

District 11-0: Geotechnical Engineering Unit

Landslide, Drainage Failures, Shallow Failure Identification and Remediation



► Identification of Failure Types

- Drainage facility failure
- Erosion of Shoulder Back up due to sheet flow
- Deep failure
 - Slip plane (red beds)
 - Increased overburden pressure
 - Soils compromised due to oversaturation
- Scour

▶ Drainage Failure



Lack of maintenance of drainage facilities results in the erosion of fines in the slope.

The failure will continue to chase its way back into the roadway.

▶ Sheet Flow removing fines in the back up

Prior to channelizing, sheet flow will wipe the fines from a surface.

Typical symptoms are leaning guide rail and a lack of shoulder back up.

Cracking can reflect up into the pavement if the supporting material is lost.



▶ Deep Failure

The slope is pulling away from the roadway.

The weight of gabions and supporting soil are causing the overburden soil to slide on a clay layer.



▶ Overburden Sliding on a Clay Layer



Saturated clay layers act like an oil slick for overburden soils/trees/roads to slide down.

▶ Deep Failure – Toe bulge visible down slope



Scour



Supporting material at the toe of wall/
slope removed. Results reflected in
pavement & leaning walls.



Scour



Stream removed toe of slope.
Compounded with sheet flow
removing fines, over steepening of
slope results in slope settlement.

Leaning trees and settlement of
guiderail are key indicators.

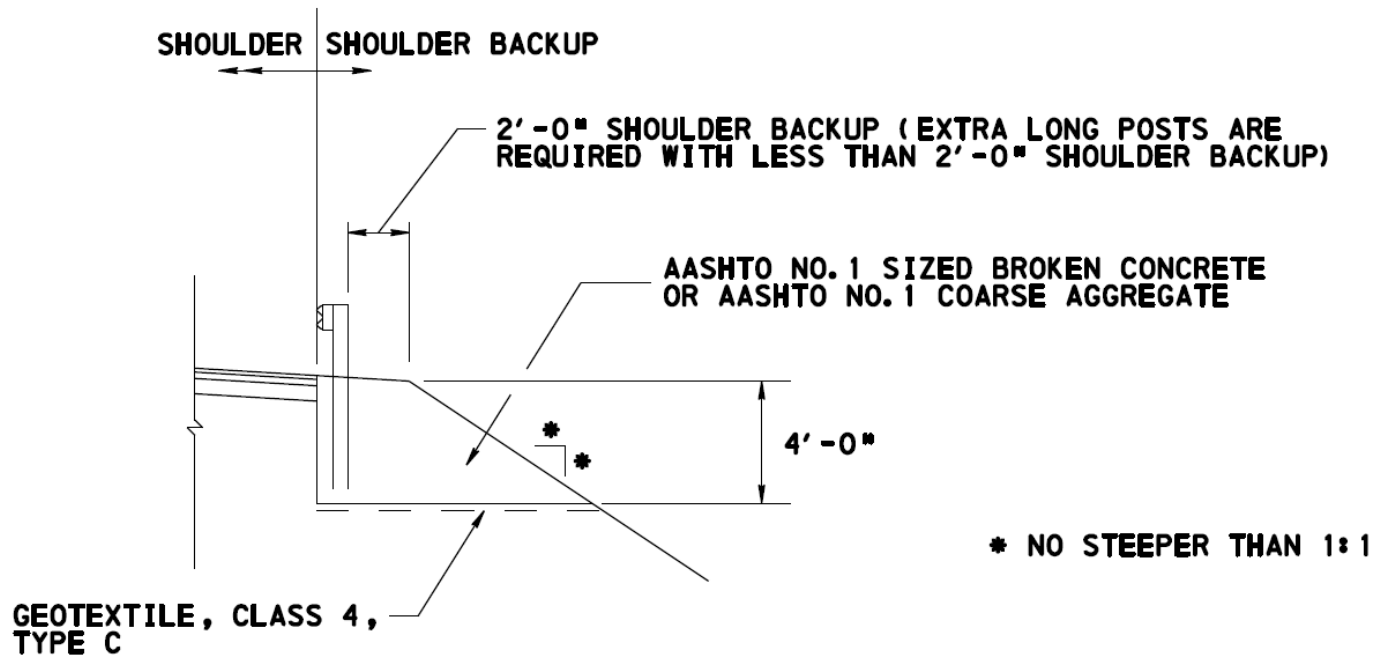
▶ Typical Repair Details

- Shoulder Backup
 - Prevents erosion of fines from sheet flow
 - 1V:1.25H Max Slope
- Rock Slope
 - Buttressing effect of competent, well drained material
 - 1V:1.25H Max Slope
- Soil Nails
 - Creates composite action tying weaker layers into competent layers
- GRS Wall
 - 1V:0.5H Max Slope

▶ Typical Repair Details

- Pile and Lagging Wall
- Low-Cost Short Term Fixes
 - Block Walls
 - Gabion Walls

Typical Shoulder Backup Detail

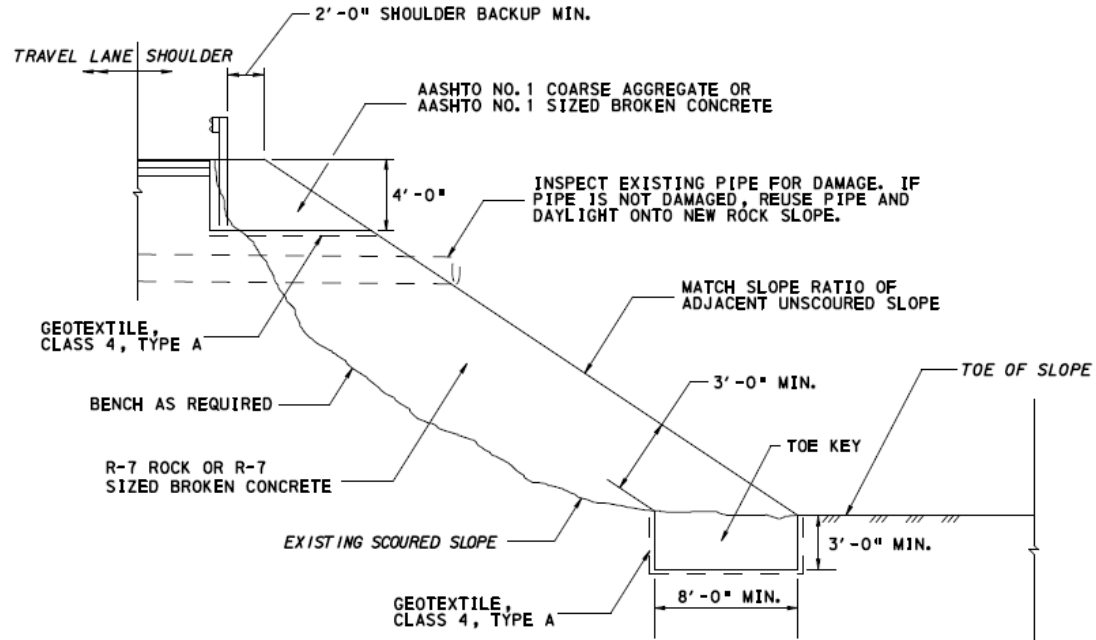


SHOULDER BACKUP RECONSTRUCT DETAIL

▶ Typical Shoulder Back up

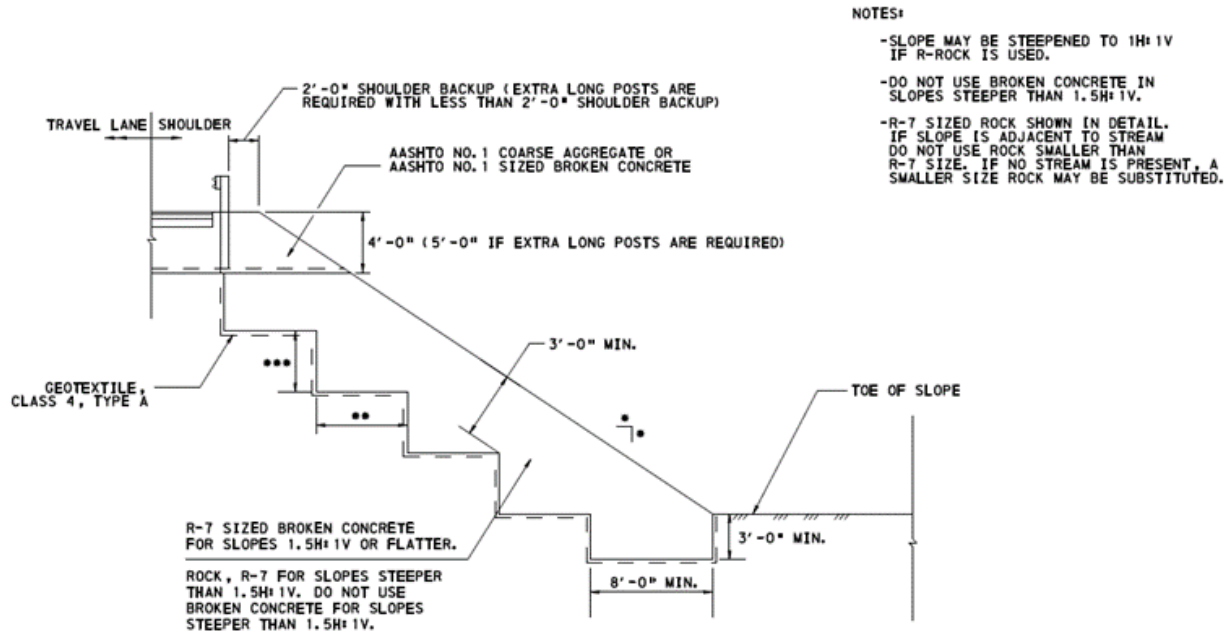


Typical Rock Slope Armoring Details



SLOPE EROSION REPAIR DETAIL

Benched Rock Slope Detail



NOTES:

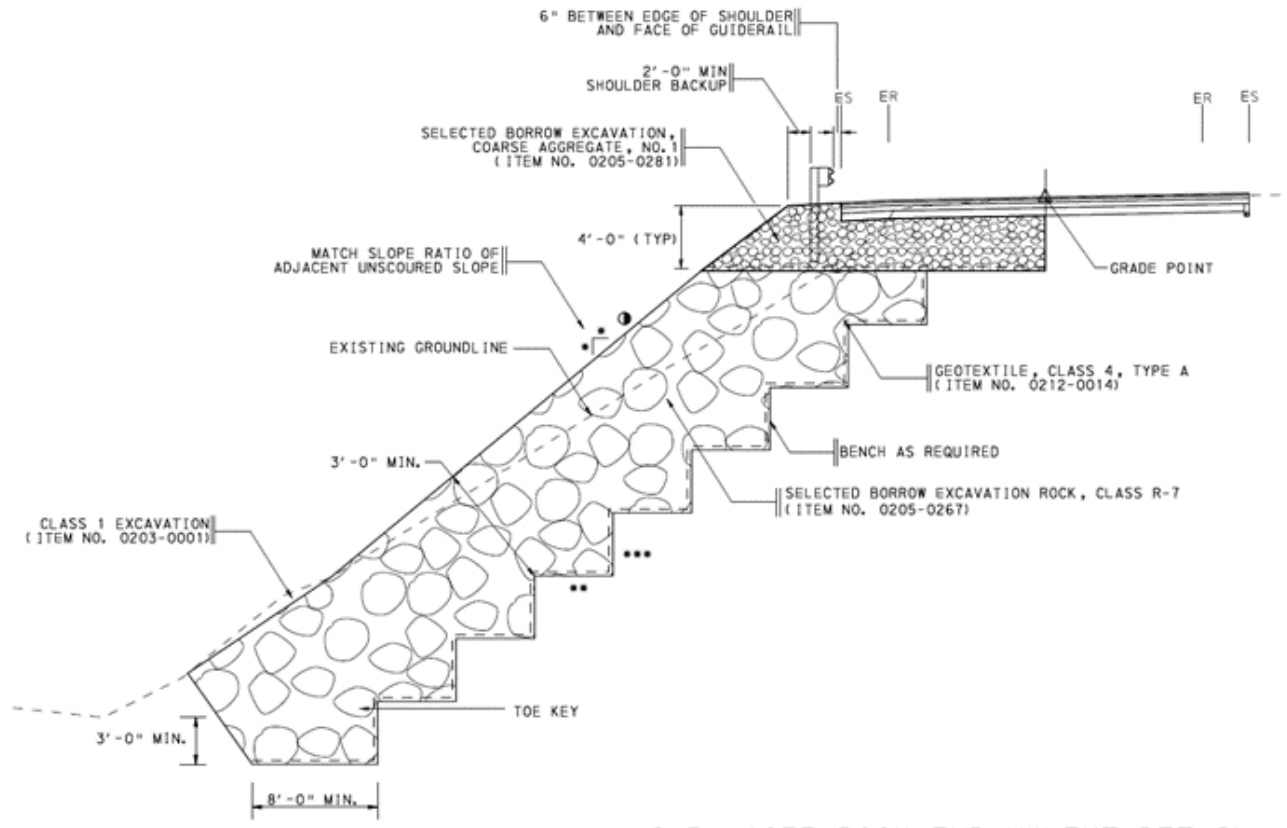
- SLOPE MAY BE STEEPENED TO 1H:1V IF R-ROCK IS USED.
- DO NOT USE BROKEN CONCRETE IN SLOPES STEEPER THAN 1.5H:1V.
- R-7 SIZED ROCK SHOWN IN DETAIL. IF SLOPE IS ADJACENT TO STREAM DO NOT USE ROCK SMALLER THAN R-7 SIZE. IF NO STREAM IS PRESENT, A SMALLER SIZE ROCK MAY BE SUBSTITUTED.

SLOPE EROSION REPAIR DETAIL

(FOR SLOPES WITH A VERTICAL HEIGHT GREATER THAN 10'-0")

- NO STEEPER THAN 1:1
- BENCH WIDTHS:
 - 2H:1V SLOPES: 6'-0" MIN
 - 1.5H:1V SLOPES: 6'-0" MIN
 - 1.25H:1V SLOPES: 5'-0" MIN, R-ROCK REQUIRED
 - 1H:1V SLOPES: 4'-0" MIN, R-ROCK REQUIRED
- BENCH HEIGHTS:
 - 2H:1V SLOPES: 3'-0" MAX
 - 1.5H:1V SLOPES: 4'-0" MAX
 - 1.25H:1V SLOPES: 4'-0" MAX, R-ROCK REQUIRED
 - 1H:1V SLOPES: 4'-0" MAX, R-ROCK REQUIRED

Typical Rock Slope



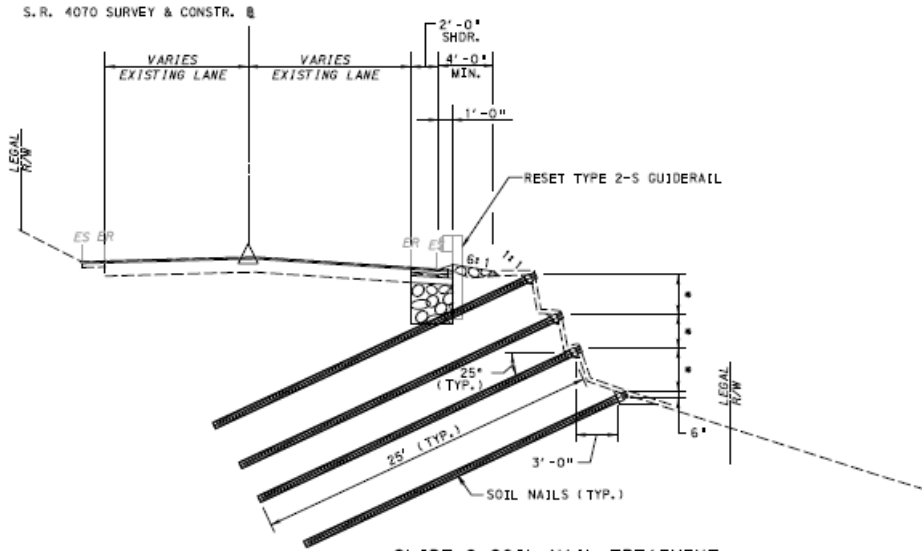
▶ Typical Rock Slope



Typical Rock Slope

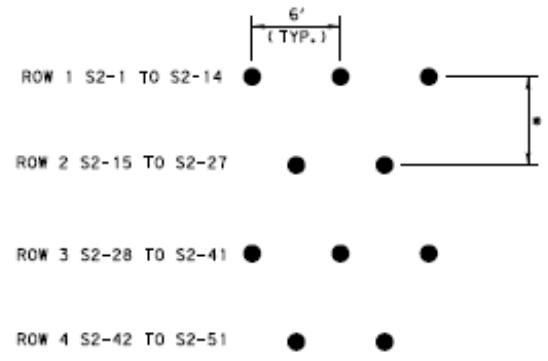


Typical Soil Nail Repair

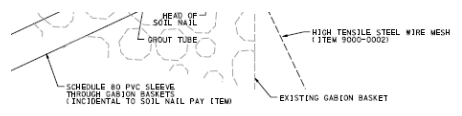


SLIDE 2 SOIL NAIL TREATMENT
TYPICAL SECTION

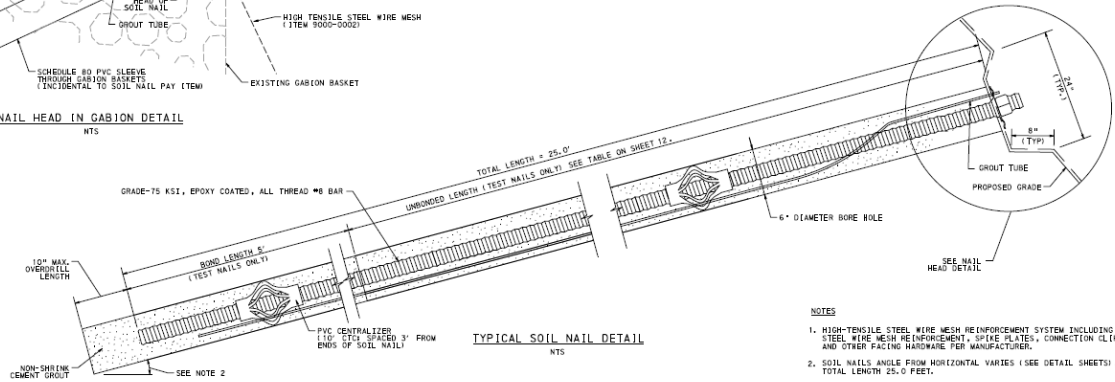
NTS
STA. 120+98.00 TO STA. 121+80.00



FOR SOIL NAIL COORDINATES, SEE SHEET 12.



NAIL HEAD IN GABION DETAIL
NTS



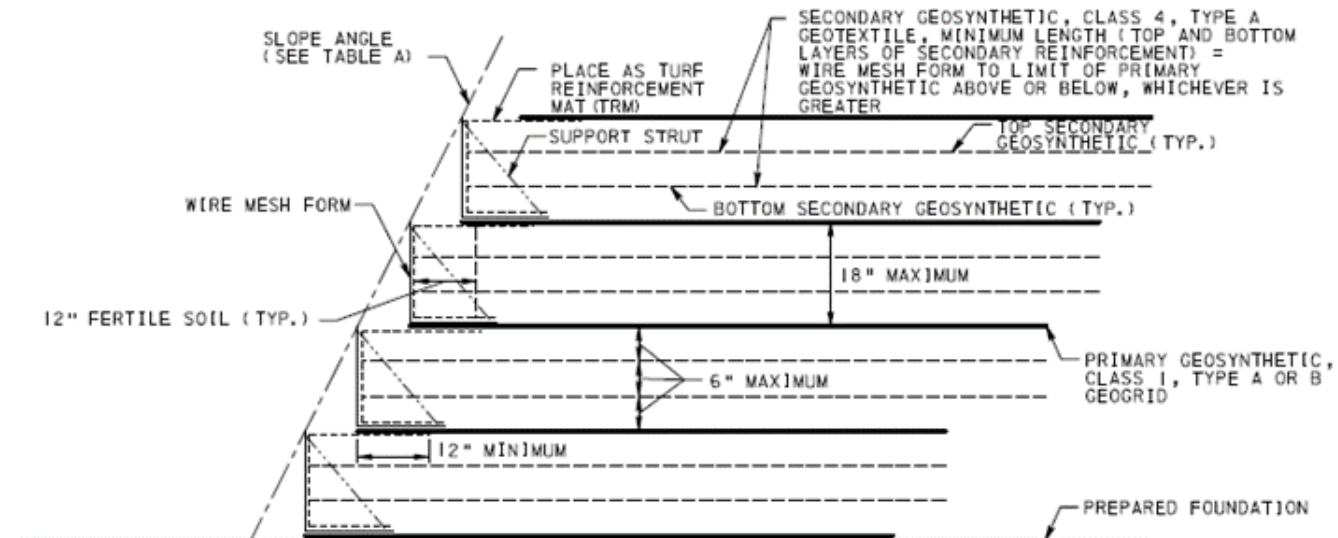
TYPICAL SOIL NAIL DETAIL
NTS

- NOTES
1. HIGH-TENSILE STEEL WIRE MESH REINFORCEMENT SYSTEM INCLUDING STEEL WIRE MESH REINFORCEMENT, SPIKE PLATES, CONNECTION CLIPS, AND STEEL FACING HARDWARE PER MANUFACTURER.
 2. SOIL NAILS ANGLE FROM HORIZONTAL VARIES (SEE DETAIL SHEETS), TOTAL LENGTH 25.0 FEET.

▶ Typical Soil Nail Repair



Typical GRS



TYPE A SLOPE LEGEND	
	= PRIMARY GEOSYNTHETIC
	= SECONDARY GEOSYNTHETIC
	= TURF REINFORCEMENT MAT (TRM)
	= WIRE MESH FORM
	= WIRE MESH SUPPORT STRUT
	= SLOPE ANGLE

TYPE A SLOPE

Typical GRS Wall Repair



▶ Pile and Lagging Wall

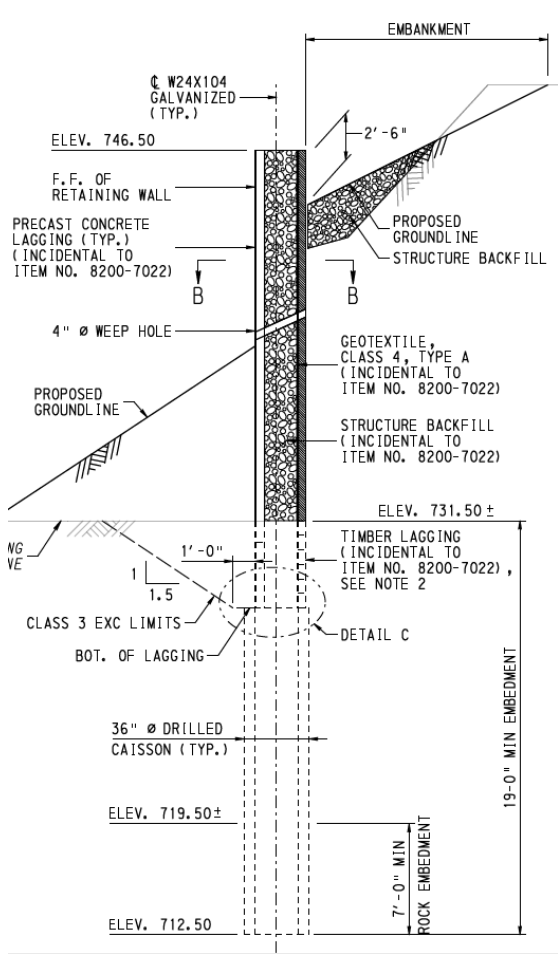


Before

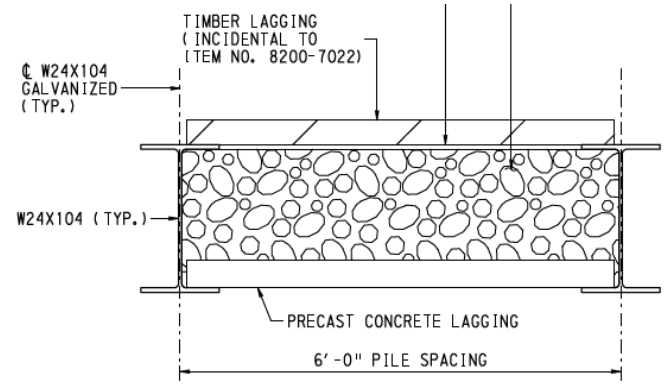


After

Pile and Lagging Wall - Details



Size in accordance with project specific details.



SECTION B-B
 1 0 1 2 FEET

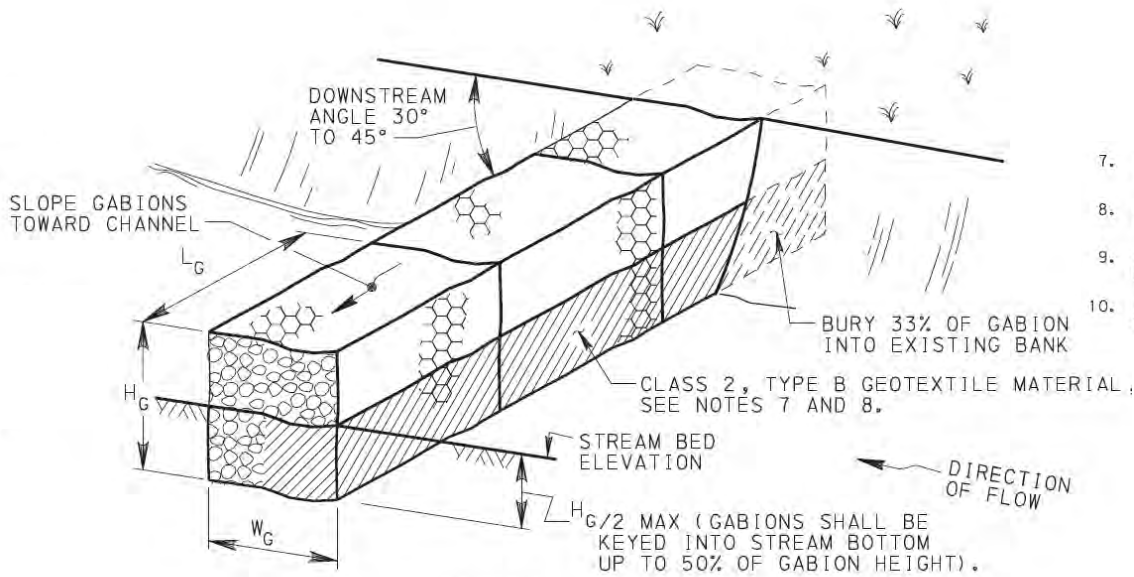
▶ Gabion Block Wall



Ensure proper installation to prevent scour.



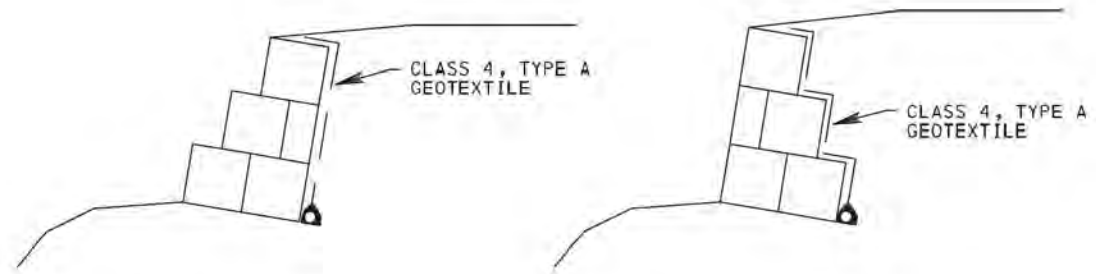
RC-43M - Gabions



CHANNEL DEFLECTOR

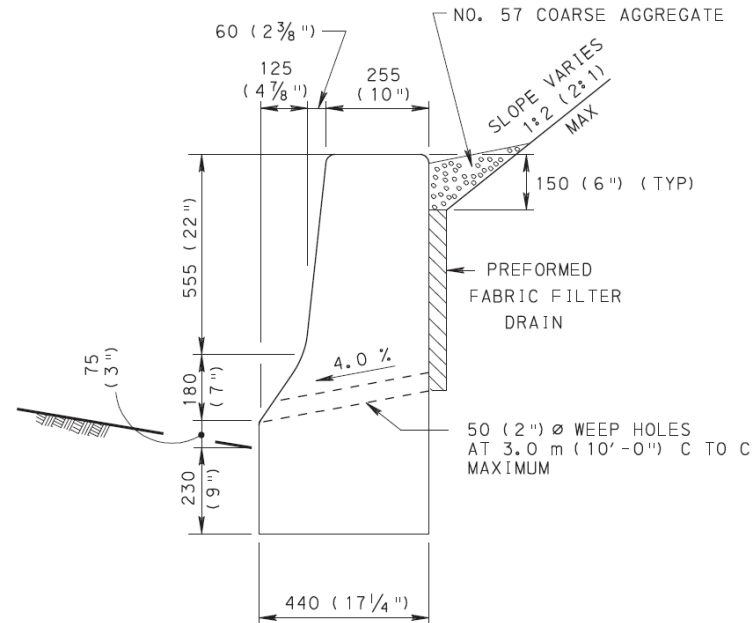
NOTES

7. PROVIDE GEOTEXTILE MATERIAL MEETING THE REQUIREMENTS OF PUBLICATION 408, SECTION 212 AND SECTION 735.
8. INSTALL GEOTEXTILE MATERIAL ALONG ALL INTERFACE AREAS WITH GROUND CONTACT.
9. ON ANY GIVEN LEVEL, BASKETS WITH EXPOSED FACES MUST BE FILLED PRIOR TO FILLING BASKETS WITH NO EXPOSED FACE.
10. BASE OF GABION TO BE CONSTRUCTED BELOW SCOUR DEPTH NEXT TO STREAMS OR BELOW FROST DEPTH, WHICHEVER IS GREATER.



GEOTEXTILE PLACEMENT

RC-58M – Single Faced Barrier Wall

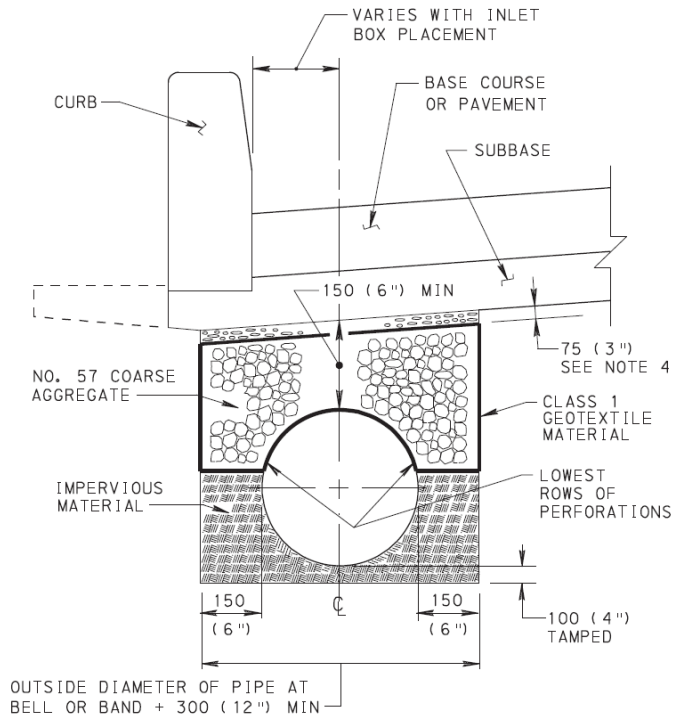


TYPICAL DRAINAGE TREATMENT

NOTES

1. PROVIDE STRUCTURAL STEEL PLATES MEETING THE REQUIREMENTS OF PUBLICATION 408, SECTION 1105. FOR PERMANENT BARRIER, GALVANIZE PLATES AS SPECIFIED IN PUBLICATION 408, SECTION 1105.02(s). ALTERNATE CONNECTIONS MAY BE USED AS APPROVED BY THE BUREAU OF DESIGN. FOR TEMPORARY BARRIER, DO NOT GALVANIZE THE STRUCTURAL STEEL PLATES.
2. WHERE SINGLE FACE CONCRETE BARRIER IS SPECIFIED FOR USE AS A RETAINING WALL AND DRAINAGE TREATMENT IS NECESSARY, CONSTRUCT A PREFORMED FABRIC FILTER DRAIN AS INDICATED AND IN ACCORDANCE WITH PUBLICATION 408, SECTION 610. CHECK STABILITY OF BARRIER USED AS A RETAINING WALL AND PROVIDE COMPUTATION WITH THE CONSTRUCTION PLANS.
3. ROUND OR CHAMFER ALL EDGES WITH A RADIUS OF 25 (1") EXCEPT AS SHOWN.

RC-30M – Combo Pipe



COMBINATION

STORM SEWER AND UNDERDRAIN

NOTE: PLACE NO. 57 COARSE AGGREGATE, TAMPED IN LAYERS 150 (6'') THICK, STARTING AT THE LOWEST ROWS OF PERFORATIONS OR THE START OF THE OPEN JOINT. PLACE GROUPS OF PERFORATIONS OR THE OPEN JOINT (1/3 PIPE CIRCUMFERENCE) SYMMETRICALLY ABOUT THE VERTICAL CENTER LINE.

NOTES

1. PROVIDE MATERIALS AND CONSTRUCTION AS SPECIFIED IN PUBLICATION 408, SECTION 610 FOR PAVEMENT BASE DRAIN, SECTION 612 FOR SUBGRADE DRAINS, SECTION 604 FOR COMBINATION STORM SEWER AND UNDERDRAIN AND SECTION 601 FOR PIPE CULVERTS.
2. PROVIDE BITUMINOUS PAPER WHEN GEOTEXTILE MATERIAL IS NOT INDICATED.
3. PREFABRICATED PAVEMENT BASE DRAIN IS NOT RECOMMENDED UNDER CURBED SECTIONS AND ADJACENT TO WIDENED PAVEMENT.
4. PLACE 2A AGGREGATE MATERIAL, IN A LIFT 75 (3'') THICK, COMPACT TO 95% SPD.
5. FOR MAXIMUM AND MINIMUM ALLOWABLE FILL HEIGHTS, REFER TO PUBLICATION 13M, DESIGN MANUAL, PART 2, CHAPTER 10, APPENDIX B (FILL HEIGHT TABLES FOR PIPES AND PIPE ARCHES).