

ENGINEERING
HANDBOOK

**drop
spillways**

section

11

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

PREFACE

SECTION 11

DROP SPILLWAYS

This handbook is intended primarily for the use of Soil Conservation Service engineers. Much of the information will also be useful to engineers in other agencies and in related fields of work.

The aim of the handbook is to present in brief and usable form information on the application of engineering principles to the problems of soil and water conservation. While this information will generally be sufficient for the solution of most of the problems ordinarily encountered, full use should be made of other sources of reference material.

The scope of the handbook is necessarily limited to phases of engineering which pertain directly to the program of the Soil Conservation Service. Therefore, emphasis is given to problems involving the use, conservation, and disposal of water, and the design and use of structures most commonly used for water control. Typical problems encountered in soil and water conservation work are described, basic considerations are set forth, and all of the step-by-step procedures are outlined to enable the engineer to obtain a complete understanding of a recommended solution. These solutions will be helpful in training engineers and will tend to promote nation-wide uniformity in procedures. Since some phases of the field of conservation engineering are relatively new, it is expected that further experience may result in improved methods which will require revision of the handbook from time to time.

This section of the Engineering Handbook has been written by M. M. Culp, Head of the Design Section of the Engineering Division, and C. A. Reese, Design Engineer. Two successive drafts have been submitted to field engineers and others for review. Suggestions received have led to improvements in the text and have been sincerely appreciated.



CONTENTS
SECTION 11
DROP SPILLWAYS

<u>Subject</u>	<u>Page</u>
<u>1. General</u>	
Description - - - - -	1.1
Material - - - - -	1.1
Functional Use - - - - -	1.1
Advantages - - - - -	1.1
Disadvantages - - - - -	1.2
<u>2. Layout</u>	
General - - - - -	2.1
Site Selection - - - - -	2.1
Channel Alignment - - - - -	2.1
Foundation Conditions - - - - -	2.2
Other Considerations - - - - -	2.2
Structure Dimensions - - - - -	2.4
Top Width of Earth Embankment - - - - -	2.4
Fill Slopes - - - - -	2.4
Required Height of Earth Fill Above Top of Headwall Extension - - - - -	2.4
Riprap of Approach Channel - - - - -	2.5
<u>3. Hydraulic Design</u>	
Hydrologic Determinations - - - - -	3.1
Discharge Capacity Determinations - - - - -	3.1
Free Discharge - - - - -	3.1
Velocity of Approach - - - - -	3.2
Freeboard - - - - -	3.7
Working Procedures, Tools, and Examples for Free Flow - - - - -	3.10
Submerged Discharge - - - - -	3.15
Examples for Submerged Flow - - - - -	3.18
Layout and Hydraulic Design Criteria - - - - -	3.21
<u>4. Structural Design</u>	
General - - - - -	4.1
Proportions Required for Stability - - - - -	4.1
Horizontal Pressures - - - - -	4.1
Loads on Headwall - - - - -	4.1
Relative Permeability of Foundation and Backfill - - - - -	4.2
Effect of Water Table Elevation - - - - -	4.2
Drainage of Fill Against Headwall - - - - -	4.3

<u>Subject</u>	<u>Page</u>
Loads on Sidewalls and Wingwalls - - - - -	4.9
Loads on Headwall Extensions - - - - -	4.9
Uplift - - - - -	4.9
Contact Pressures - - - - -	4.12
Piping - - - - -	+.14
Overturning - - - - -	4.19
Sliding - - - - -	4.19
Codes and Criteria - - - - -	4.21
Headwall Analysis - - - - -	4.21
Sidewall Analysis - - - - -	4.22
Wingwall Analysis - - - - -	4.26
Apron Analysis - - - - -	4.26
Buttress Analysis - - - - -	4.26
Longitudinal Sill Analysis - - - - -	4.30
Transverse Sill Analysis - - - - -	4.30
Headwall Extension Analysis - - - - -	4.31
<u>5. Type B Drop Spillway</u>	
General - - - - -	5.1
Tailwater - - - - -	5.2
Volumes of Concrete and Steel - - - - -	5.4
<u>6. Structural Design Example</u>	
General - - - - -	6.1
Hydraulic Design - - - - -	6.1
Stability Design - - - - -	6.5
Headwall Design - - - - -	6.16
Sidewall Design - - - - -	6.19
Apron Design - - - - -	6.23
Buttress Design - - - - -	6.32
Longitudinal Sill Design - - - - -	6.35
Transverse Sill Design - - - - -	6.42
Wingwall Design - - - - -	6.45
Design of Headwall Extension - - - - -	6.52
<u>7. Masonry Drop Spillways</u>	
General - - - - -	7.1
Design Procedures and Aids - - - - -	7.1
Reinforced Concrete Apron and Sill Design - - - - -	7.1
Example 7.1--Design of Masonry Drop Spillway - - - - -	7.4

ENGINEERING STANDARD DRAWINGS

SECTION 11

DROP SPILLWAYS

<u>Title</u>	<u>Drawing No.</u>	<u>Page</u>
Required Width of Headwall Extension		
Footings for Type B - - - - -	ES-48	5.10
Apron Design--Moments and Shears - - - - -	ES-56	4.27
Nomenclature and Symbols of Drop Spillway - - - - -	ES-63	1.3
Required Base Width for Gravity Walls with Various Loads and Loadings - - - - -	ES-64	7.17
Solution of Equation $Q = (3.1 Lh^{3/2}) \div (1.10 + 0.01F)$ - -	ES-65	3.11
Approximate Volumes of Reinforced Concrete in Cubic Yards--Type B - - - - -	ES-66	5.7
Layout and Hydraulic Design Criteria--Type B - - - - -	ES-67	5.3
Dimensionless Coordinates of Water Surfaces for Aerated Nappe Over Weir with Level Flush Approach Channel - - -	ES-68	6.3
Typical Layouts - - - - -	ES-70	2.3
Details of Masonry Drop Spillways - - - - -	ES-71	7.16
Minimum Concrete Volumes--Type B - - - - -	ES-74	5.9
Riprap of Approach Channel - - - - -	ES-79	2.6
Details of R/C Drop Spillway - - - - -	ES-80	6.53
Aeration of Weirs - - - - -	ES-81	3.3

