E-6 RIPRAP WATERWAYS

PURPOSE & APPLICATIONS

Riprap is a permanent, erosion-resistant ground cover constructed of large, loose, angular or sub-angular (rounded) stone. Riprap may be used, as appropriate, at storm drain outlets, on channel banks and/or bottoms, roadside ditches, drop structures, at the toe of slopes or to stabilized streams, etc. This practice is applicable where the soil conditions, water turbulence and velocity, expected vegetative cover, etc., are such that the soil may erode under the design flow conditions. Its purpose is:

- To protect the soil surface from the erosive forces of concentrated runoff.
- To slow the velocity of concentrated runoff while enhancing the potential for infiltration.
- To stabilize slopes with seepage problems and/or fine textured non-cohesive soils.

CONSIDERATIONS

Since riprap is used where erosion potential is high, construction must be sequenced so that the riprap is put in place without delay. Disturbance of areas where riprap is to be placed should be undertaken only when final preparation and placement of the riprap can follow immediately behind the initial disturbance. Where riprap is used for outlet protection, the riprap should be placed before or in conjunction with the construction of the pipe or channel so that it is in place when the pipe or channel begins to operate.

SPECIFICATIONS

Design Criteria

Refer to the detail drawing located at the back of this section for the proper construction of a ripraped channel. Also refer to the RIPRAP SLOPE STABILIZATION BMP.

Types of Riprap: Refer to MDOT specifications for information about standard types of riprap.

Gradation: Since graded riprap consists of a variety of stone sizes, the average size of stone in a mixture is described as the D50. In other words, it is specifying a diameter of stone in the mixture for which 50 percent, by weight, will be smaller and 50 percent will be larger.

A mixture composed primarily of the larger stone size but with a sufficient mixture of other sizes filling the progressively smaller voids between the stones is described as a well-graded mixture. The diameter of the largest stone size in such a mixture should be 1.5 times the D50 size.

The designer, after determining the riprap size that will be stable under the flow conditions, shall consider that size to be minimum size and then, based on riprap gradations actually available in the area, select the size or sizes that equal or exceed the minimum size.

Roughness coefficient: The most significant effect on the retardance of flow velocity is from the friction that occurs along the flow channel. For riprap, Manning's n is calculated as follow:

$$n = \frac{y^{1/8}}{[21.6 \log_{10}(y/D_{50}) + 14.0]}$$

where: y = depth of water in feet

D_{50} = riprap diameter in feet

Thickness: The minimum thickness of the riprap layer shall be 2.2 times the maximum stone diameter (for a D_{50} of 12" or smaller), but not less than 6 inches. For D_{50} specified greater than 12 inches, the riprap layer thickness shall be 2 times the D_{50}.

Quality of Stone: Stone for riprap shall consist of sub-angular field stone or rough unhewn quarry stone of approximately rectangular shape. The stone shall be hard and of such quality that it will not disintegrate on exposure to water or weathering, be chemically stable and it shall be suitable in all other respects for the purpose intended. The bulk specific gravity (saturated surface-dry basis) of the individual stones shall be at least 2.5.

Riprap at Outlets: Design criteria for sizing the stone and determining the dimension of riprap pads used at the outlet of drainage structures are contained in the PIPE OUTLET PROTECTION BMP.

Riprap for Channel Stabilization

Riprap for channel stabilization shall be designed to be stable for the condition of bank-full flow in the reach of channel being stabilized. Riprap shall extend up the banks of the channel to a height equal to the maximum depth of flow for a 10-year storm event or to a point where vegetation can be established to adequately protect the channel bottom width. The riprap shall extend across the bottom and up both sides of the channel.

Bank Protection: Where riprap is used only for bank protection and does not extend across the bottom of the channel, riprap shall be keyed into the bottom of the channel. The minimum depth of the key must equal to 2.25 times the D_{50} and must extend across the bottom of the channel for the same distance.

Flow Velocity: The D_{50} of the riprap should be designed for the maximum velocity as follow:

FLOW VELOCITY(cfs)	RIPRAP D50
16	36 inch
13	24 inch
11	18 inch
10	15 inch
8	10 inch
6	6 inch
4	3 inch

Other methods for determining D_{50} sizes may be used but need to be documented.

Filter Blankets: A filter blanket is a layer of material that prevents soil movement into or through the riprap. A filter blanket can be either a gravel layer or geotextile filter cloth. The need for a filter blanket is determined by comparing the particle sizes of the overlying material and the base material in accordance with the criteria below:

Filter Blankets: A filter blanket is a layer of material placed between the riprap and the underlying soil surface to prevent soil movement into or through the riprap. The need for a filter blanket is determined by comparing the particle sizes of the overlying material and the base material. Refer to the GEOTEXTILES and RIPRAP SLOPE STABILIZATION BMPs.

Flow Depth: The riprap rock size should be determined for maximum anticipated flow depth within the channel as follow:

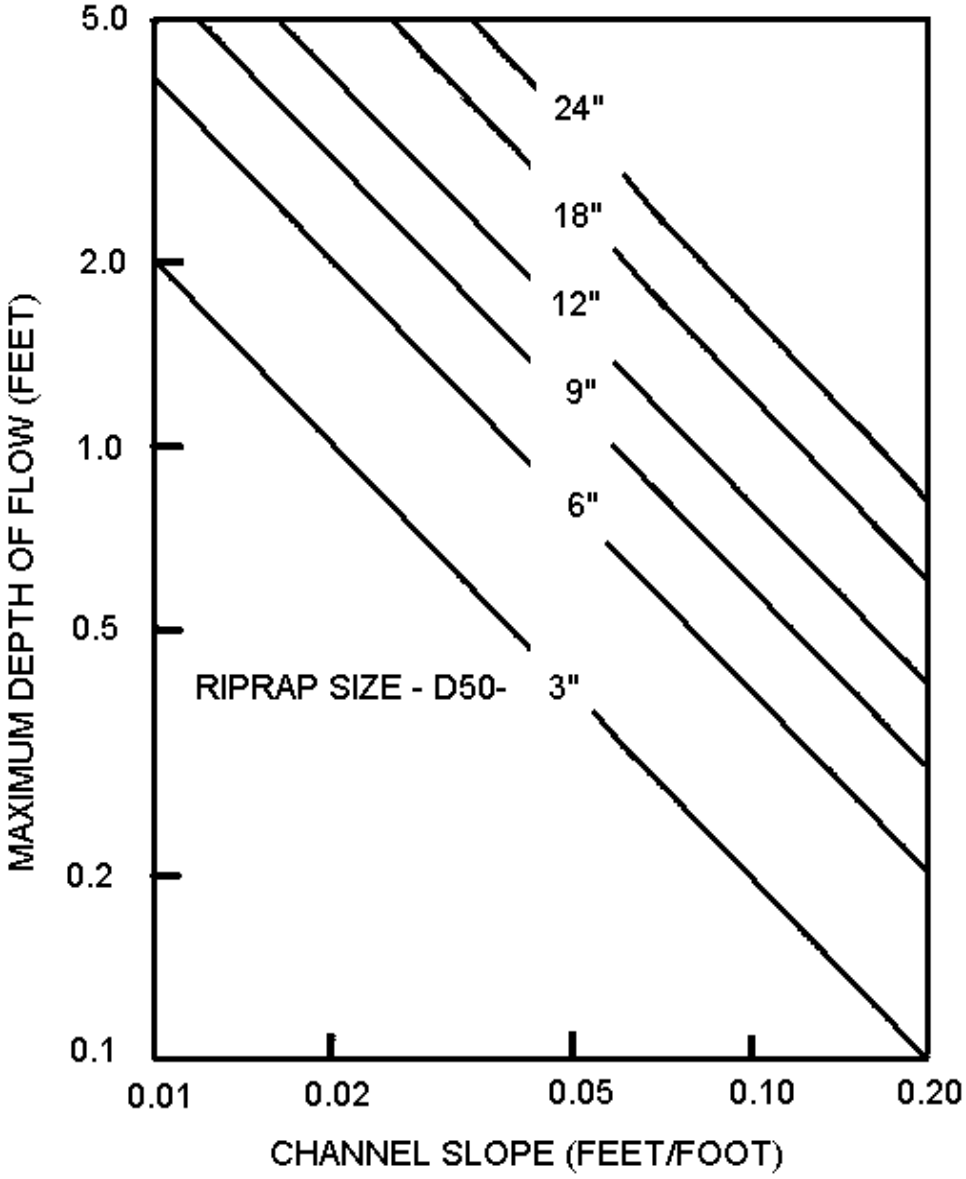
Installation Requirements

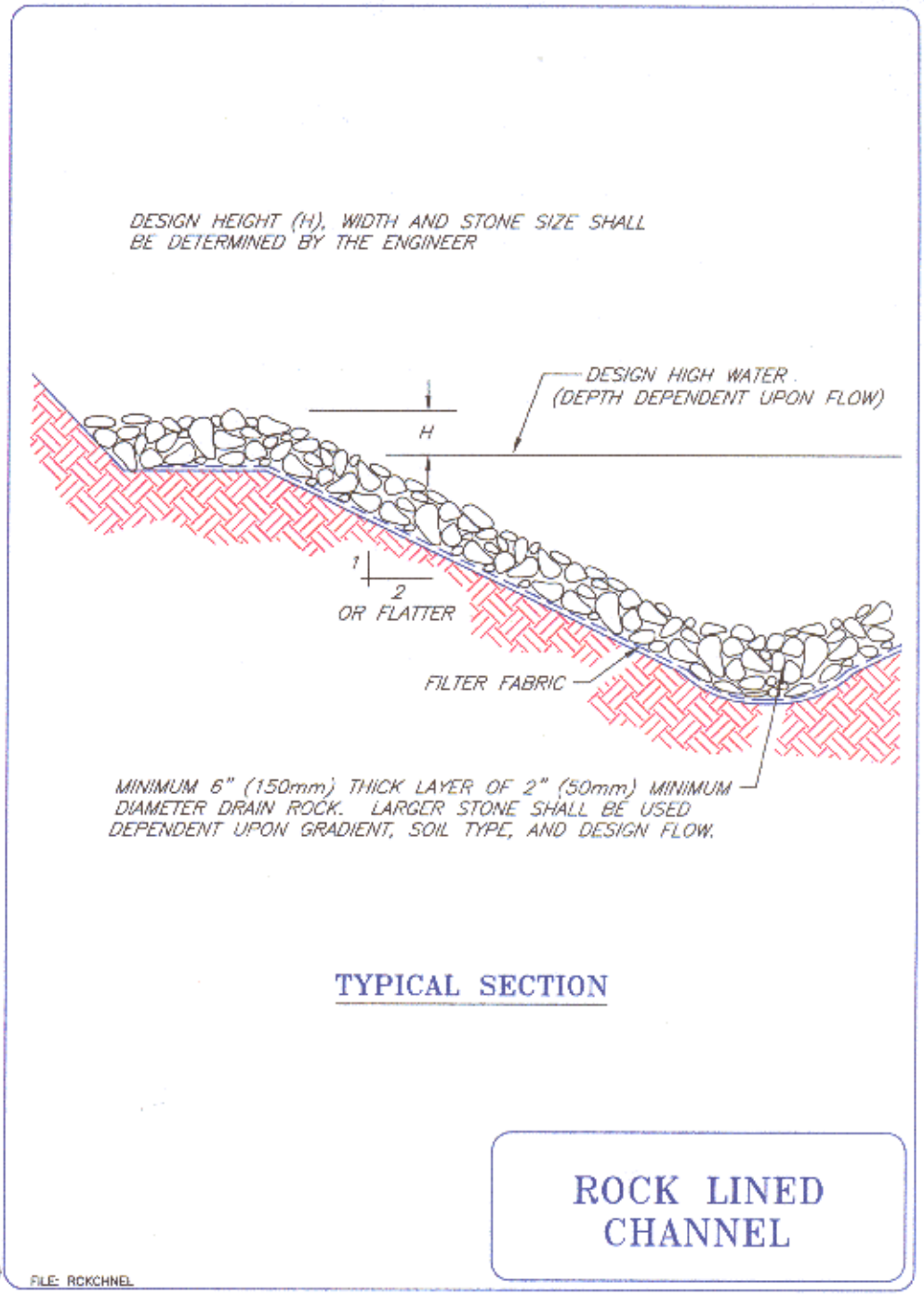
Subgrade Preparation: The subgrade for the riprap or filter shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density approximating that of the surrounding undisturbed material and to a 95% compaction as determined by Standard Proctor Density. All brush, trees, stumps and other objectionable material (i.e., organic matter) shall be removed.

Filter Blanket: The placement of the filter blanket should be done immediately after the slope preparation. For geotextile filter cloths, the cloth should be placed directly on the prepared slope, installed and anchored according to the manufacturer's recommendations. Refer to the GEOTEXTILE BMP

Stone Placement: The placement of riprap should follow immediately after placement of the filter. The riprap should be placed so that it produces a dense well-graded mass of stone with a minimum of voids. Refer to the RIPRAP SLOPE STABILIZATION BMP.

Maintenance: Once a riprap installation has been completed, it should require very little maintenance. It shall, however, be inspected periodically to determine if high flows have caused scour beneath the riprap or dislodged any of the stone. If repairs are needed, they should be accomplished immediately.


5.0
2.0
1.0
0.5
0.2
0.1
MAXIMUM DEPTH OF FLOW (FEET)
24"
18"
12"
9"
6"
RIPRAP SIZE - D50-
3"
0.01
0.02
0.05
0.10
0.20
CHANNEL SLOPE (FEET/FOOT)


DESIGN HEIGHT (H), WIDTH AND STONE SIZE SHALL BE DETERMINED BY THE ENGINEER
DESIGN HIGH WATER (DEPTH DEPENDENT UPON FLOW)
H
1
2
OR FLATTER
FILTER FABRIC
MINIMUM 6" (150mm) THICK LAYER OF 2" (50mm) MINIMUM DIAMETER DRAIN ROCK. LARGER STONE SHALL BE USED DEPENDENT UPON GRADIENT, SOIL TYPE, AND DESIGN FLOW.
TYPICAL SECTION
ROCK LINED CHANNEL
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FILE: ROKCHNEL