" = 1'-0"





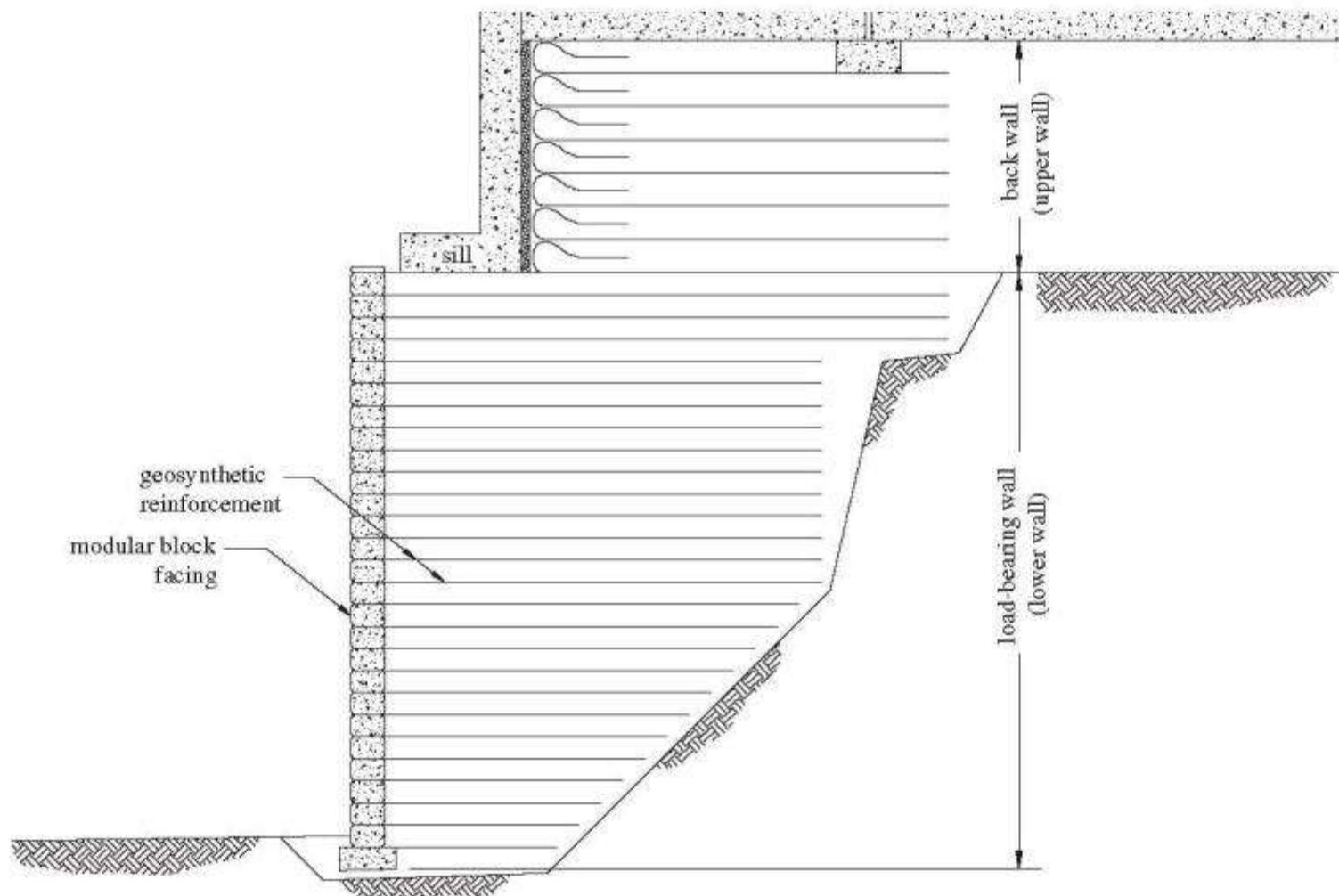
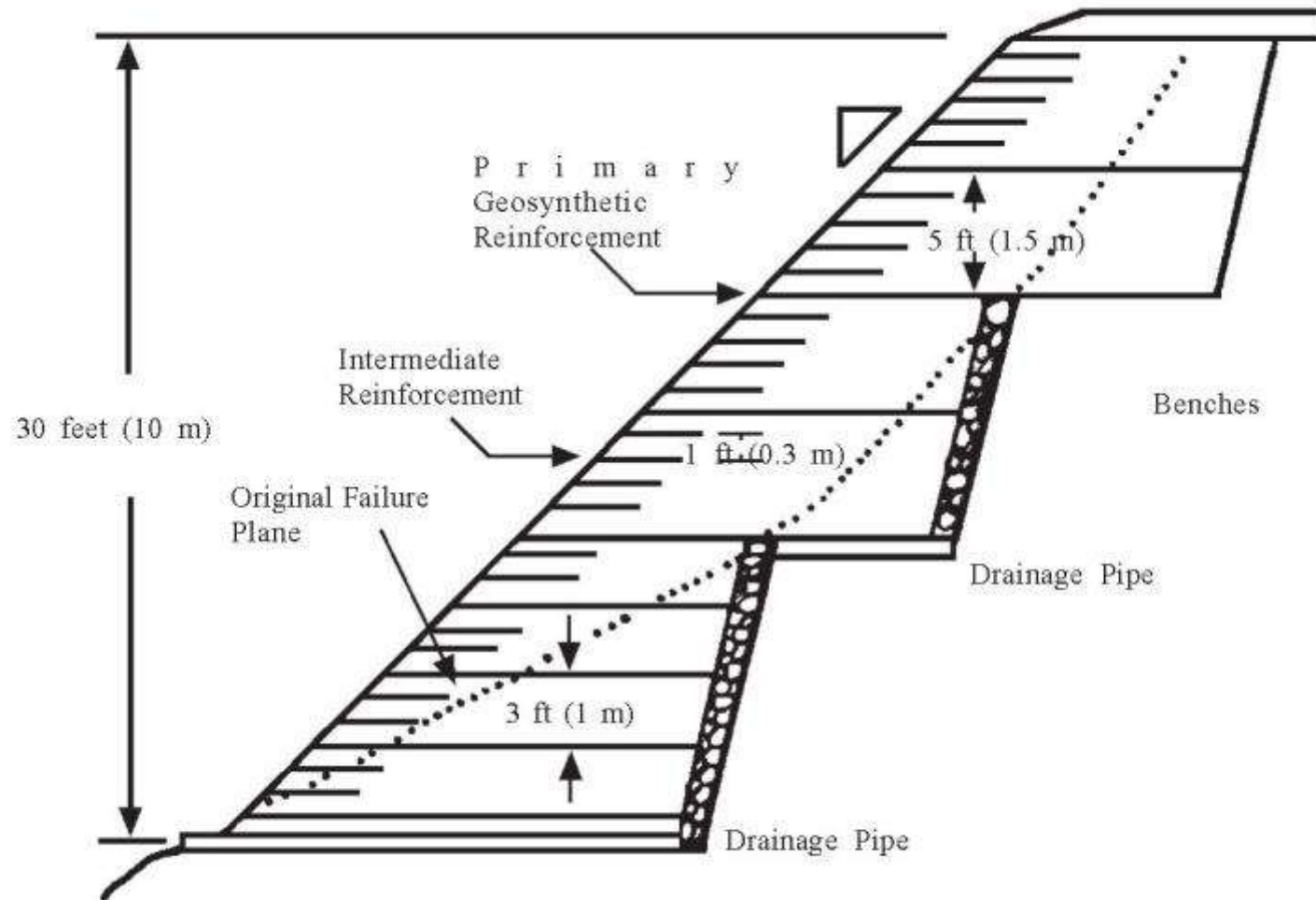


Figure 1-1. Typical GRS bridge abutment with a segmental concrete block facing.



# Reinforced Fills



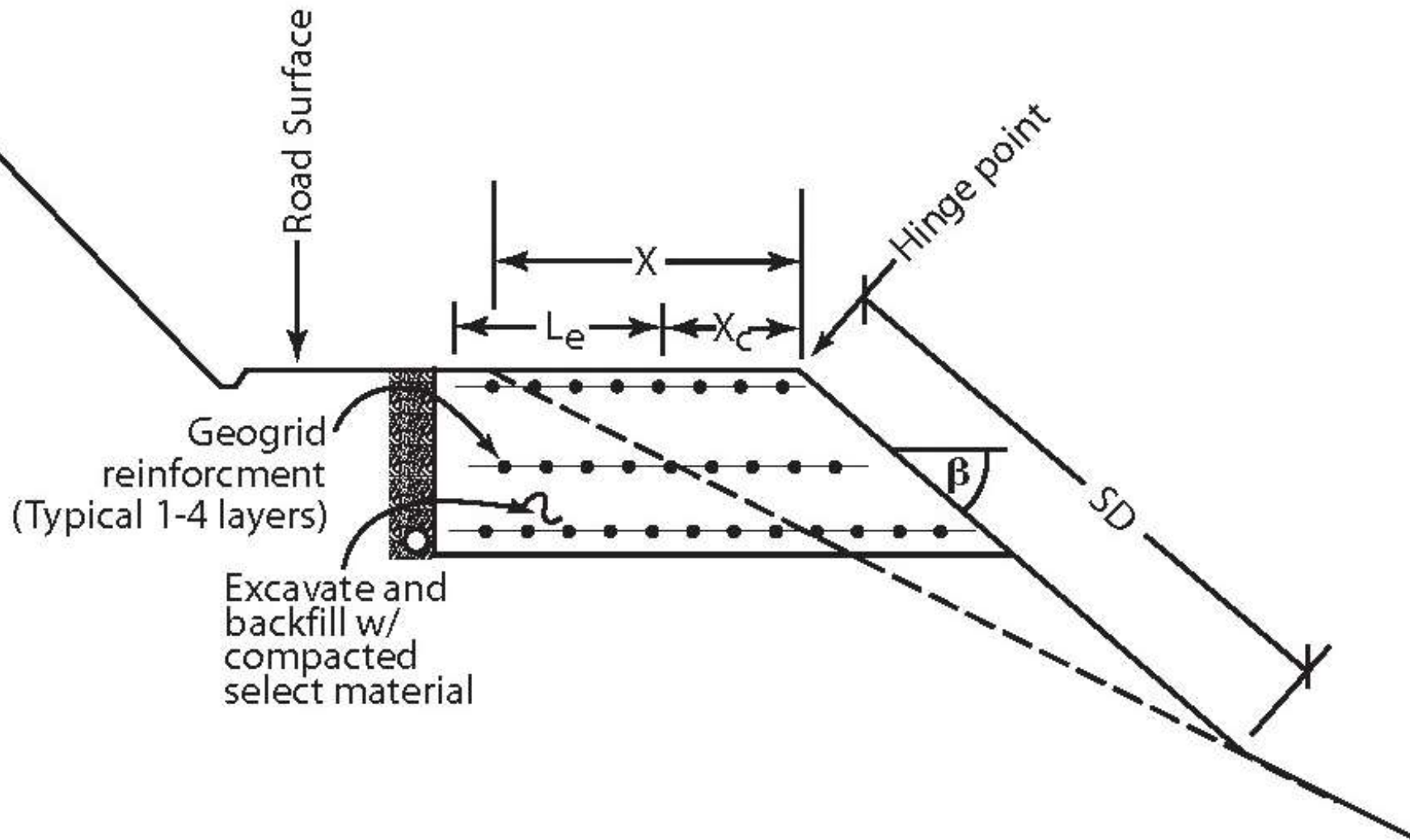
Cross-section of a reinforced fill using geogrid or geotextile, with excavated benches and a subdrain.







# “Deep Patch”









# Geosynthetic Requirements

- Allowable long-term tensile strength
- Drainage and survivability??

## Materials Commonly Used

- Needle-punch Non-woven
- Slit-film Woven
- Woven Monofilament (strong)
- Geogrids



Design charts for Geosynthetic Reinforced Walls (based on the Simplified CTI Method).  
 Drawing A - Wall Height (H) = 8 feet (2.4 meters)

Friction Angle of Backfill, $\phi$ (degrees)		30°	32°	34°	36°	38°	40°	42°
Reinforcement Length, L (feet)		6.2	6.0	5.9	5.7	5.5	5.3	5.2
$T_{ed}$ (lb/ft)	s = 8 in	380	350	320	290	270	250	220
	s = 12 in	570	520	480	440	400	370	340
	s = 16 in	750	690	640	590	540	490	450
$T_{ult}$ (lb/ft)	s = 8 in	1130	1040	960	880	810	740	670
	s = 12 in	1700	1560	1440	1320	1210	1110	1010
	s = 16 in	2260	2090	1920	1760	1610	1470	1340

**Notes:**

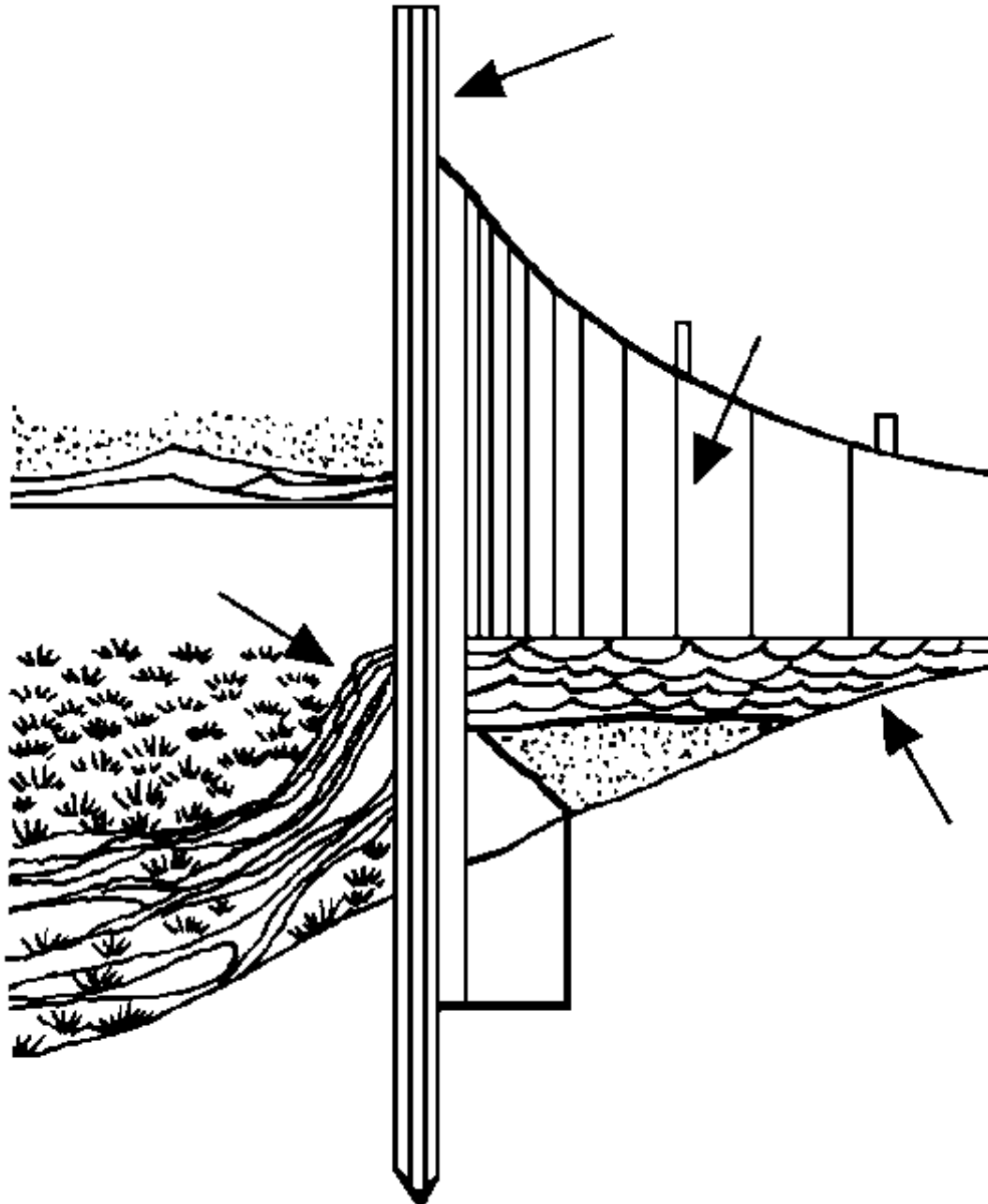
1. Design limit strain,  $\epsilon_d = (1.3 * D_{max}) \%$ , where  $D_{max}$  is the maximum allowable lateral wall movement (in inches).
2.  $T_{ed}$  : required force/width of geosynthetic reinforcement at design limit strain ( $\epsilon_d$ ).
3.  $T_{ult}$  : minimum required ultimate strength of geosynthetic reinforcement.
4. s: vertical spacing of reinforcement.
5. Surcharge pressure = 250 psf (increase  $T_{ed}$  and  $T_{ult}$  each by 22 % for every additional 250 psf surcharge pressure).
6. CTI = Colorado Transportation Institute (Denver, Colorado, USA).

Source: Adapted from Wu, 1994.

# EROSION CONTROL



# Silt Fence









D. Elton



D. Elton

# Erosion Control Netting





**Check Dams**



# Turf Reinforcement Mats



TRM





# Geosynthetic Requirements

- Filtration and Drainage
- UV Resistance
- Biodegradability

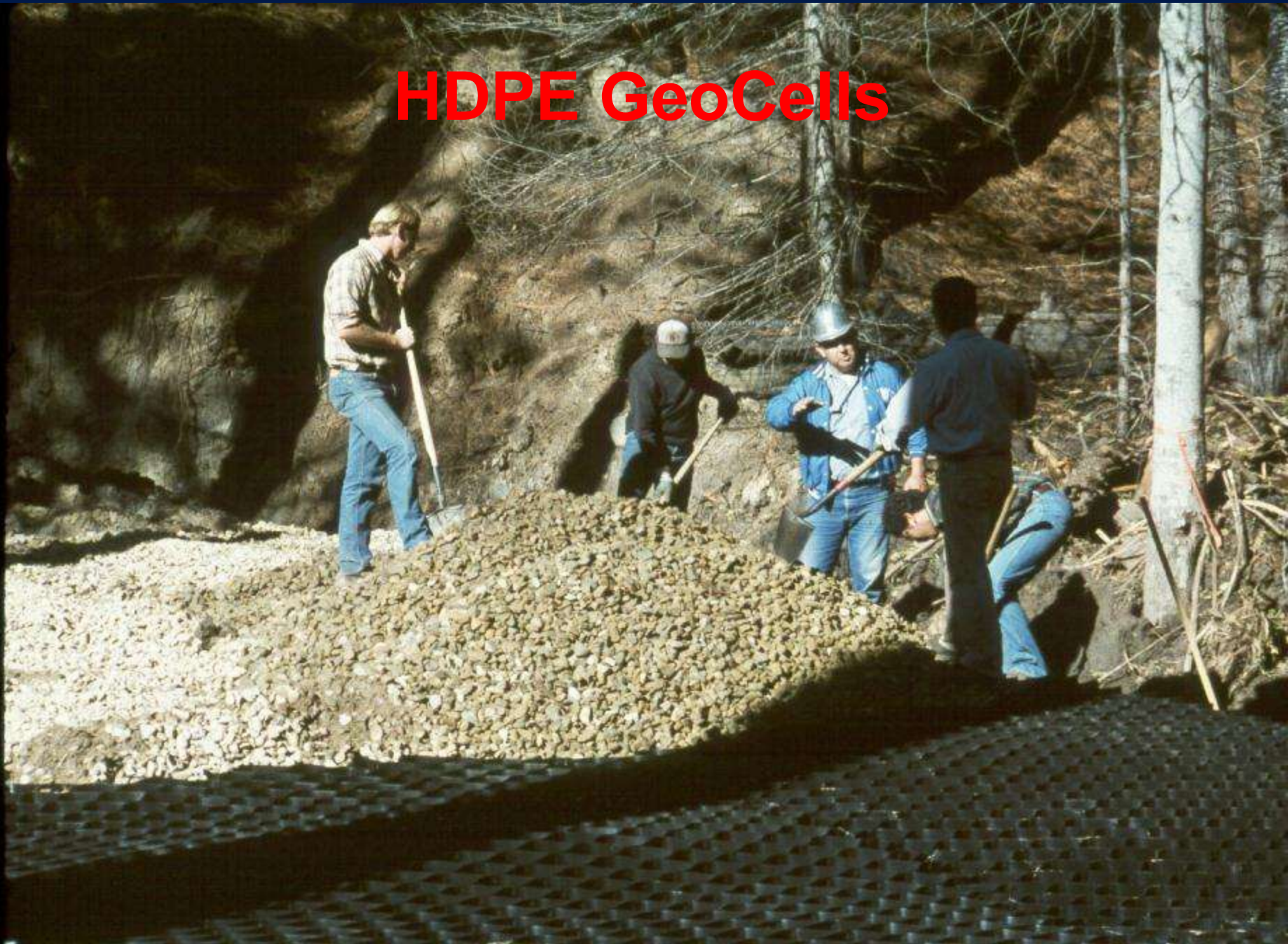
## Commonly Used Materials

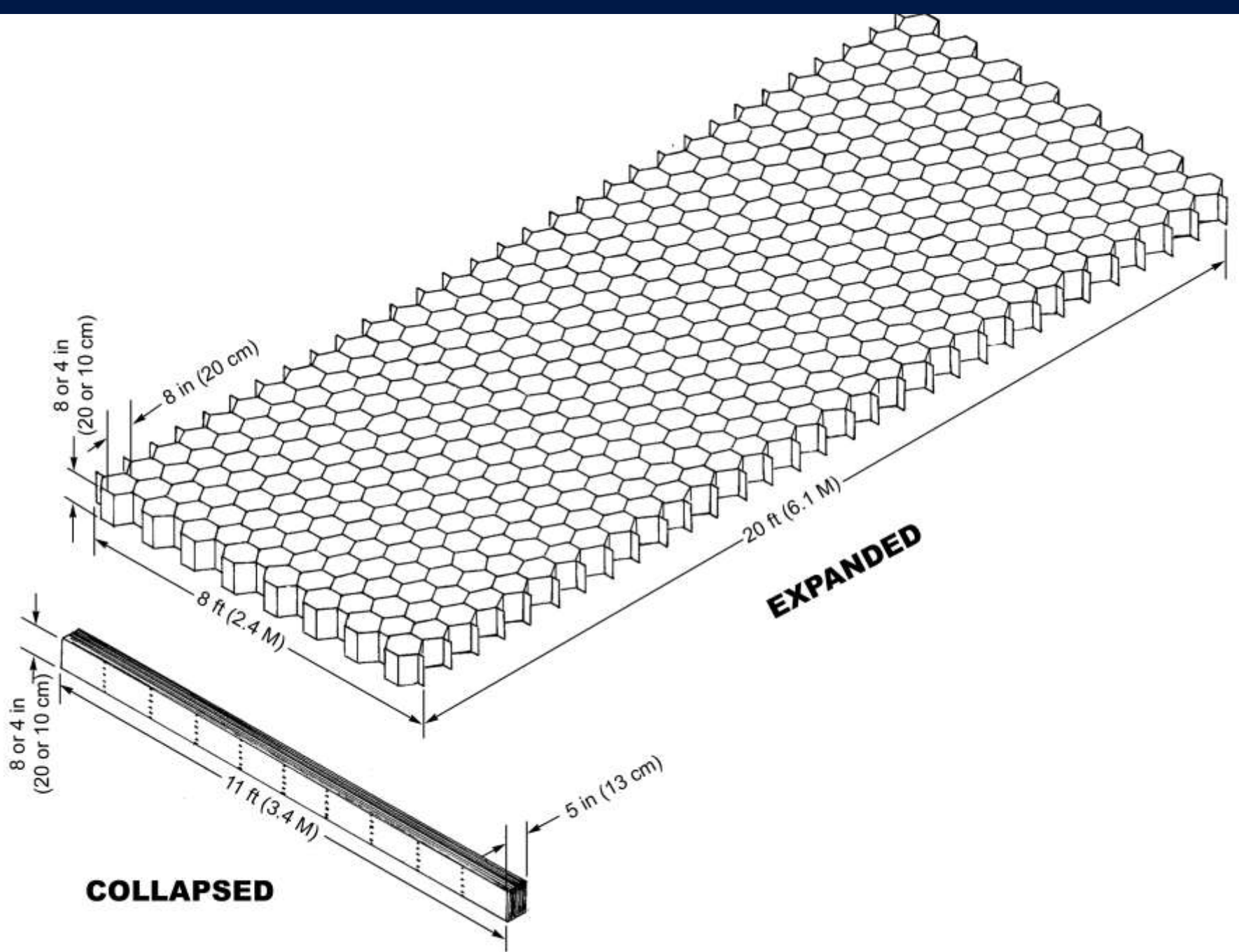
- Slit-Film Wovens
- Woven Monofilament
- Netting



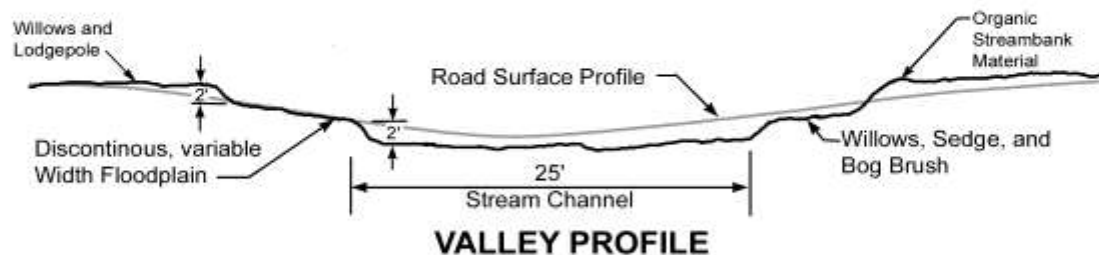
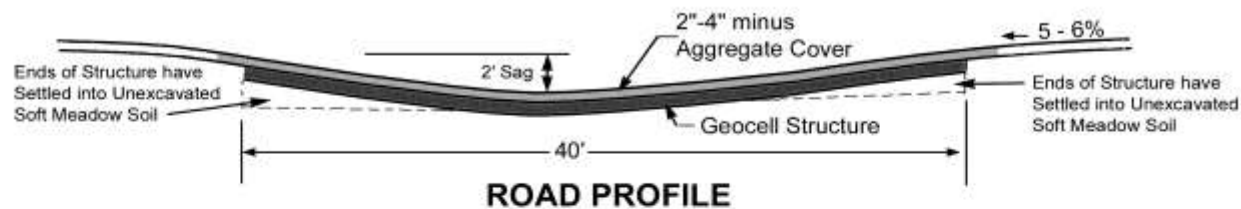
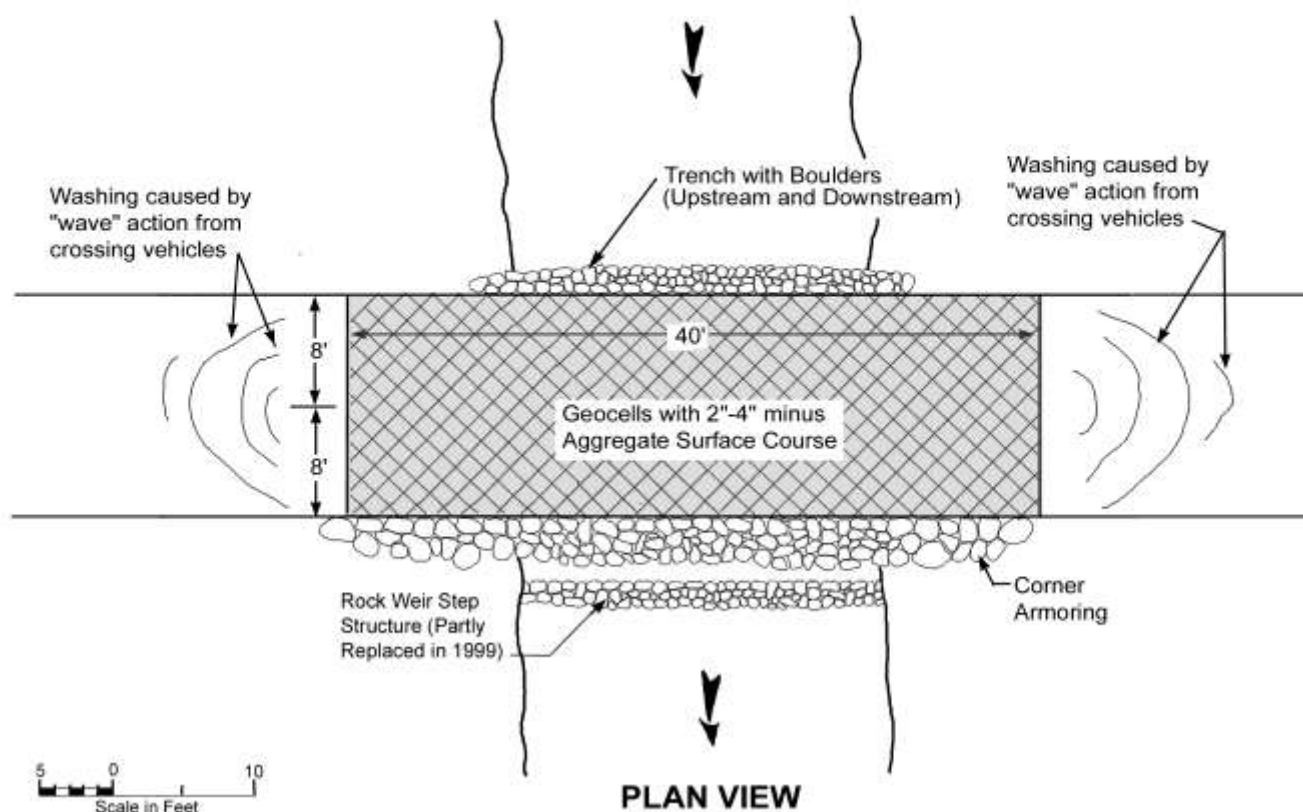


# HDPE GeoCells





**GEOCELLS**





# GeoCell Walls





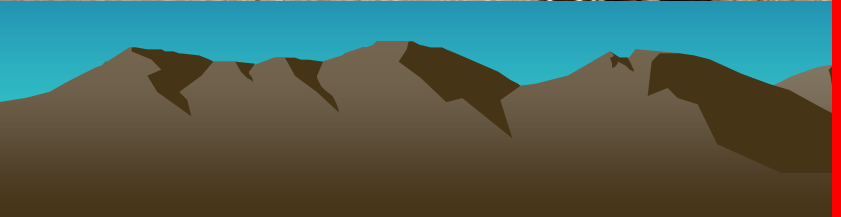


# GeoFoam

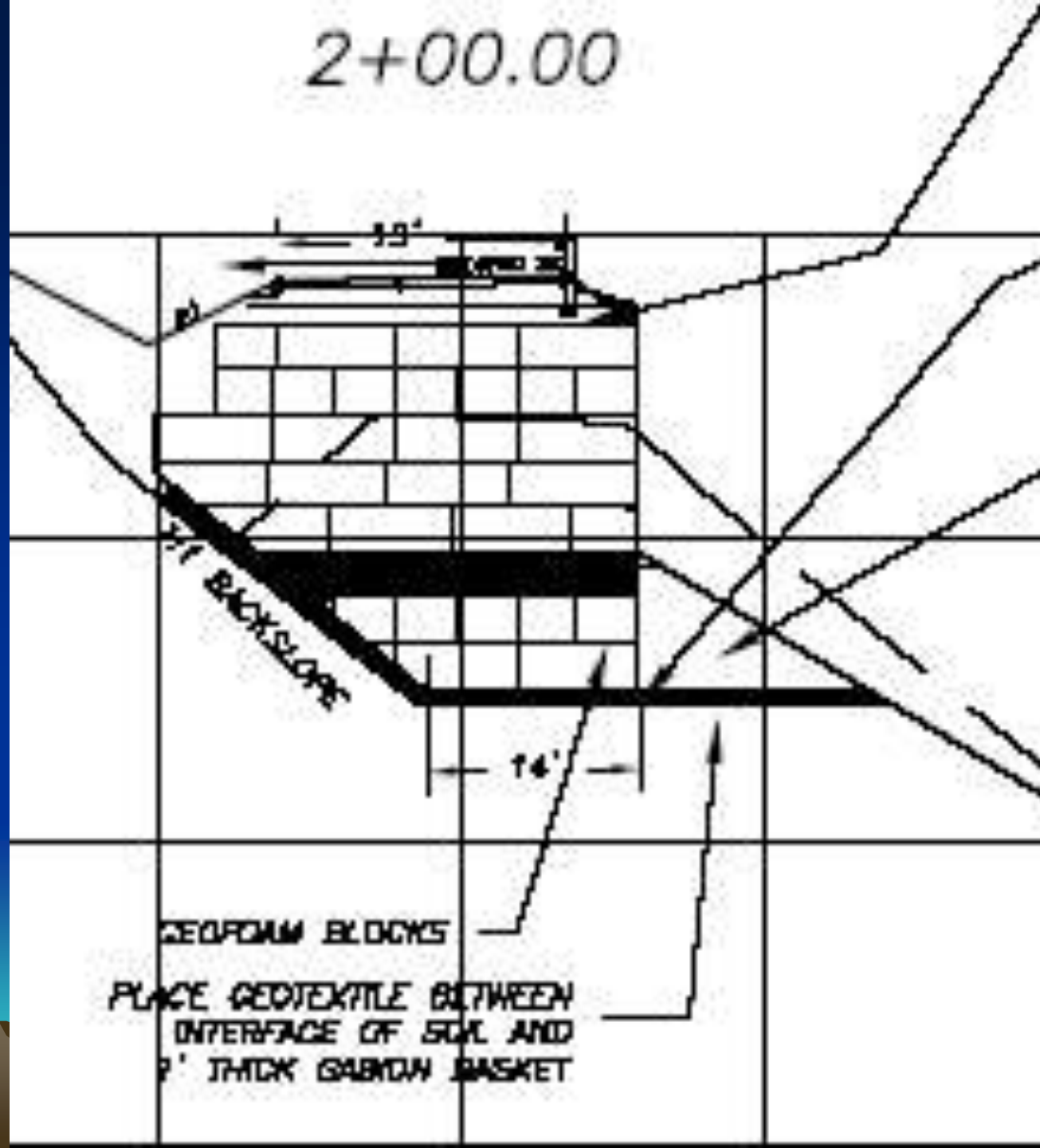




8040  
7' x 8' x 16"  
709 P05056  
11-6-89  
594



2+00.00







**GeoPipe**





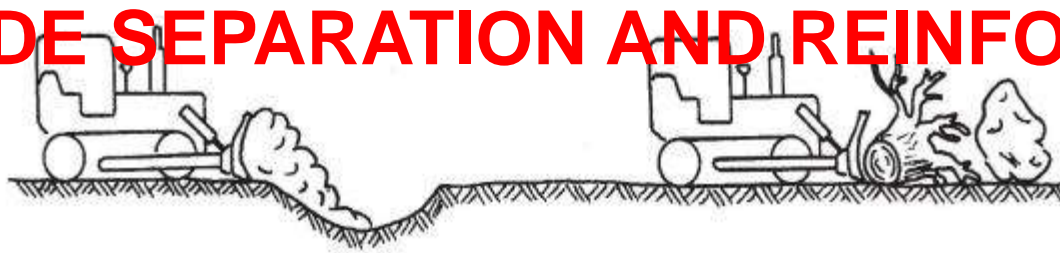




Take it Jeb!!



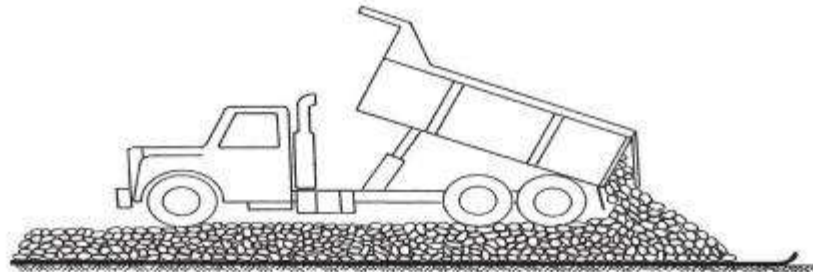
# SUBGRADE SEPARATION AND REINFORCEMENT



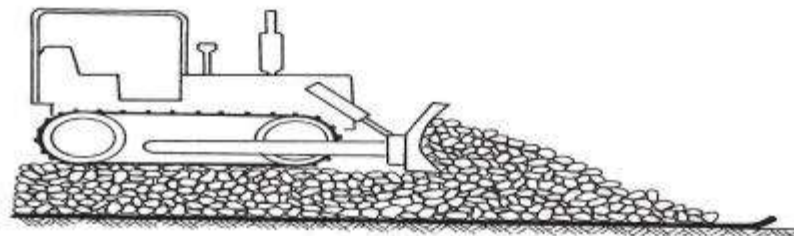
A. Prepare the ground by removing stumps, boulders, etc. Fill in the low spots.



B. Unroll the geotextile directly over the ground to be stabilized. If more than one roll is required, overlap the rolls. Inspect the geotextile and pull it out tight. Stake down as needed.



C. Back dump aggregate onto the previously placed aggregate. Do not drive on the geotextile. Maintain 6 to 12 inches (150 to 300 mm) cover between the truck tires and geotextile.



D. Spread the aggregate over the geotextile to the design thickness. Finally, compact the aggregate using dozer tracks or smooth drum vibratory roller.

Construction sequence using a geotextile over soft subgrade soils.













AMANCO-Colombia





# GeoMembranes





U.S. Department  
of Transportation  
**Federal Highway  
Administration**

Publication No. FHWA HI-95-038  
Revised April 1998

NHI Course No. 13213

# Geosynthetic Design and Construction Guidelines

## Participant Notebook



*National Highway Institute*

**Thank You**





# Questions?

# Thank You!

# Gracias!

# Obrigado!

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