



TRC0305

**Development of Guidelines for  
Construction Best Management  
Practices**

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Final Report

2005

# **FINAL REPORT**

## **BMP EVALUATION REPORT**



**FOR**

**TRC-0305**

**DEVELOPMENT OF GUIDELINES FOR CONSTRUCTION  
BEST MANAGEMENT PRACTICES**

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**DECEMBER 2004**

**(REVISED APRIL 2005)**

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## **Introduction**

Recent promulgation of stormwater discharge regulations by the Environmental Protection Agency (EPA) will have a significant effect on how the Arkansas State Highway and Transportation Department (AHTD) and many communities and counties in Arkansas address erosion control on highway construction projects. The EPA regulations require placement and maintenance of best management practices (BMPs) on construction projects to reduce stormwater pollution to the "maximum extent practicable."

There is little research available to indicate which BMPs will reduce pollution to the maximum extent practicable. Additionally, the geologic and climatic conditions that are particular to Arkansas will have an impact on the efficiency and operation of BMPs. To ensure that the BMPs used by AHTD satisfy the regulators and that the BMPs will reduce stormwater pollution of the streams, rivers, and lakes of Arkansas, it was proposed that a thorough evaluation of currently available BMPs be conducted.

The objective of this research was to compare the effectiveness of four BMPs selected by AHTD in terms of runoff and pollution reduction under Arkansas soil and climatic conditions. A full description of the research is contained in a Master's thesis published by the Department of Civil Engineering at the University of Arkansas. Each BMP was tested seven times under simulated rainfall conditions on an unvegetated slope and the results compared to tests conducted to the unvegetated slope without a BMP. The 40 ft x 10 ft test plots were constructed on a 1V:4H slope and topped with a silty clay loam, which was selected by the AHTD. Each BMP was tested using a rainfall simulator, which produced a rainfall intensity of 4 in/hr for a duration of 30 minutes per event.

## BMP Evaluation Results

The pollutants measured in the runoff from the plots during these tests were: total sediment yield, solids concentration with time, and average suspended solids, ammonia, total phosphorous, COD, and Zinc concentrations.

### Total sediment and runoff yield

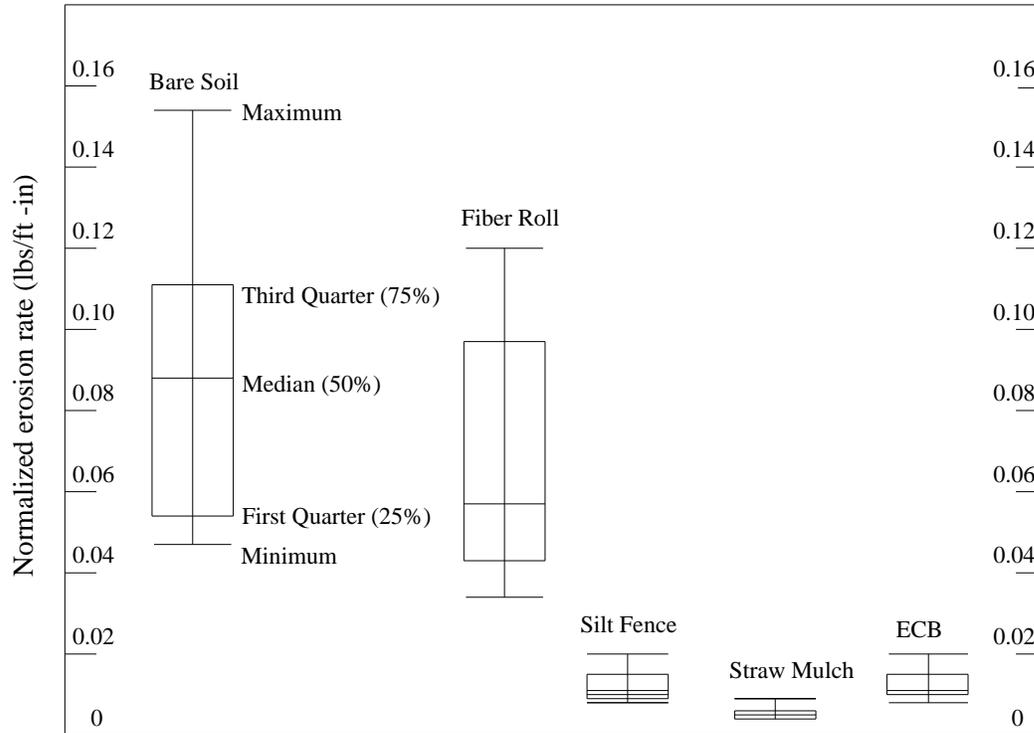
All runoff and associated sediment from the plots was captured in a holding tank and the mass of sediment in the runoff from each test determined. The normalized erosion rates and runoff yields for each of the BMPs and for bare soil are shown in Table 1 and a plot of the same data is presented in Figure 1. The sediment and runoff reduction for each treatment is presented in Table 2.

**Table 1. Normalized erosion rate and runoff yield for treatments.**

Treatment	Measurement <sup>(1) (2)</sup>	Statistic	Value
Bare Soil	Normalized Erosion Rate (lbs/ft <sup>2</sup> /in.)	Mean	0.088
		Standard Deviation	0.037
	Runoff (gallon)	Mean	446
		Standard Deviation	11
		% of Rainfall Volume	89%
Fiber Roll	Normalized Erosion Rate (lbs/ft <sup>2</sup> /in.)	Mean	0.066
		Standard Deviation	0.031
	Runoff (gallon)	Mean	407
		Standard Deviation	11
		% of Rainfall Volume	84%
Silt Fence	Normalized Erosion Rate (lbs/ft <sup>2</sup> /in.)	Mean	0.010
		Standard Deviation	0.001
	Runoff (gallon)	Mean	372
		Standard Deviation	12
		% of Rainfall Volume	74%
Straw Mulch	Normalized Erosion Rate (lbs/ft <sup>2</sup> /in.)	Mean	0.006
		Standard Deviation	0.002
	Runoff (gallon)	Mean	402
		Standard Deviation	12
		% of Rainfall Volume	80%
Erosion Control Matting	Normalized Erosion Rate (lbs/ft <sup>2</sup> /in.)	Mean	0.012
		Standard Deviation	0.004
	Runoff (gallon)	Mean	397
		Standard Deviation	12
		% of Rainfall Volume	79%

<sup>(1)</sup> lbs/sq ft / in – means lbs of sediment per square foot of watershed per inch of precipitation.

<sup>(2)</sup> % of Rainfall Volume – is the volume of runoff expressed as a percent of rainfall applied



**Figure 1. Erosion rates for each soil treatment.**

**Table 2. Erosion and runoff reduction.**

Parameter		Bare soil	Fiber roll	Silt fence	Straw mulch	ECM
Sediment yield <sup>(1)</sup>	Lbs/sq ft/in	0.088	0.066	0.001	0.006	0.012
Sediment yield reduction	--	0.0%	25.0%	88.6%	93.2%	86.4%
Runoff volume	gallons	448	425	372	402	397
Runoff reduction	--	0.0%	5.1%	17.0%	10.3%	11.4%

<sup>(1)</sup> lbs/sq ft / in – means lbs of sediment per square foot of watershed per inch of precipitation.

<sup>(2)</sup> % of Rainfall Volume – is the volume of runoff expressed as a percent of rainfall applied

**Silt Fence.** Although there is little research to justify the practice, specifications from other states require that silt fence be installed at ratio of at least 1:100 (foot of silt fence : sq ft of drainage area). AHTD does not currently have an installation ratio standard. In this phase of this research project, the silt fence was tested at a more at a more conservative installation ratio of 2.5:100. In addition the silt fence was installed to hold all runoff; therefore, there was no by-pass of runoff with any

associated sediment carried past the silt fence. Although holding all runoff behind the silt fence is recommended, often silt fence is not installed properly. Finally, ten feet of silt fence was installed on the test plot by a trained researcher, who undoubtedly was more conscientious in the installed than a laborer installing thousands of feet of silt fence. These three facts would greatly impact the results for silt fence. Although the results for silt fence appear very positive, these results are inconclusive until further research can be conducted on shorter lengths of silt fence (at and below an installation ratio of 1:100).

Fiber Role. As with other construction BMPs, there is little research to on the proper placement of fiber role. The spacing standards in other states vary from every 10 to 40 feet down a slope. This phase of this research project was conducted at the longest recommended spacing (40 feet) and showed that placing one fiber roll at the bottom of the forty foot slope was too large of spacing. Subsequent phases of this research project will be used to determine the proper placement of fiber rolls.

Erosion Control Matting. The erosion control matting (ECM) tested was one of the lightest (in terms of straw in the matting) that is made; yet, it performed very well and had a consistent performance. Correct installation of ECM is simple and requires little training than silt fence and fiber role.

Straw Mulch. The straw mulch was installed according to AHTD standards at a rate of 4000 lbs/acre and was not tacked down during testing. Mulch is the simplest BMP to install correctly and provided excellent results.

### **Average concentration of suspended solids**

To evaluate the ability of each BMP to keep smaller particles of sediment from the runoff or remove small particle of sediment from the runoff, the runoff was captured in a holding tank and the sediment was allowed to settle for five minutes, then the supernatant was sampled for suspended solids. The results from these tests are shown in Table 3.

**Table 3. Average suspended solids of settled runoff.**

<b>Test No.</b>	<b>Bare Soil (g/L)</b>	<b>Fiber Roll (g/L)</b>	<b>Silt Fence (g/L)</b>	<b>Straw Mulch (g/L)</b>	<b>ECM (g/L)</b>
1	17.66	15.71	2.73	2.11	3.70
2	11.47	13.42	1.94	1.81	2.65
3	9.75	8.85	1.90	1.62	2.29
4	10.07	7.72	2.05	1.50	2.08
5	7.36	5.87	1.86	1.60	1.32
6	6.82	6.18	1.74	1.23	1.84
7	6.68	4.83	1.61	1.41	1.25

These results indicate that the average suspended solids in the settled runoff are lowest for straw mulch, silt fence, and ECM; whereas the fiber roll and bare soil have similar results. Again, the fiber roll would have performed better with more rolls placed on the slope and the silt fence might not have performed as well with more runoff area contributing to the length of silt fence tested.

**Average concentration of suspended solids with time**

During each of the seven tests of each BMP, samples of the runoff from the plots were taken every five minutes and evaluated for suspended solids. The results of these tests are presented in Table 4.

**Table 4. Suspended solids concentration in runoff on 5 minute intervals.**

<b>Time (minute)</b>	<b>Bare Soil (g/L)</b>	<b>Fiber Roll (g/L)</b>	<b>Silt Fence (g/L)</b>	<b>Straw Mulch (g/L)</b>	<b>ECM (g/L)</b>
5	20.21	15.48	3.28	1.59	2.71
10	19.37	14.29	2.99	1.46	2.55
15	19.04	14.27	2.78	1.31	2.21
20	17.74	13.29	2.69	1.26	1.95
25	16.13	13.25	2.54	1.23	1.76
30	9.97	9.23	2.30	0.61	0.77
40			1.86		
50			1.60		
60			1.41		
70			1.21		

These results indicate that the amount of suspended sediment in the runoff decreased with time for all BMPs. This was to be expected, as the amount of easily erodible sediment would decrease during each test. A comparison of sediment yield of the BMPs leads to the same conclusion drawn from the results in the sections above.

### Water Quality Parameters

The average concentration of five water quality parameters of the runoff captured in the holding tank during testing of each BMP was determined and the results are presented in Table 5.

**Table 5. Water quality parameters concentration in settled runoff.**

Parameter	Unit	Detect Limit	Bare Soil	Fiber Roll	Silt Fence	Straw Mulch	ECM
pH	S.U.	0.01	8.03	8.02	8.04	8.04	7.98
COD	mg/L		195.3	192.9	147.3	98.3	84.5
Ammonia	mg/L	0.04	0.04	0.043	0.04	0.158	0.137
Phosphorus	mg/L	0.005	0.16	0.21	0.08	0.10	0.11
Zinc	mg/L	0.0004	0.01	0.01	0.01	0.02	0.01

The average concentration of five water quality parameters of the runoff indicate that the erosion control BMPs (straw mulch and ECM) performed better at keeping COD (organic material) and Phosphorus from getting into the runoff. Whereas the straw that makes up these two BMPs introduced some ammonia to the runoff. The results from the Zinc measurements were inconclusive in large part due to the fact that zinc was not present in the soil tested.

### Conclusions & Recommendations

For all pollutants except ammonia, the erosion control BMPs (straw mulch and erosion control matting) performed the best at keeping pollutants from being introduced into the runoff. As tested, silt fence performed well at removing pollutants from the runoff; but, the results are better than should be expected

under field conditions. The pollutant removal performance of fiber roll was low; the researchers feel that this was in part due to testing one placement on the 40 foot slope.

Subsequent phases of this research project will provide more data as to the effectiveness of these four BMPs. Follow up tests for silt fence should be directed at determining a recommended length of silt fence for contributing area for various slopes. Follow up tests for fiber rolls should be directed at a recommended spacing between rolls for different slopes. Follow up tests for erosion control blankets should be directed at determining the recommended straw content for various conditions, including slope. The follow up tests for straw mulch should be directed at a recommended application rate for different slopes. Until subsequent phases of this research project have been completed, no recommendations can be made regarding either which BMPs are most effective or the proper placement of these BMPs.

## **Design and Construction Guidance**

Proper design, placement, and maintenance of stormwater BMPs is necessary to insure that pollutants are kept out of nearby streams. Since BMPs work in different methods, the proper design and placement of them is dependent on the type of BMP. There are two types of construction stormwater BMPs: 1) erosion control, which includes straw mulch and erosion control matting and 2) sediment control, which includes silt fence and fiber rolls.

### **Straw Mulch**

The function of straw mulch is to dissipate the energy imparted by raindrops hitting the ground and to slow the runoff as it works its way down slope. Straw mulch must be thick enough to intercept most raindrops and must stay in-place until live vegetation (e.g., grass) can protect the soil from erosion. To provide enough cover to protect the soil, straw mulch is typically applied at a rate of 1.5 to 2 tons per acre. To ensure that the mulch stays in-place, it is typically applied on slopes less than 1V:3H and must be anchored in-place immediately after application by either mechanical or chemical means. Regular, proper, and timely maintenance is required to keep straw mulch effective at preventing erosion.

### **Erosion Control Matting**

The function of erosion control matting (ECM) is to dissipate the energy imparted by raindrops hitting the ground and to slow the runoff as it works its way down slope. ECM must be thick enough to intercept most raindrops and must stay in-place until live vegetation (e.g., grass) can protect the soil from erosion. Because ECMs are a manufactured product, numerous types of ECMs are available from over 15 US manufacturers. The material the ECM is manufactured from, the amount of material the ECM is made of, and the method of securing the ECM to the soil are provided by the manufacturer. Regular, proper, and timely maintenance is required to keep ECM effective at preventing erosion.

### **Silt Fence**

The function of silt fence is to capture runoff that is carrying sediment and allow the sediment to settle out of suspension by providing an area for the runoff to pool.

Silt fence should only be placed to capture sheet flow and rill flow (very shallow flows) and should not be used to try to capture concentrated flows (gully or channel flows). To capture flow, silt fence should be run along a contour not across contours and should be curled uphill for five to ten feet on each end to pool runoff behind the silt fence. The drainage area to the fence (not including the uphill curled ends) should be 1:100 (ft of silt fence to sq ft of drainage area). The silt fence must be securely embedded in the soil to ensure that the captured water does not wash under it. Regular, proper and timely maintenance is required to keep silt fence effective at removing sediment from runoff.

### **Fiber Roll**

The function of fiber roll is to capture runoff that is carrying sediment and allow the sediment to settle out of suspension by providing an area for the runoff to pool. Fiber roll should only be placed to capture sheet flow and rill flow (very shallow flows) and should not be used to try to capture concentrated flows (gully or channel flows). To capture flow, fiber roll should be run along a contour not across contours and should be curled uphill for five feet on each end. The drainage area to the roll (not including the uphill curled ends) should be 1:20 or 1:10 (ft of fiber roll to sq ft of drainage area) depending on the slope. The fiber roll must be partially buried and secured in the soil to ensure that the captured water does not wash under it. Regular, proper and timely maintenance is required to keep fiber roll effective at removing sediment from runoff.

## **Model BMP Specifications & Details**

The AHTD currently has standard specifications for mulch, erosion control matting, and silt fence. In this section, the AHTD Standard Specification for each BMP is given and then followed by comments to consider for changes. Standard specifications for fiber roll were derived from the Caltrans BMP Guidance Manual and manufacturer's specifications. The AHTD Standard Specifications format was followed with sections on materials, installation, maintenance, measurement, and basis of payment are given for each BMP. Details for each BMP are presented in the section of this report titled Details.

### **Mulch**

#### Materials.

Specifications for the composition of mulch are given in Section 620.02 of the AHTD Standard Specifications.

(d) Mulch cover shall consist of straw from threshed rice, oats, wheat, barley, or rye; of wood excelsior; or of hay obtained from various legumes or grasses, such as lespedeza, clover, vetch, soybeans, Bermuda, carpet sedge, bahia, fescue, or other legumes or grasses; or a combination thereof. Mulch shall be dry and reasonably free from Johnson grass or other noxious weeds, and shall not be excessively brittle or in an advanced state of decomposition. All material will be inspected and approved prior to use.

This is a well written specification. A specification could be added to allow additional mulches such as wood chips, bark, and plant residue. By allowing or requiring that vegetation that has been cleared from the construction site be used for mulching, AHTD can utilize some of the on-site material and discontinue allowing burning of that material and lessen air pollution from AHTD projects. But, use of this vegetation can cause problems with growth of grasses due to low pH and nitrogen content of the soil; so, this mulch should not be used in conjunction with areas that have been seeded.

#### Installation

The construction requirements of mulch are given in Section 620.03 of the AHTD Standard Specifications.

**(d) Mulch Cover.** Mulch cover shall be applied at the rate of 4000 pounds per acre (4500 kg/ha) immediately after seeding and shall be spread uniformly over the entire area by approved power mulching equipment. When approved by the Engineer, the Contractor may use hand methods to apply mulch cover to small or inaccessible areas. If the Contractor so elects, an approved mulching machine may be used whereby the application of mulch cover and tackifier may be combined into one operation. If this method is used, no change in application rates will be allowed. In its final position, the anchored mulch shall be loose enough to allow air to circulate, but compact enough to partially shade the ground and reduce the impact of rainfall on the surface of the soil. Care shall be taken to prevent tackifier materials from discoloring or marking structures, pavements, utilities, or other plant growth. Removal of any objectionable discoloration shall be at no cost to the Department.

**(e) Mulch Anchoring.** Immediately following or during the application of the mulch cover on seeded areas, the mulch shall be anchored by one of the following methods:

- **Tracking or Roller Method.** The mulch shall be effectively pressed into the soil using steel cleated track or cleated roller equipment. The anchoring shall be performed so that the grooves formed are perpendicular to the flow of water down backslopes and foreslopes. The equipment and method used shall produce acceptable results.
- **Asphalt Tackifier.** Asphalt shall be applied at the rate of approximately 0.05 gallon per square yard (0.2 L/sq m). Application shall be made using a pressure distributor to ensure constant and uniform distribution. The use of asphalt may be reduced or eliminated by the Engineer at selected locations.
- **Other Tackifiers.** Tackifiers listed on the QPL shall be applied according to the rates recommended in the QPL.

The method used shall be at the Contractor's option unless otherwise specified or directed. In lieu of separate application of tackifiers, the Contractor may use equipment that combines the application of mulch and tackifier into one operation. Application shall be at the specified rates.

Although it may be stated elsewhere, there is no mention of the allowable slope for application of different types of mulches. It is recommended that non-hydraulically applied mulches (e.g., straw, wood excelsior; or hay) be applied on slopes flatter than 1V:3H.

The specification does not allow for hydraulic mulches (e.g., bonded fiber matrix), which although they are more expensive than non-hydraulically applied mulches have been used very successfully on steep slopes. Addition of hydraulically applied mulches to the Standard Specifications would require that those company's products be approved and placed on the QPL.

Although the specification of 4000 pounds of mulch per acre is conservative as compared to typically recommended values, it is based on straw and does not necessarily guarantee adequate coverage. Whereas, specifying 95% coverage, no matter what mulch material is used would provide better erosion control for all mulch materials.

Since it is not possible to anchor the mulch until after it is applied and since in some instances it may be necessary to use two methods of anchoring, the requirement of anchoring could read,

“Immediately following the application of the mulch cover, the mulch shall be anchored by one or more of the following methods:”

#### Maintenance

The AHTD does not currently have Standard Specifications regarding maintenance of mulch. Requiring that the contractor maintain 95% coverage until the job is accepted or until live grass provides 95% coverage would provide better erosion control. In addition, the specification should state how long the mulch cover should be maintained (e.g. until the project is accepted or until live vegetation provides 95% coverage).

#### Measurement

The specifications for the measurement of mulch cover are given in Section 620.04 of the AHTD Standard Specifications.

(c) Mulch Cover will be measured by the acre (hectare) of actual area covered.

It is assumed that “actual area” means the measurements are taken on the contour of the ground and not on the horizontal (plan view). If there is no misunderstanding between AHTD and its contractors then this specification is fine.

## Basis of Payment

The specifications for the basis of payment of mulch are given in Section 620.05 of the AHTD Standard Specifications.

(c) Mulch cover completed and accepted and measured as provided above will be paid for at the contract unit price bid per acre (hectare) for Mulch Cover, which price shall be full compensation for furnishing, hauling, and applying mulch material; for mulch anchoring; and for all labor, equipment, tools, and incidentals necessary to complete the work.

There is no mention of maintenance of the mulch cover, which could leave AHTD open for the contractor to request payment for maintaining the cover.

## **Erosion Control Matting**

### Materials.

The specifications for the composition of erosion control matting are given in Section 626.02 of the AHTD Standard Specifications, which specifies the AHTD's QPL (Qualified Products List).

**Materials.** Materials shall be furnished according to AHTD Class 1, Class 2, and Class 3. All materials shall be listed on the QPL.

The Class of matting shall be as shown on the plans and/or as specified in the project specifications. The type matting used within a particular Class shall be at the option of the Contractor, unless otherwise specified. Any matting from a higher numbered class may be used in lieu of the matting specified, but at no additional cost to the Department.

[A listing of approved products is provided in the QPL]

Method of Documentation of Acceptance: By brand and manufacturer.

Method of Approval for Materials to be added to this Qualified Products List:

1. The erosion control matting is matting of a natural or synthetic woven material or a natural or synthetic nonwoven material. The materials shall be held together either with netting, fused together, and/or adhesively bonded together to form a mat.

2. The following are requirements for erosion control matting:

(a) Class 1 Matting. Class 1 matting acts to promote seed germination and control erosion on slopes of 3:1 or flatter under all soil conditions. In general, this class of matting includes natural, synthetic, or synthetic and natural matting; wood fiber mulches (applied at

a minimum of 3.4 mton/hectare, 1.5 tons/acre, with a tackifier); and heavily applied straw mulch (minimum of 9 mton/hectare, 4 tons/acre, with a tackifier). The biodegradable life (include UV stable) of the matting shall be a minimum of 6 months.

(b) Class 2 Matting. Class 2 matting acts to control erosion as a liner for channels and ditches and on slopes of 2:1 or flatter under all soil conditions. In general, this class of matting includes woven matting made of natural, synthetic, or synthetic and natural materials. The biodegradable life (include UV stable) of the matting shall be a minimum of 12 months.

(c) Class 3 Matting. Class 3 matting acts to control erosion as a liner for channels and ditches. This class is for use in areas of high susceptibility to erosion. Class 3 matting shall have a biodegradable (include UV stable) life of 5 years and the matting shall be able to withstand minimum limiting shear stresses of .096 kN/m<sup>2</sup> (2.0 lbs/ft<sup>2</sup>) over bare soil for 50 hours.

[A listing of manufacturers and contact information is provided in the QPL]

There are few specific requirements regarding the composition and configuration of ECM in the AHTD Standard Specifications; therefore, quality control is within the product approval process. Placing minimum requirements for ECM in the Standard Specifications would make the requirements public. Besides the requirements given in the QPL, other requirements could include: 1) weed free straw, 2) mesh photodegradability, 3) mesh biodegradability, 4) mesh size, 5) mesh composition, 6) mat thickness, 7) length of fibers, 8) weight per mat area, 9) allowable stitching, 10) minimum mat width. In addition, ASTM has standards for Erosion Control Blankets (D6475-00, Standard Test Method for Measuring Mass Per Unit Area of Erosion Control Blankets; and D6459-99, Standard Test Method for Determination of Erosion Control Blanket (ECB) Performance in Protecting Hillslopes from Rainfall-Induced Erosion) that could be incorporated into AHTD Standards Specifications.

### Installation

The construction requirements of ECM are given in Section 626.03 of the AHTD Standard Specifications.

**626.03 Construction Requirements.** The matting shall be applied after the area has been properly shaped, fertilized, and seeded as specified on the plans.

The materials shall be applied according to the manufacturer's recommendations. Size and gage of staples, staple spacing, overlap of materials, direction of matting, etc., shall follow the manufacturer's instructions for installation for the site conditions. The Contractor shall supply the Engineer with manufacturer's guidelines before installation.

The Contractor shall maintain the matting areas until all work on the entire project has been completed and accepted

This is a common method of specifying installation of ECM; but, the Standard Specifications could include: 1) site preparation requirements, 2) minimum trenching requirements, and 3) minimum overlap requirements.

### Maintenance

The specifications for the maintenance of ECM are given in the last sentence in Section 626.03 (see above), Section 621.03, and Section 626.04 of the AHTD Standard Specifications.

**621.03 Construction Requirements. (a) General.** The Contractor shall actively maintain the areas or items constructed under this subsection from the time of their completion until final stabilization of the area has been accomplished. Additional work and materials required because of loss from erosion or other causes beyond the Contractor's control will be paid for unless they were required due to Contractor's negligence, in which case the maintenance shall be at no cost to the Department.

**626.04 Restoration.** Additional work and materials required because of loss through erosion will be paid for under the pertinent contract items. Additional work and materials required due to the Contractor's negligence in maintaining the completed work shall be accomplished at no cost to the Department.

This specification allows the contractor to charge AHTD for replacement of ECM "because of loss through erosion." Therefore, AHTD is put in the possible position of having to pay for loss due to incorrect installation and lack of maintenance on the contractor's part and having to determine what is negligence on the contractor's part. Possibly, it would be better to require the contractor to maintain ECM without additional compensation. In addition, if a Class 1 ECM is placed in the winter and vegetation does not develop enough to protect the soil before the ECM degrades (photo or bio), the AHTD could have to pay to replace the ECM

even though scheduling by the contractor caused the problem.

Measurement

The specifications for the measurement of ECM are given in Section 626.05 of the AHTD Standard Specifications.

**626.05 Method of Measurement.** Matting will be measured by the square yard (square meter) of actual area covered.

It is assumed that “actual area” means the measurements are taken on the contour of the ground and not on the horizontal (plan view). If there is no misunderstanding between AHTD and its contractors then this specification is fine.

Basis of Payment

The specifications for the basis of payment of matting are given in Section 626.06 of the AHTD Standard Specifications.

**626.06 Basis of Payment.** Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per square yard (square meter) for Erosion Control Matting of the Class specified, which price shall be full compensation for furnishing all labor, materials, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
Erosion Control Matting (Class_____)	Square Yard (Square Meter)

There is no mention of maintenance of the mulch cover, which could leave AHTD open for the contractor to request payment for maintaining the cover.

**Silt Fence**

The function of silt fence is given in Section 621.01

(e) **Silt Fence.** This item consists of placing and securing a geotextile fabric to an existing support system or constructing a self-supporting geotextile fence where shown on the plans or as directed by the Engineer for the purposes of impeding the flow of water carrying silt toward existing streams and/or across adjacent property; redirecting the flow of silt-laden water to a sediment basin; and/or routing clean water through the construction area.

This definition is different than what is typically used in the industry in that silt fence is not well suited to “redirecting the flow” or “routing clean water” because it does not provide protection for the channel bottom and use of silt fence as a diversion structure can cause significant channel erosion. In addition, contractors will come to believe that silt fence should be used to divert water and not understand what silt fence is designed to do, which is to pond water, allow sediment to settle out, and for runoff to infiltrate into the ground or filter through the fabric.

There are two types of silt fence as defined in Section 625.02 of the AHTD Standard Specifications.

**625.02 Materials.** Geotextile fabric shall be a woven or non-woven synthetic fiber fabric listed on the Department’s Qualified Products List and complying with AASHTO M 288, as follows:

Type 3 shall comply with the requirements for Temporary Silt Fence, Supported Silt Fence. This geotextile is used as a vertical, permeable interceptor designed to remove suspended soil from overland water flow and shall be supported between posts with wire or polymeric mesh.

Type 4 shall comply with the requirements for Temporary Silt Fence, Unsupported Silt Fence (Self-Supporting). This geotextile is used as a vertical, permeable interceptor designed to remove suspended soil from overland water flow.

### Materials.

Specifications for the requirements of silt fence are given in Section 625.02 of the QPL.

#### For Type 3 Silt Fence

[A listing of approved silt fence is given in the QPL. For each listing the permittivity and apparent opening size is given. Permittivities range from 0.07 to 2.1 (1/sec) and

apparent opening sizes range from 0.6 to 0.212 (mm)]

#### For Type 4 Silt Fence

[A listing of approved silt fence is given in the QPL. For each listing the permittivity and apparent opening size is given. Permittivities range from 0.05 to 1.5 (1/sec) and apparent opening sizes range from 0.212 to 0.6 (mm)]

By specifying that silt fence complies with AASHTO M 288 and requiring product approval, the AHTD Standard specifications for silt fence meet industry standards.

#### Installation

The construction requirements for silt fence are given in Section 621.03.

(f) Geotextile fabric for silt fence shall be attached to the supporting system in such manner that it will remain attached and fully supported for the entire time the barrier is needed for service.

The fabric toe shall be buried to secure the base as shown on the plans. Splices shall be securely fastened. Re-anchoring of the toe of the installed silt fence and re-securing the geotextile fabric to the supports shall be considered normal maintenance and will be considered included in the unit price bid for silt fence.

These basic specifications could be expanded to include: 1) placement instructions (e.g. only in areas with sheet flow runoff, at the bottom of a slope, and only along a contour and not across contours), 2) maximum allowable contribution area per foot of silt fence (e.g. 100 sq ft. per foot of silt fence or less based on the slope of the drainage area), 3) placement of posts versus direction of slope, 4) splice requirements (e.g. at posts with a minimum of six inches of overlap, properly sealed), 5) maximum spacing of posts, 6) minimum fabric embedment requirements, 6) requirements to curve ends of silt fence uphill to allow ponding, and 7) required end treatments to lessen erosion caused by excess water overflowing the silt fence impoundment. ASTM has a standard for installation of silt fence (D6462-99) that could be used or incorporated into the AHTD Standard Specification.

## Maintenance

The specifications for maintenance of silt fence are given in Section 621.03.

**621.03 Construction Requirements. (a) General** The Contractor shall actively maintain the areas or items constructed under this subsection from the time of their completion until final stabilization of the area has been accomplished. Additional work and materials required because of loss from erosion or other causes beyond the Contractor's control will be paid for unless they were required due to Contractor's negligence, in which case the maintenance shall be at no cost to the Department.

This specification allows the contractor to charge AHTD for replacement of silt fence "because of loss from erosion or other causes." Therefore, AHTD is put in the possible position of having to pay for loss due to incorrect installation and lack of maintenance on the contractor's part and having to determine what is negligence on the contractor's part. Possibly, it would be better to require the contractor to maintain the silt fence without additional compensation.

## Measurement

The specifications for measurement of silt fence are given in Section 621.04.

(e) Silt Fence will be measured by the linear foot (meter) complete in place.

This is the typical method of measurement.

## Basis of Payment

The specifications for basis of payment for silt fence are given in Section 621.05

(e) Silt Fence completed and accepted and measured as provided above will be paid for at the contract unit price bid per linear foot (meter) for Silt Fence.

There is no mention of maintenance of the silt fence, which leaves open the possibility that the contractor could ask for payment to maintain the silt fence.

## **Fiber Roll**

AHTD does not currently use fiber roll for sediment control; therefore,

specifications for Caltrans and manufacturers were used as guidance in this section.

### Materials.

The materials for fiber roll are typically specified very similarly as with erosion control matting (ECM); in fact, many agencies allow ECM to be rolled and used as fiber roll. A suggested specification is as follows:

Fiber rolls shall be a straw-filled tube of flexible netting material or rolled erosion control matting. The straw filler shall be certified weed free forage. The netting shall consist of seamless, high-density polyethylene and ethyl vinyl acetate and contain ultra violet inhibitors.

### Installation

A suggested installation specification is as follows:

Proper site preparation is essential to ensure complete contact of the fiber roll with the soil. The slope should be prepared to receive the surface mulching/re-vegetation treatment prior to installation of the erosion control and fiber rolls. Remove all rocks, clods, vegetation or other obstructions so that the installed fiber roll will have direct contact with the soil. A small trench 8-10 cm (2-3 inches) in depth should be excavated on the slope contour and perpendicular to water flow. Soil from the excavation should be placed down-slope next to the trench.

Install the fiber rolls in the trench, insuring that no gaps exist between the soil and the bottom of the fiber roll. The ends of adjacent fiber roll should be tightly abutted so that no opening exists for water or sediment to pass through. Alternately, fiber rolls may be lapped, 6" minimum to prevent sediment passing through the field joint.

Wooden stakes should be used to fasten the fiber rolls to the soil. When conditions warrant, a metal rod can be used to drive a "pilot hole- through the fiber roll and into the soil.

Wooden stakes should be placed 6" from the fiber roll end angled towards the adjacent fiber roll and spaced at 1.2 meter centers (4 feet) leaving less than 3-5 cm (1-2 inches) of stake exposed above the fiber roll. Alternately, stakes may be placed on each side of the fiber roll tying across with a natural fiber twine or staking in a crossing manner ensuring direct soil contact at all times.

Terminal ends of fiber roll shall be turned up slope to ensure containment

and prevent channeling of sedimentation.

Backfill the upslope length of the fiber roll with the excavated soil and compact.

### Maintenance

A suggested maintenance specification is as follows:

The fiber rolls shall be inspected after installation to insure that they are trenched-in and that no gaps exist under the fiber roll or between adjacent ends of the fiber roll.

Fiber rolls shall be inspected after significant rainfall events. Rills or gullies upslope of the fiber roll and any undercutting is to be repaired.

Sediment deposits that impair the filtration capability of the fiber roll shall be removed when the sediment reaches one-third of the fiber roll's functional freeboard height. Removed sediment shall be deposit within the project in such a way that the sediment is not subject to erosion by wind or water, or as directed by the Engineer.

### Measurement

A suggested measurement specification is as follows:

Fiber roll will be measured by the linear foot (meter) complete in place.

### Basis of Payment

A suggested basis of payment specification is as follows:

Fiber roll completed, accepted, maintained as required, and measured as provided above will be paid for at the contract unit price bid per linear foot (meter) for fiber roll.

## Estimated Installation Prices

In the original proposal for this research, it was proposed to survey the construction companies doing business with AHTD to determine in-place prices for the BMPs evaluated in this research. During the subsequent negotiations on the content of the research, the AHTD committee indicated that AHTD has prices from its contracts for all the BMPs it has used and did not need a survey of contractors. The information below is compiled from the prices AHTD makes public on its website plus the 2003 Caltrans construction costs published on its website.

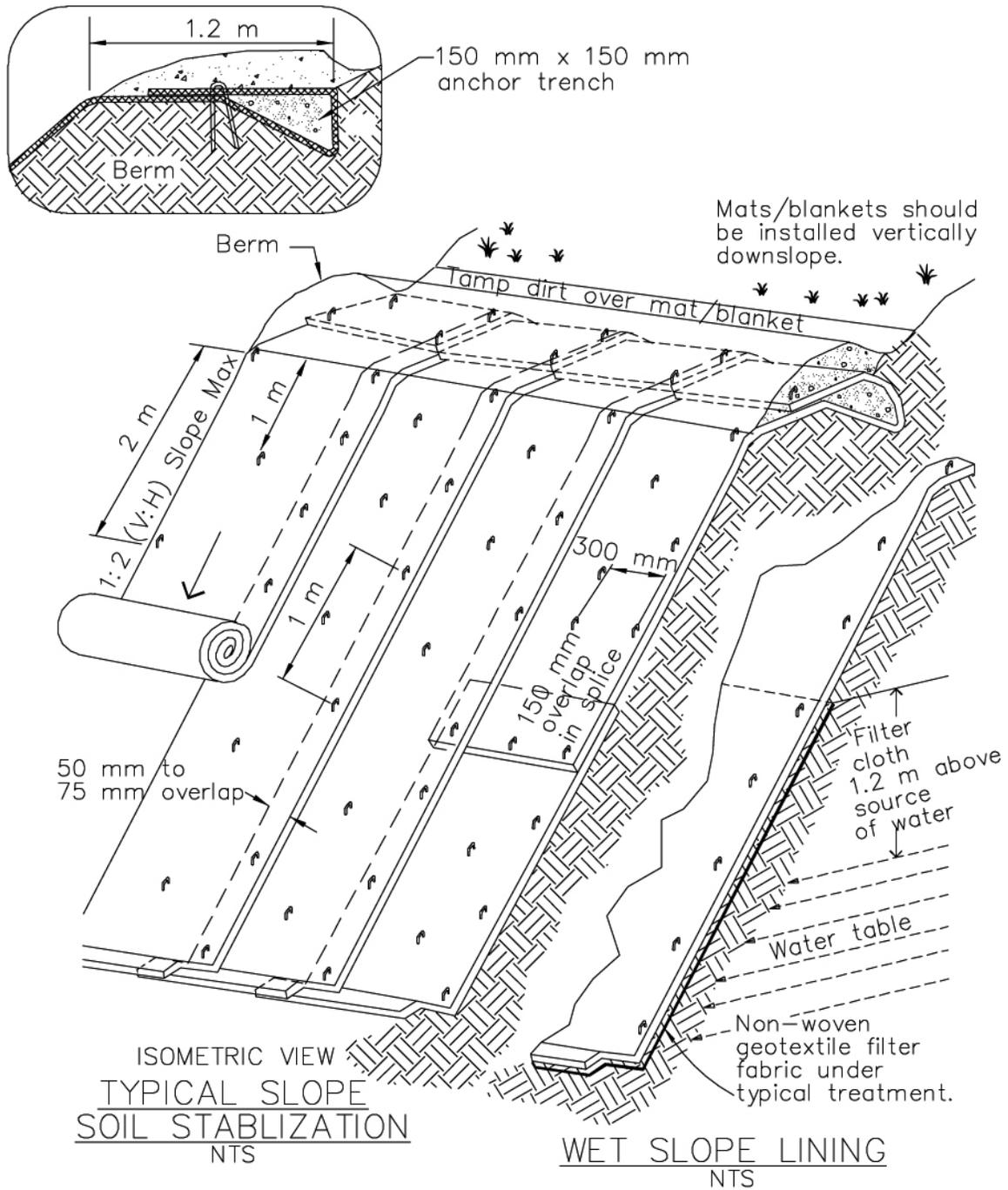
BMP	Unit of Measure	2004 AHTD Published Cost			2003 Caltrans Cost from Caltrans	
		high	low	w. avg.	high	low
Mulch	ACRE	\$ 5,000.00	\$ 200.00	\$ 654.31		
Erosion Control Mat-1	SQYD	\$ 2.00	\$ 2.00	\$ 2.00		
Erosion Control Mat-2	SQYD	\$ 9.45	\$ 2.25	\$ 2.96		
Erosion Control Mat-3	SQYD	\$ 12.60	\$ 4.73	\$ 6.54		
Silt Fence	LF	\$ 10.00	\$ 1.80	\$ 2.65		
Fiber Roll	LF				\$ 6.72	\$ 2.00

## **Details**

AHTD has details for erosion control matting (ECM) and silt fence; whereas, mulch typically does not have details. Details are provided for ECM and silt fence for comparison with AHTD details. All details provided are from the Caltrans "Construction Site Best Management Practices (BMPs) Manual" at:

[http://www.dot.ca.gov/hq/construc/stormwater/CSBMPM\\_303\\_Final.pdf](http://www.dot.ca.gov/hq/construc/stormwater/CSBMPM_303_Final.pdf)

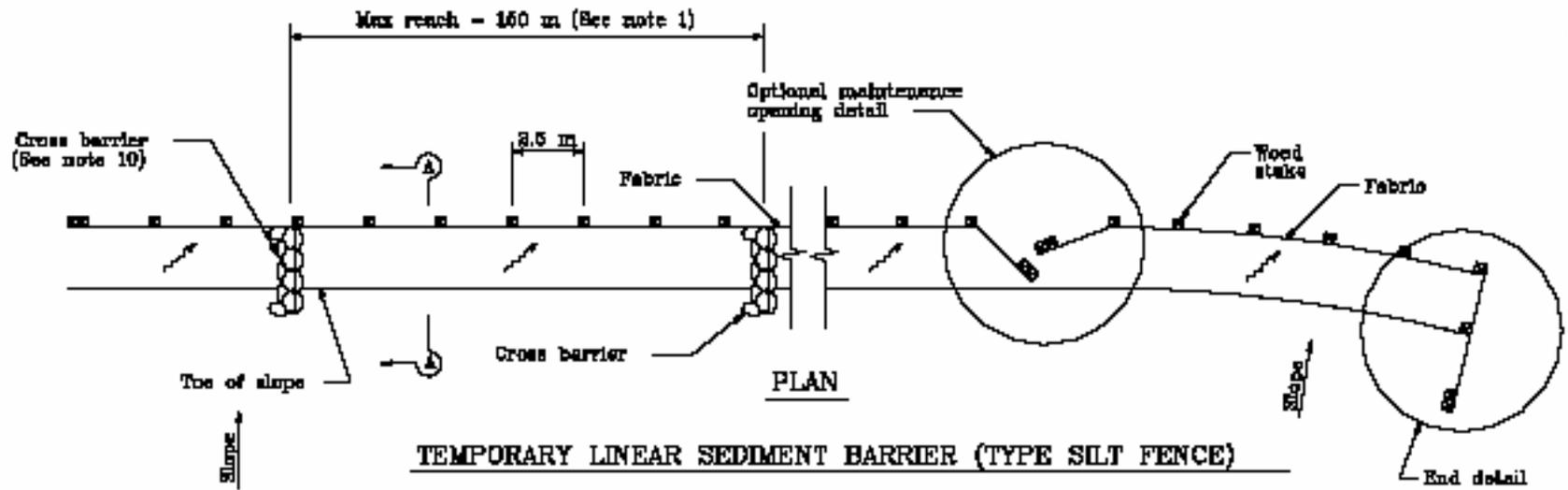
## Erosion Control Matting

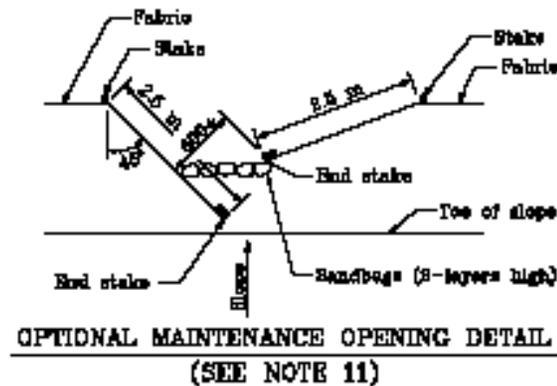
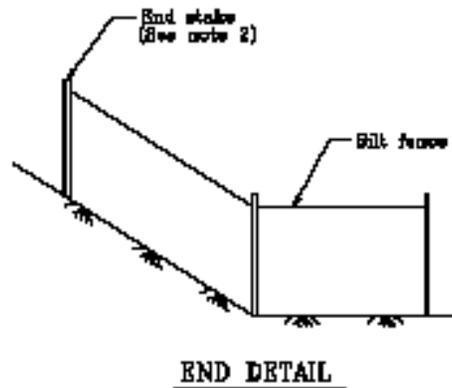
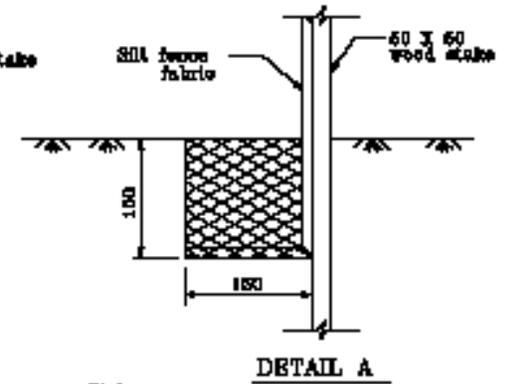
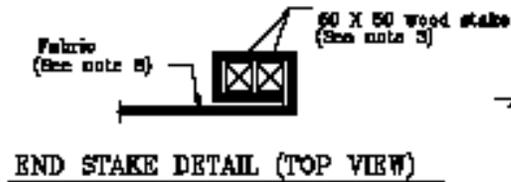
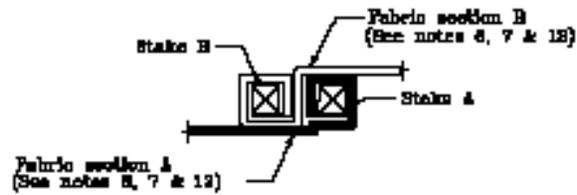
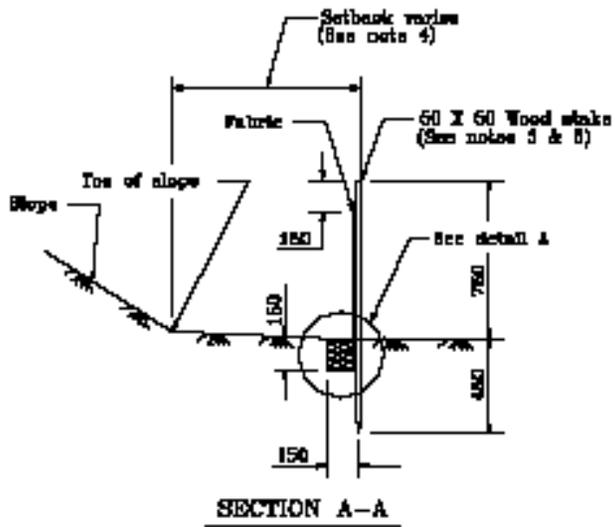


### NOTES:

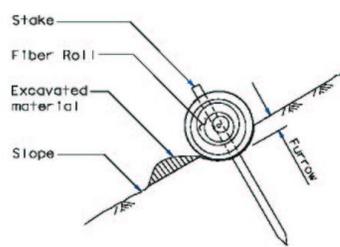
1. Slope surface shall be free of rocks, clods, sticks and grass. Mats/blankets shall have good soil contact.
2. Lay blankets loosely and stake or staple to maintain direct contact with the soil. Do not stretch.
3. Install per manufacturer's recommendations

# Silt Fence

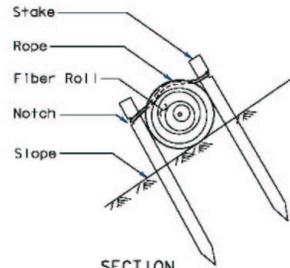




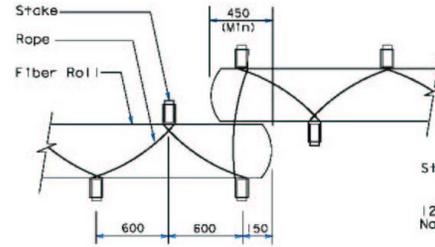
# Fiber Roll



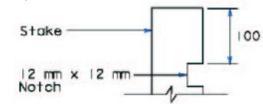
SECTION  
TEMPORARY FIBER ROLL  
(TYPE 1)



SECTION  
TEMPORARY FIBER ROLL  
(TYPE 2)

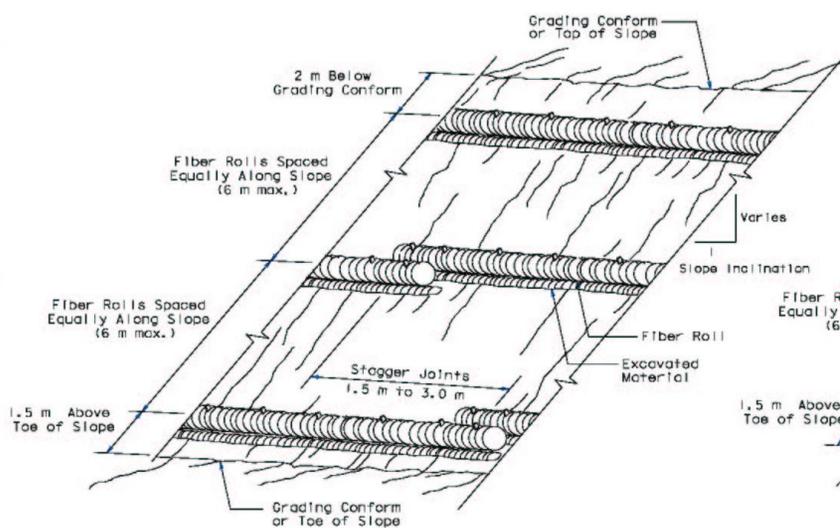


PLAN

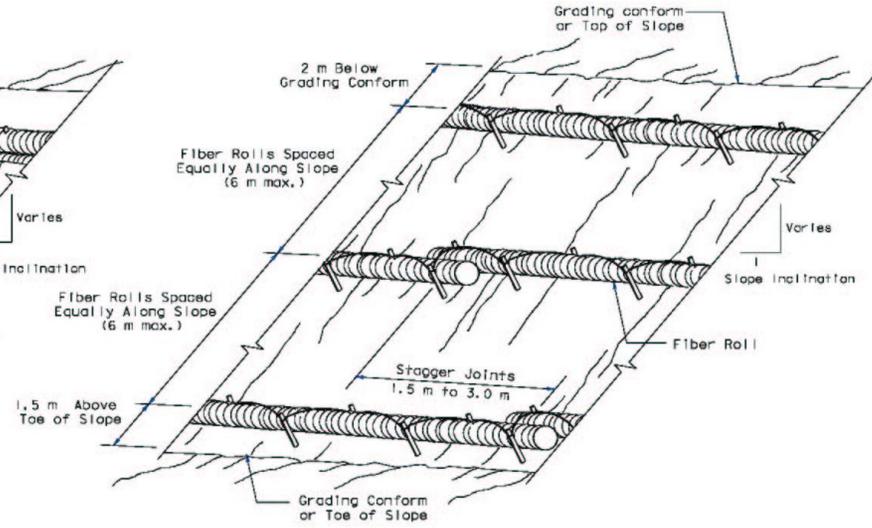


ELEVATION  
NOTCH DETAIL

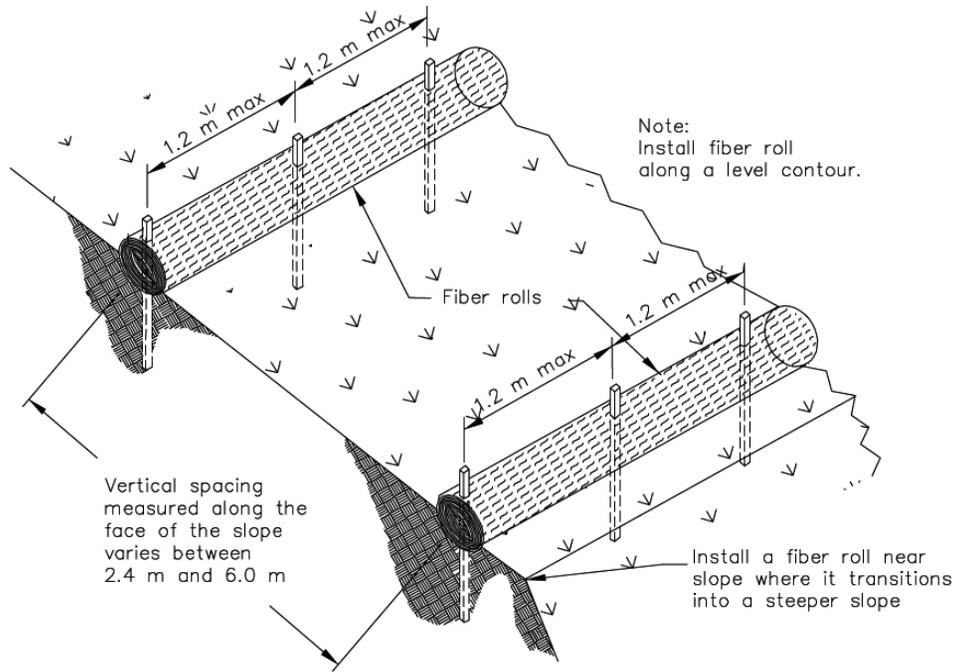
**NOTE**  
1. Temporary fiber roll spacing varies depending upon slope inclination.



PERSPECTIVE  
TEMPORARY FIBER ROLL (TYPE 1)

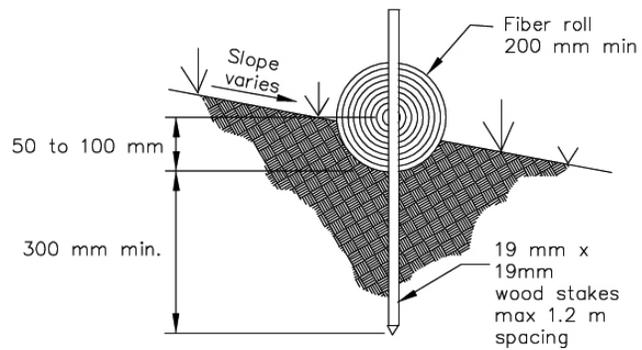


PERSPECTIVE  
TEMPORARY FIBER ROLL (TYPE 2)



TYPICAL FIBER ROLL INSTALLATION

N.T.S.



ENTRENCHMENT DETAIL

N.T.S.