

# Basic Engineering Design Process

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# What is an Engineering Design?

- ◆ An orderly process of collecting, recording, and analyzing all the facts and data needed to arrive at a satisfactory solution to a problem.
- ◆ NEM-VA501.09 through VA501.19 outlines the policy for performing engineering work for NRCS in Virginia.
- ◆ EFH, Chapter 5 – Preparation of Engineering Plans

# Preparing an Engineering Design

- ◆ The following basic steps should be followed for all engineering designs (regardless of complexity):
  1. Identification of the problem and its scope.
  2. Site Investigation.
  3. Collection of basic design data.
  4. Assembly and analysis of data.
  5. Design.
  6. Preparation of plans and specifications.
  7. Review and approval of plan.

# Basic Engineering Design

- ◆ What is an engineering design (the final product) made up of?
  - Drawings:
    - ◆ Coversheet
    - ◆ Plan View Sheet
    - ◆ Standard Detail Sheet
    - ◆ Cross-Section or Profile Sheet
  - Construction Specifications
  - O&M Plan
  - Miscellaneous
    - ◆ Bill of Materials
    - ◆ Cost Estimate
- ◆ The landowner (or cooperator) should be given a copy of all of this!!!

# Construction Drawings

- ◆ Should be:
  - Clear
  - Concise
  - Neat
  - Legible
- ◆ CAD is a tool, not required.
- ◆ Goal is production...not a chance to be an artist.

# Standard Engineering Coversheet

- ◆ Required on all engineering designs.

Location map should provide sufficient information so that someone unfamiliar with the job can locate the site (not the same as the plan view)

Design Copy Routing: \_\_\_\_\_ Cooperators Folder \_\_\_\_\_ Landowner \_\_\_\_\_ Contractor \_\_\_\_\_ Supplier \_\_\_\_\_

### Notes

1. The landowner/operator is responsible for obtaining and complying with all permits and easements. This includes all federal, state and local permits.
2. The landowner/operator is responsible for checking and complying with all local ordinances that may affect the project.
3. MISS UTILITY (1-800-257-7777 or 1-800-552-7001) must be contacted at least 3 working days before construction begins. The landowner/operator is responsible to ensure that the excavator/contractor contacts MISS UTILITY and the excavator/contractor must be able to provide the MISS UTILITY ticket number within 24 hours upon request by the NRCS representative.
4. The landowner/operator is responsible for locating any buried utilities (water lines, electric lines, telephone lines, gas lines, sewer lines, etc.) in the work area that are not covered by the MISS UTILITY program.
5. Prior to beginning construction, the cover sheet must be signed by NRCS, the landowner/operator and the excavator/contractor. The landowner/operator is responsible to inform the excavator/contractor of their responsibilities by providing them a copy of the cover sheet. The excavator/contractor must sign the cover sheet acknowledging that they understand their responsibilities and the landowner/operator must return the signed cover sheet to the NRCS employee or office providing assistance. If requested by NRCS, the landowner/operator shall arrange for a meeting between the contractor and NRCS to review the construction drawings and specifications prior to construction.
6. NRCS makes no representation of the existence or nonexistence of utilities. The presence or absence of utilities on the construction drawings does not assure that there are or are not utilities in the work area.
7. The excavator/contractor is responsible for knowing and following the appropriate safety standards required by the Virginia Safety and Health Codes Board.
8. The landowner/operator shall notify the local NRCS or SWCD representative at least one week prior to when construction is to start, and at the times specified in this construction plan and attached specifications. NRCS or SWCD representative telephone number \_\_\_\_\_.
9. Any deviation from these construction drawings and specifications without written approval from NRCS may result in this practice not meeting NRCS specifications and the withdrawal of technical assistance for this project.

### Benchmark Descriptions

TBM # \_\_\_\_\_  
 \_\_\_\_\_  
 Elevation (assumed) \_\_\_\_\_  
 TBM # \_\_\_\_\_  
 \_\_\_\_\_  
 Elevation (assumed) \_\_\_\_\_

### Acknowledgment Signatures

These construction drawings and attached specifications have been reviewed and all parties understand what is required. (Sign and date below)

Landowner/Operator \_\_\_\_\_  
 Contractor \_\_\_\_\_  
 NRCS Representative \_\_\_\_\_

### "As Built" Documentation

Certified By and Date \_\_\_\_\_  
 Date Completed \_\_\_\_\_  
 Engineering Job Class \_\_\_\_\_

Site Location Map  
 Scale 1 inch = \_\_\_\_\_ feet

### Index of Sheets

Sheet No.	Title

### Specifications

No.	Title

### Table of Estimated Quantities

Item	Unit	Est. Quantity

VIRGINIA ENGINEERING FUNDING PROGRAM  
 /s/ Andrew Lewis, P.E. VIRGINIA ENGINEERING FUNDING PROGRAM  
 VIRGINIA ENGINEERING FUNDING PROGRAM  
 VIRGINIA ENGINEERING FUNDING PROGRAM  
 VIRGINIA ENGINEERING FUNDING PROGRAM

DRAWING			
DATE	APPROVED BY	TITLE	BY
11/25	ANDREW LEWIS	SD	ANDREW LEWIS
11/25	ANDREW LEWIS	SD	ANDREW LEWIS

Date \_\_\_\_\_

Checked \_\_\_\_\_

Approved \_\_\_\_\_

Cover Sheet

Project Name \_\_\_\_\_

Landowner \_\_\_\_\_

County \_\_\_\_\_

Tract # \_\_\_\_\_

Virginia

**NRCS**  
 National Resource Conservation Service  
 United States Department of Agriculture

File Name: VA-SD-100-CoverSheet.dwg  
 Drawing Name: \_\_\_\_\_

Sheet \_\_\_\_\_ of \_\_\_\_\_

# Plan View Sheet

Plan view should show the detailed layout of the proposed practice, topographic features, dimensions, etc.

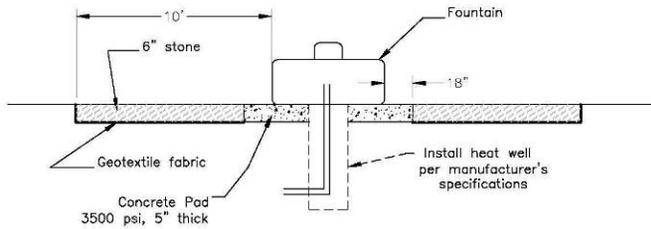
File Name	Project Name _____	Design	Date
Drawing Name	Landowner _____	Drawn	
Sheet	County _____	Checked	
	Tract# _____	Signed	
	_____ Virginia		



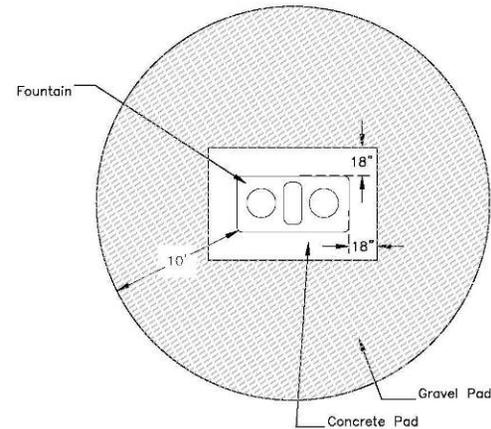
**NRCS**  
Natural Resources Conservation Service  
United States Department of Agriculture

# Use Standard Drawings Whenever Possible

Frost-free Fountain Installation— Side View



Frost-free Fountain Installation— Top View



Construction Notes

- 1.The watering facility shall be installed according to Virginia Watering Facility Standard (614).
  - 2.The concrete pad for the fountain shall extend a minimum of 18" past the edges of the fountain. The pad dimensions recommended by the manufacturer will be used if the dimensions are larger. Concrete shall be 3500 psi installed a minimum of 5" thick. 6"x6" 6/6 gage welded wire mesh reinforcing will be used in the 5" slab. Position the hole for the heat well and pipes per manufacturer's recommendations.
  - 3.The fountain must be attached to the concrete pad per manufacturer's recommendations.
  - 4.A valve shall be installed in the line to regulate flow to the fountain. The valve should be installed in housing that is weatherproof, well drained, and easily accessible. It must also be protected from livestock. High quality ball valves are recommended. Valves installed in the field may be housed in water-meter boxes, concrete casing, or other suitable housing.
  - 5.All backfill for pipelines under the fountain shall be compacted to the degree required to prevent caving after construction.
  - 6.The foundation under and around the fountain location shall be cleared of all material not suited for the subgrade, including sod. All loose surface soil shall be removed to undisturbed material.
  - 7.The fountain site shall be free draining.
  - 8.A protective surface shall be placed around the fountain according to Virginia Heavy Use Area Protection Standard (561). At the minimum, install geotextile fabric around the pad and place VDOT #357 stone six inches deep in a ten foot radius around the fountain. A two inch cap of VDOT #57 or #21A can be placed on the #357. Other types of stone may be installed with approval of the designer.
  - 9.Geotextile shall meet the minimum requirements in Virginia Construction Specification VA-795-4.
  - 10.Seed all disturbed areas at the rates given in Virginia Construction Specification VA-706-3.
- \* If seeding is done outside recommended seeding dates, a nurse crop is to be used.

Available designs include various types of watering troughs, livestock shade structures, temporary waste pads, stream crossings, spring developments, pole structures and waterways.

VIRGINIA ENGINEERING STANDARD DRAWING	
/s/ Matthew Lyons, SDE	Standard Drawing shall NOT be altered without State Conservation Engineer Approval
STANDARD DWG NO.	VA-SO-802-Frost Free Trough
DATE	10/08
SHEET	1 OF 1

Designed	_____
Drawn	_____
Checked	_____
Approved	_____
Project Name	_____
Landowner	_____
County	_____
Traffic	_____
Virginia	_____
<b>NRCS</b> Natural Resources Conservation Service United States Department of Agriculture	
File Name	_____
Drawing Name	_____
Sheet	_____ of _____

# Cross Section Sheet

Cross sections are typically perpendicular to a baseline or centerline (road, stream, etc.)

Used for showing existing ground and design slopes, elevations, grade changes, structure details, etc.

Date	_____
	_____
Design	_____
	_____
Drawn	_____
	_____
Checked	_____
	_____
Signed	_____
	_____
Project Name	_____
Landowner	_____
County	_____
Tract#	_____
	_____ Virginia
 National Resources Conservation Service United States Department of Agriculture	
File Name	VA-SO-315A
Drawing Name	_____
Sheet	_____ of _____

# Profile Sheet

Profiles are typically along or parallel to a baseline or centerline (road, stream, etc.)

Used for showing existing ground and design slopes, elevations, grade changes, structure details, etc.

File Name	Project Name	Tract#	Date
Drawing Name	Landowner	County	Designed
Sheet of		Virginia	Drawn
			Checked
			Approved

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United States Department of Agriculture

# Construction Specifications

## CONSTRUCTION SPECIFICATION

### VA-761. LOOSE ROCK RIPRAP

#### 1. SCOPE

The work shall consist of the construction of loose rock riprap revetments and blankets, including filter layers or bedding where specified.

#### 2. MATERIALS

Rock for loose rock riprap, filter layers or bedding shall come from sources approved by an NRCS representative and meet the size and gradation requirements shown on the design drawings. The rock shall be excavated, selected and handled as necessary to meet the quality and grading requirements of this specification and the construction drawings. Individual rock fragments shall be dense, sound and free from cracks, seams and other defects conducive to accelerated weathering. The rock fragments shall be angular to subrounded in shape. The least dimension of an individual rock fragment shall be not less than 1/3 the greatest dimension of the fragment unless otherwise specified on the construction drawings.

Except as provided below, the rock shall have the following properties:

- a. Bulk specific gravity (saturated surface-dry basis) not less than 2.5.
- b. Absorption not more than 2 percent
- c. Soundness: Weight loss in five cycles not more than 10 percent when sodium sulfate is used or 15 percent when magnesium is used.

Bulk specific gravity and absorption shall be determined according to ASTM C 127. The test for soundness shall be performed according to ASTM C 88.

Rock that fails to meet the requirements stated in a, b, and c above may be accepted only if similar rock from the same source has been demonstrated to be sound after 5 years or more of service under conditions of weather, wetting and drying, and erosive forces similar to those anticipated for the rock to be installed under this specification.

The rock shall conform to the grading limits, specified on the drawings, after it has been placed as the riprap.

#### 3. SUBGRADE PREPARATION

The subgrade surfaces on which the riprap or bedding course is to be placed shall be cut or filled and graded to the lines and grades shown on the drawings. When fill to subgrade lines is required, it shall consist of approved materials and shall be compacted to a density equal to the adjacent existing soil material.

Rock materials shall not be placed until the foundation preparation is completed and the subgrade surfaces have been inspected and approved by the NRCS representative.

#### 4. EQUIPMENT-PLACED ROCK RIPRAP

The rock shall be placed by equipment on the surfaces and to the depths specified. The riprap shall be constructed to the full course thickness in one operation and in such a manner as to avoid serious displacement of the underlying materials. The rock shall be delivered

and placed in a manner that will insure that the riprap in place shall be reasonably homogeneous with the larger rocks uniformly distributed and firmly in contact, one to another with the smaller rocks and spalls filling the voids between the larger rocks.

Riprap shall not extend above grade on side slopes so that water is ponded outside the riprap.

Riprap shall be placed in a manner to prevent damage to structures. Hand placing will be required to the extent necessary to prevent damage to the permanent works.

#### 5. HAND-PLACED RIPRAP

The rock shall be placed by hand on the surfaces and to the depths specified. It shall be securely bedded with the larger rocks firmly in contact, one to another. Spaces between the larger rocks shall be filled with smaller rocks and spalls. Smaller rocks shall not be grouped as a substitute for larger rock. Flat slab rock shall be laid on edge unless otherwise specified.

#### 6. FILTER LAYERS OR BEDDING

When the drawings specify filter layers or bedding beneath riprap, the filter or bedding material shall be spread uniformly on the prepared subgrade surfaces to the depth specified. Compaction of filter layers or bedding will not be required, but the surface of such layers shall be finished reasonably free of mounds, dips or windrows.

Filter fabric may be used in lieu of filter gravel if approved by the NRCS representative. The fabric shall be manufactured to provide the necessary life and filtering action. The fabric and riprap shall be placed in accordance with the manufacturer's recommendations.

#### 7. TESTING

The contractor will furnish such test data as are required to verify that the riprap, filter, and bedding materials and the completed work meet the requirements of the specifications.



# Bill of Materials & Cost Estimate

## Practice Spring #1

Item #	Item	Quantity	Unit	Unit Price	Cost
1	Hand Mix Concrete	0.5	cu.yd.	\$50.00	\$25.00
2	VDOT #57 Stone	1	tons	\$15.00	\$15.00
3	Precast Concrete Spring Box w/ Lid	1	ea.	\$125.00	\$125.00
4	2" Sch 40 PVC Pipe	525	l.ft.	\$1.75	\$918.75
5	Precast Concrete Trough	1	ea.	\$500.00	\$500.00
6	Geotextile 15' Wide	50	l.ft.	\$1.70	\$85.00
7	VDOT #21A Stone	3	tons	\$15.00	\$45.00
8	Backhoe	4	hrs.	\$55.00	\$220.00
					\$1,933.75

## Practice Spring #2

Item #	Item	Quantity	Unit	Unit Price	Cost
1	4" Perforated Plastic Tile	100	l.ft.	\$0.40	\$40.00
2	VDOT #57 Stone	3	tons	\$15.00	\$45.00
3	Precast Concrete Spring Box w/ Lid	1	ea.	\$125.00	\$125.00
4	4" Nonperforated Plastic Tile	140	l.ft.	\$0.40	\$56.00
5	2" Sch 40 PVC Pipe	330	l.ft.	\$1.75	\$577.50
6	Precast Concrete Trough	1	ea.	\$500.00	\$500.00
7	Geotextile 15' Wide	50	l.ft.	\$1.70	\$85.00
8	VDOT #21A Stone	3	tons	\$15.00	\$45.00
9	Backhoe	8	hrs.	\$55.00	\$440.00
					\$1,913.50

# Basic Engineering Design

- ◆ What should be kept in the job folder?
  - Copy of design (everything given to landowner or cooperator).
    - ◆ Coversheet should be signed by NRCS representative, landowner, and contractor prior to construction.
  - Field notes, before and after construction.
  - Design notes & computations.
    - ◆ See NEM VA501.16 *Technical Quality*.
  - Photographs, before and after construction.
  - As-built drawings and notations.
  - See “Design Data” and “Check Data” under applicable practice standards for required data.

# Basic Engineering Design

- ◆ Why supply the information previously mentioned?
  - To comply with Conservation Practice Standards.
  - To maintain technical and professional quality.
  - At the direction of the State Conservation Engineer.
    - ◆ Operating under his technical supervision and P.E. license.

# In Review...

- ◆ What is the first step of any engineering design?
- ◆ Should the cooperator receive a copy of the final design?
- ◆ Is drafting the construction drawings in CAD a requirement?



Questions?