Section E – DOWNDRAINS & FLUMES

March 2003

16.0 STANDARDS AND SPECIFICATIONS

FOR

PIPE SLOPE DRAIN

Description of Practice

A pipe slope drain is a pipe that is installed to convey surface runoff down the face of unstabilized slopes. It is used to minimize erosion on the slope face. **Use of flexible piping is preferred.**

Conditions Where Practice Applies

Pipe slope drains are used in conjunction with earth dikes. The dikes direct surface runoff to the slope drain, which conveys concentrated flow down the face of a slope. When used to convey water down an unstabilized fill slope on a road construction project the drainage area to the pipe slope drain will be limited to 2 acres. When used as an inflow protection device the drainage area will be 5 acres.

Table 19: Design Criteria for Pipe Slope Drain

Size	Diameter (inches)	Pipe/Tubing Maximum Drainage Area (Acres)
PSD-12	12	0.5
PSD-18	18	1.5
PSD-21	21	2.5
PSD-24	24	3.5
PSD-(2) (24)[14]	24	5.0

Inlet

At the inlet of the pipe slope drain, the height of the earth dike shall be at least two times the pipe diameter and measured from the invert of the pipe. A standard flared entrance section shall be installed and secured at the inlet to the pipe slope drain with a watertight connection. To prevent erosion, geotextile fabric shall be placed under the inlet and shall extend 5' in front of the inlet and be keyed in 6" on all sides.

[14] Due to the height limitations on earth dikes, the maximum pipe diameter for pipe slope drain is 24". For drainage areas over 3 ½ acres two 24" pipes shall be used. A minimum spacing of 2D (4 feet) is required between pipes.

Outlet

When the drainage area is disturbed, the pipe slope drain shall outlet into a sediment trap or basin, or a stable conveyance that leads to a trap or basin. The point of discharge shall be as far away from the trap or basin outlet structure as possible. When the drainage area is stabilized, the pipe slope drain shall outlet onto a stabilized area at a non-erosive velocity. The point of discharge may be protected by rock outlet protection.

Construction Specifications

1. The Pipe Slope Drain (PSD) shall have a slope of 3 percent or steeper.

2. The top of the earth dike over the inlet pipe shall be at least 2 times the pipe diameter measured at the invert of the pipe.

3. Flexible tubing is preferred. However, corrugated metal pipe or equivalent PVC pipe can be used. All connections shall be watertight.

4. A flared end section shall be attached to the inlet end of pipe with a watertight connection. Geotextile Class E[15] or better shall be placed under the inlet of the pipe slope drain and shall extend out 5' from the inlet. The geotextile fabric shall be keyed in on all sides.

5. The Pipe Slope Drain shall be securely anchored to the slope. Spacing for anchors shall be as provided by manufacturer's specification. In no case shall less than two (2) anchors be provided, equally spaced along the length of pipe. These details should be provided by pipe suppliers.

6. The soil around and under the pipe and end section shall be hand tamped in 4-inch lifts to the top of the earth dike.

7. Whenever possible where a PSD drains an unstabilized area, it shall outlet into a sediment trap or basin. If this is not possible then the slope drain will discharge into a stable conveyance that leads to a sediment trap or basin. When discharging into a trap or basin the PSD shall discharge at the same elevation as the wet pool elevation. The discharge from the PSD must be as far away from the sediment control outlet as possible.

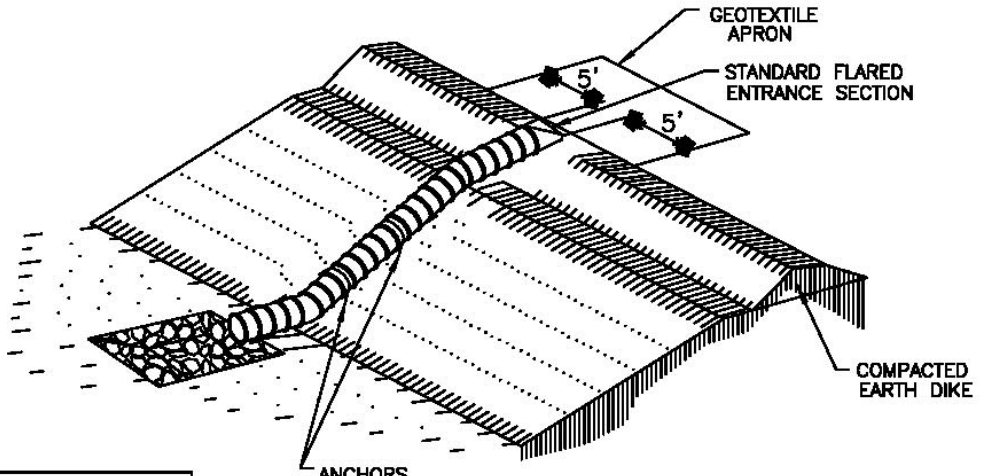
8. When the drainage area is stabilized, the PSD shall discharge onto a stabilized area at a non-erosive velocity. 4"- 7" stone underlain with Geotextile Class SE[16] shall be employed as necessary.

[15] Refer to Table 44 (located on page L-53-1)
[16] Refer to Table 44 (located on page L-53-1)

9. Inspection and any required maintenance shall be performed periodically and after each rain event.

10. The inlet must be kept open at all times.

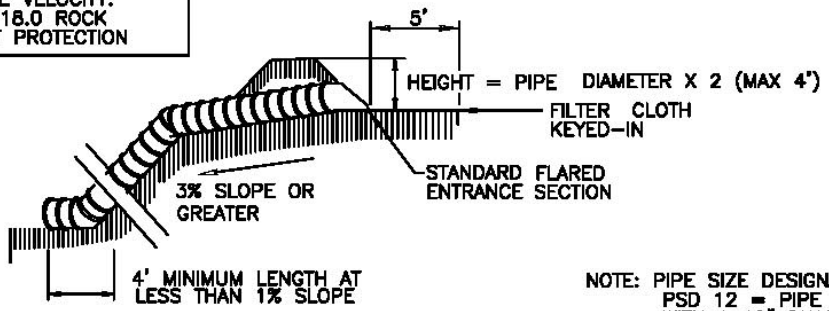
DETAIL 24 – PIPE SLOPE DRAIN



DISCHARGE INTO A STABILIZED WATER–COURSE, SEDIMENT TRAPPING DEVICE, OR INTO A STABILIZED AREA AT A NON–EROSIVE VELOCITY. REF: 16.0 ROCK OUTLET PROTECTION

STANDARD SYMBOL

PSD – 12



NOTE: PIPE SIZE DESIGNATION IS: PSD 12 = PIPE SLOPE DRAIN WITH A 12" DIAMETER PIPE.

Table 6 Design Criteria for Pipe Slope Drain

Size	Pipe/Tubing Diameter (D) in	Maximum Drainage Area (Acres)
PSD–12	12	0.5
PSD–18	18	1.5
PSD–21	21	2.5
PSD–24	24	3.5
PSD–24 (2)	24	5.0

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PIPE SLOPE DRAIN

Construction Specifications – Pipe Slope Drain

1. The Pipe Slope Drain (PSD) shall have a slope of 3 percent or steeper.

2. The top of the earth dike over the inlet pipe shall be at least 2 times the pipe diameter measured at the invert of the pipe.
pipe.

3. Flexible tubing is preferred. However, corrugated metal pipe or equivalent PVC pipe can be used. All connections shall be watertight.
pipe.

4. A flared end section shall be attached to the inlet end of pipe with a watertight connection. Filter cloth shall be placed under the inlet of the pipe slope drain and shall extend out 5' from the inlet. The filter cloth shall be "keyed in" on all sides.
pipe.

5. The Pipe Slope Drain shall be securely anchored to the slope by staking at the grommets provided. Spacing for anchors shall be as provided by manufacturer's specification. In no case shall less than two (2) anchors be provided, equally spaced along the length of pipe. These details should be provided by pipe suppliers.
pipe.
pipe.

6. The soil around and under the pipe and end section shall be hand tamped in 4 inch lifts to the top of the earth dike.

7. All pipe connections shall be watertight.

8. Whenever possible where a PSD drains an unstabilized area, it shall outlet into a sediment trap or basin. If this is not possible then the slope drain will discharge into a stable conveyence that leads to a sediment trap or basin. When discharging into a trap or basin the PSD shall discharge at the same elevation as the wet pool elevation. The discharge from the PSD must be as far away from the sediment control outlet as possible.

9. When the drainage area is stabilized, the PSD shall discharge onto a stabilized area at a non–erosive velocity.

10. Inspection and any required maintenance shall be performed periodically and after each rain event.

11. The inlet must be kept open at all times.

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17.0 STANDARDS AND SPECIFICATIONS

FOR

PAVED FLUME

Definition

A permanent paved channel constructed on a slope.

Purpose

To conduct stormwater runoff safely down the face of a slope without causing erosion problems on or below the slope.

Conditions Where Practice Applies

Wherever concentrated stormwater runoff must be conveyed from the top to the bottom of cut or fill slopes on a permanent basis and a riprap-lined channel is not capable of conveying the runoff without erosion.

Planning Considerations

Paved flumes are used routinely on highway cuts and fills to convey concentrated stormwater runoff from the top to the bottom of the slope without erosion. Standards and specifications have been developed for these structures which apply to all secondary and primary highway construction projects.

Fortunately, these structures have equal applicability to cut-and-fill slopes for construction projects other than highways.

Consideration must be given to protecting structures against buoyancy failures. The potential for buoyancy failures due to hydrostatic uplift forces exists in channels constructed in periodically saturated areas (basically all channels will experience saturation of the subgrade by virtue of the function of the channel) and especially if a submerged outfall condition exists.

Paved flumes should be utilized and constructed carefully. Field experience has shown a significant amount of post-construction problems with these controls. If the base contains some unsuitable material or is too "soft, " the flume will subject to undermining and fracturing. There are also many cases where the outlet velocities and flow rates of stormwater which travels in a paved flume are so great that erosion and flooding at the

end of the structure are inevitable, no matter what type of treatment is installed at the outlet.
In these cases, strong consideration should be given to a riprapped channel or to a system of inlets, manholes, and pipe to safely convey the stormwater to the receiving channel or drainage structure.

Design Criteria

Capacity

Paved flumes shall be capable of passing the peak flow expected from a 10-year frequency storm.

Cross-Sections

Detail 24A illustrates a typical trapezoidal cross-section of a Standard Paved Flume. Where additional flow capacity is required, larger trapezoidal cross-sections may be designed. The following criteria apply to all trapezoidal flume designs:

1. The maximum slope of the structure shall be 1.5:1 (67%).

2. Curtain Walls shall be provided at the beginning and end of all paved flumes not abutted to another structure. The curtain wall shall be as wide as the flume channel, extend at least 18 inches into the soil below the channel, and have a thickness of 6 inches. Curtain walls shall be reinforced with #4 reinforcing steel bars placed on 6-inch centers.

3. Anchor Lugs shall be spaced at a maximum of 10 feet on center for the length of the flume. Where no curtain wall is required, an anchor lug shall be installed within 2 feet of the end of the flume. Anchor lugs are to be as wide as the bottom of the flume channel, extend at least 1 foot into the soil below the channel, and have a thickness of 6 inches. Anchor lugs shall be reinforced with #4 reinforcing steel bars placed on 4-inch centers.

4. The flume channel shall have at least a 4-inch thickness of class A-3 concrete with welded wire fabric (6 X 6 - W2.1 x W2.1) in the center for reinforcement.

5. Expansion Joints shall be provided approximately every 90 feet. Eighteen-inch dowels of #4 reinforcing steel placed on 5-inch centers shall be located at all required joints.

Outlet

Outlets of paved flumes should be protected from erosion. The use of an energy dissipator with outlet protection (Section F) is recommended in order to temporarily reduce the existing velocity of the flow, thus preventing undermining of the structure and providing a stable transition zone between the flume and the receiving channel or

drainage structure at the base of the slope. Detail 24B shows an Energy Dissipator, which is designed for use in conjunction with the Paved Flume. OUTLET PROTECTION should still be utilized with the use of an energy disipator structure to further dissipate flow energy and to provide a smooth transition into the receiving channel. Larger energy dissipator systems may be similarly designed for larger flume cross-sections.

Construction Specifications

1. The subgrade shall be constructed to the required elevations. All soft sections and unsuitable material shall be removed and replaced with suitable material. The subgrade shall be thoroughly compacted and shaped to a smooth, uniform surface. The subgrade shall be moist at the time the concrete is poured.

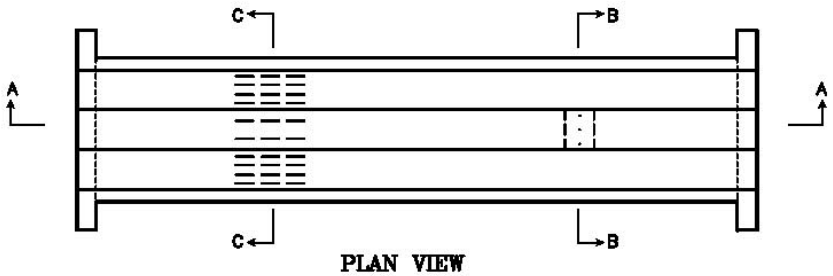
2. Anchor lugs and curtain walls shall be formed to be continuous with the channel lining.

3. Traverse joints for crack control should be provided at approximately 20-foot intervals and when more than 45 minutes elapses between consecutive concrete placements. All sections should be at least 6 feet long. Crack control joints may be formed by using a 1/8-inch thick removable template, by scoring or sawing to a depth of at least 3/4 inch or by an approved "leave-in" type insert.

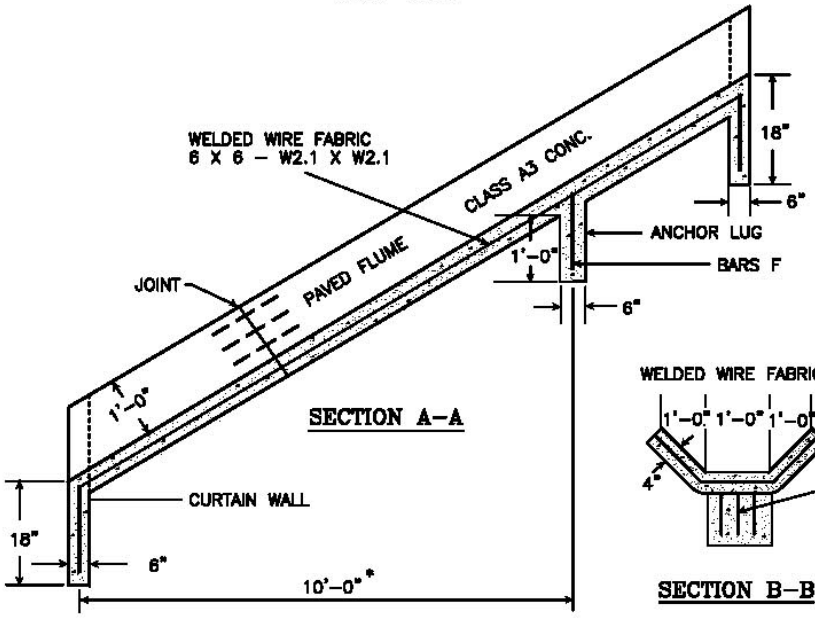
Maintenance

Prior to permanent stabilization of the slope, the structure should be inspected after each rainfa1l. Damages to the slope, flume or outlet area must be repaired immediately. After the slope is stabilized, the structure should be inspected to ensure continued adequate functioning (see potential problems noted in Planning Considerations).

DETAIL 25A - PAVED FLUME



PLAN VIEW



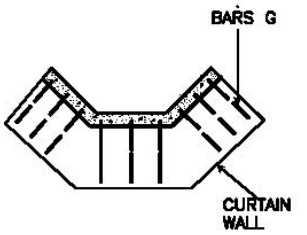
SECTION A-A

SECTION B-B

* 10'-0" C-C MAXIMUM TYPICAL SPACING BETWEEN ANCHOR LUGS. WHERE CURTAIN WALL IS NOT REQUIRED ANCHOR LUG IS TO BE A MAXIMUM OF 2' FROM END OF CHANNEL.

SCHEDULE OF REINFORCING STEEL

MARK	NO.	LENGTH 2:1	LENGTH 1 1/2:1	SIZE	SPACING C-C	SHAPE
F	3	1'-2"	1'-2"	4	4"	STRAIGHT
G	9	1'-5"	1'-5"	4	6"	STRAIGHT
DOWELS	10	1'-6"	1'-6"	4	5"	STRAIGHT



SECTION C-C

NO. SHOWN ARE FOR ONE ANCHOR LUG, CURTAIN WALL AND JOINT

SOURCE: VDOT ROAD AND BRIDGE STANDARDS

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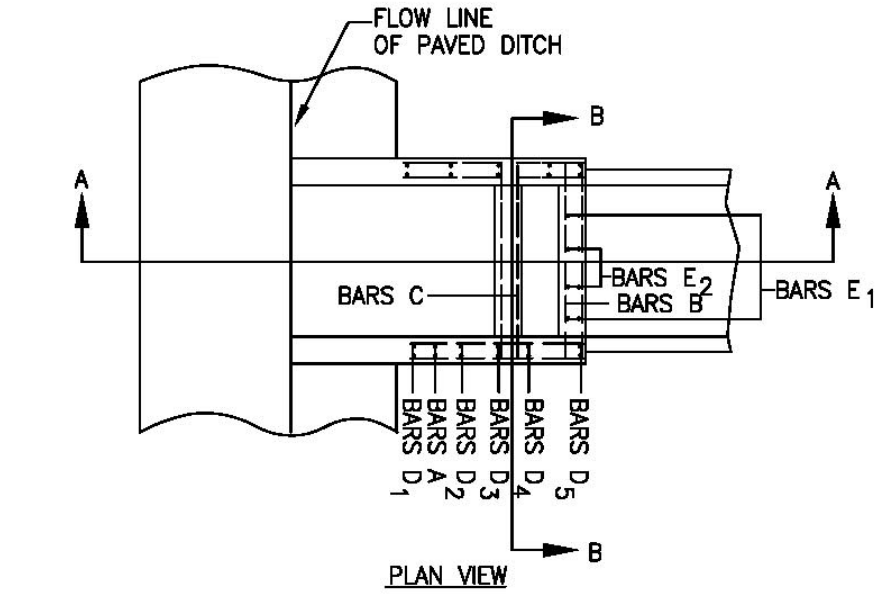
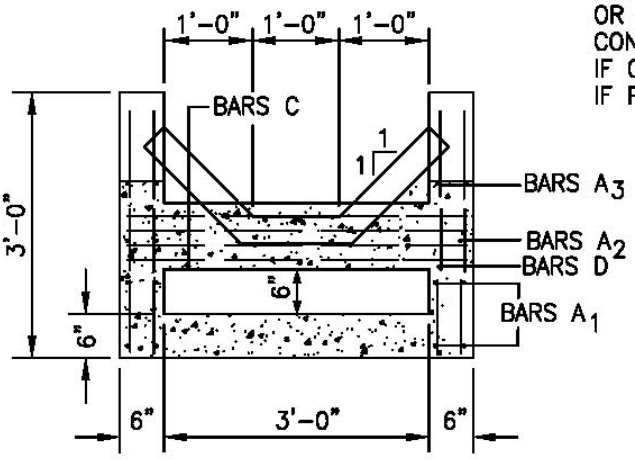
DETAIL 25B - ENERGY DISSIPATOR

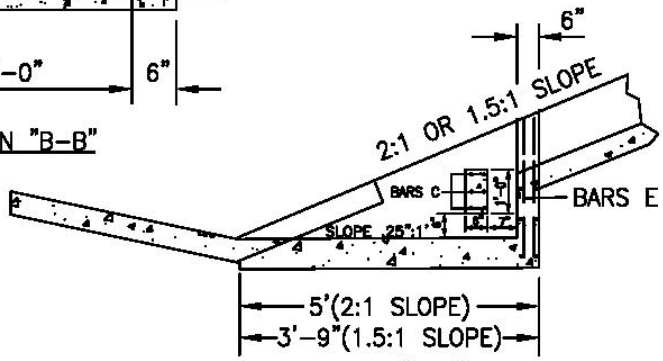


PLAN VIEW

THIS ITEM MAY BE PRECAST
OR CAST IN PLACE.
CONCRETE TO BE CLASS A3
IF CAST IN PLACE, CLASS A4
IF PRECAST.



SECTION "B-B"



SECTION "A-A"

SOURCE: VDOT ROAD AND BRIDGE STANDARDS

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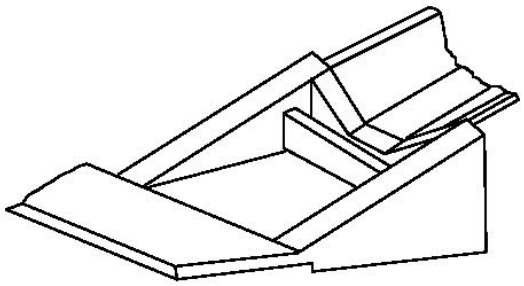
DETAIL 25B – ENERGY DISSIPATOR (CONTINUED)



ISOMETRIC

SCHEDULE OF REINFORCING STEEL

MARK	NO.	LENGTH		SIZE	SPACING C–C	SHAPE
		2:1	1.5:1			
A_1	8	2'–10"	2'–10"	3	8"	STRAIGHT
A_2	4	2'–6 1/4"	1'–10"	3	8"	STRAIGHT
A_3	4	1'–0 3/4"	0'–10"	3	8"	STRAIGHT
B	6	3'–9"	3'–9"	3	8"	STRAIGHT
C	8	3'–8"	3'–8"	3	2 1/2"	STRAIGHT
D_1	4	1'–2 1/2"	0'–8"	3	8"	STRAIGHT
D_2	4	1'–6 1/2"	1'–1 1/2"	3	8"	STRAIGHT
D_3	4	1'–10 1/2"	1'–7"	3	8"	STRAIGHT
D_4	4	2'–2 1/2"	2'–0 1/2"	3	8"	STRAIGHT
D_5	4	2'–6 1/2"	2'–6"	3	8"	STRAIGHT
E_1	4	1'–11 1/2"	1'–11 1/2"	3	8"	STRAIGHT
E_2	4	1'–5 1/2"	1'–5 1/2"	3	8"	STRAIGHT

APPROXIMATE QUANTITIES			
		CONCRETE	REINFORCING STEEL
		CU. YDS.	LBS.
ENERGY DISSIPATOR	2:1	0.7479	61.20
	1.5:1	0.5921	57.63

SOURCE: VDOT ROAD AND BRIDGE STANDARDS

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