United States Department of Agriculture
Soil Conservation Service
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Washington, D.C.
20013

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NEH-011A

NATIONAL ENGINEERING HANDBOOK, SECTION 11
210-VI
Circular No.-1

SUBJECT: ENG - NEH-11, DROP SPILLWAYS

Purpose. To cancel a chapter of NEH Section 11, Drop Spillways, and itemize other items in the handbook that need more detailed or alternative consideration during structural analysis and design.

Effective Date. This circular is effective when received.

Chapter 6 which contains the structural design example is canceled. The example design is a good illustration of the documentation and process to be used in a design analysis. However, the example used is not representative of the potential loadings commonly encountered in a new design. A detail listing is provided of the shortcomings contained in the example.

Chapters 4 and 5 contain some procedures and data that should be used with caution. The concerns on the contents are contained herein and need to be considered in all designs developed using this handbook as a reference.

NEH-11 was written in the 1950's and the procedures contained were used for the design of the Type B series of National Standard Detail Drawings. The structures designed up to that period of time in SCS were usually small and the results of some of the simplifying assumptions made were not critical to the structure performance. However, when the analysis is applied to larger structures or differing critical loading combinations, poor or unsatisfactory performance can result. There is still a lot of material in the handbook that is of value. Most of the content, if critically read, can be very helpful in gaining insight into the structural behavior of this shape spillway.

Below are listed the items of concern in the handbook. These items have limited application when used without modification.

A revision of this handbook is planned. An outline of the proposed revision has been prepared and reviewed by the NTC design engineers. Chapters 4 and 6 will be replaced by ones entitled "Structural Design Considerations" and "Structural Design of Monolithic Drop Spillways."

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Areas of Limited Application.

I. Chapter 4. "Structural Design"

A. Simplified approaches are used for pore water pressure determinations at soil/structure interfaces, specifically determination of water pressures against the headwall and uplift pressures acting on the base of the spillway. An empirical procedure is used to determine phreatic line elevations at the headwall (NEH-11, pages 4.1-4.8), and "line of creep" theory is used to determine uplift against the base (pages 4.9-4.11, 4.14-4.19). Seepage analyses and flow net procedures are now available and can be used to obtain interface pore water pressures of interest.

B. Apron system analyses assume the apron slab is subjected to one-way bending transversely and that the longitudinal sills provide non-yielding supports to these continuous spans (pages 4.26-4.28). Relative stiffness analyses show that longitudinal sills of the proportions used in the Type B Drop Spillway series of National Standard Detail Drawings are often not sufficiently stiff and can not in fact provide non-yielding supports. Relative stiffness analyses can be used to determine the required sizes of longitudinal sills, if used, and the required sizes of transverse sills to ensure that the sills do provide essentially non-yielding supports. Two-way slab theory can be used to proportion the apron slabs and determine required reinforcement.

C. Considerable discussion centers around monolithic construction between headwalls and headwall extensions and between sidewalls and wingwalls (pages 4.9, 4.19, 4.22-4.26). Current practice tends toward use of various articulation joints.

II. Chapter 5. "Type B Drop Spillway"

A. Load assumptions used to design the Type B series of National Standard Detail Drawings are minimal and often inadequate, depending on the backfill (page 5.4-5.5). Lateral earth pressures deserve careful assessment. Conditions producing "at rest" values should be recognized.

B. Volumes of concrete and steel for Type B Drop Spillways (pages 5.4-5.9) are based on very low loads and acceptance of 8" and 9" slab thicknesses. Current practice would reject these slabs; thicknesses of 10", 11", 12", and even 15", are usually considered minimum.

III. Chapter 6. "Structural Design Example"

This chapter has been canceled for design application due to the following limitations.

A. The design example treats three loading conditions: no fill no flow, fill no flow, and fill full flow. Statements are made concerning which loading condition is critical. It is often difficult to predict which loading is critical. Often, other, intermediate loadings will control various components of the design.

B. Determination (selection) of headwall saturation elevation for full flow, $y_2$, as $y_2 = t + s$, is a computational convenience but is probably misleading to the infrequent reader (pages 6.4-6.5, 6.7-6.8). Also see I.A. above.

C. Improved technology is available to replace the use of "line of creep" theory for uplift computations (page 6.8). Also see I.A. above

D. Use of gross weight for toewall and cutoff wall in uplift computations is wrong when uplift is referenced to bottom of apron (pages 6.8, 6.9, 6.11). Bouyant weight should be used.

E. The sliding factor of safety computations neglect consideration of water below elevation of bottom of apron (page 6.15). Though the effect is slight, the actual factor of safety is less than the computed value.

F. The sidewall design does not consider water pressures on either side of the wall (pages 6.19-6.22). Though the effect is slight for this example, in general one should include water loadings to ensure the critical loading is addressed.

G. The apron design assumes longitudinal sills and buttresses provide non-yielding supports (pages 6.23-6.32). Also see I.B. above.

H. The apron slab design completely neglects consideration of water acting on the fill side of the sidewall for both no flow and full flow (pages 6.24-6.30).

I. The apron design considers one-way transverse bending only, i.e., no account taken of longitudinal bending spanning from headwall to transverse sill (pages 6.24-6.32).

J. The longitudinal sill design assumes the sill is loaded with two piecewise uniform loads (page 6.36). Could just as easily have used the uniformly varying loads.

K. The transverse sill design does not consider the loading brought to the sill via apron panel reactions (page 6.42). This is a direct result of recognizing only one-way transverse bending in the apron.

L. The possible need of web steel for flexural shear is not mentioned in the example design. Web steel is sometimes needed in buttresses, in longitudinal sills, and/or in transverse sills.

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M. There is no recognition of the presence of torsion in any components of the drop spillway.

N. The wingwall design is deficient in several respects (pages 6.47-6.52). Some of these are:
   1) Effects of water pressures against the wingwall are not considered.
   2) Only one loading, moist backfill is considered. Often design features will be controlled by loadings intermediate between no flow and full flow.
   3) The wingwall footing is sized by overturning analysis of the section at the articulation joint between wingwall and sidewall and the section at the downstream end of the wingwall. The footing is then varied uniformly between the two sections. Investigation of intermediately located sections would often show the inadequacy of this procedure (page 6.46-6.47).
   4) The stability design for overturning assumes earth pressures, on the vertical plan through end of footing, are inclined. This is not conservative because it assumes a stabilizing force whose existence and magnitude are uncertain. Without the vertical component, the overturning criteria is not satisfied (page 6.46).
   5) The internal strength design of the footing is inconsistent. The vertical component of inclined earth pressures is used to compute bearing pressures but is then neglected in determining downward loading on the footing. Hence, computed moment and shear is less than the actual moment and shear (page 6.51).
   6) The sliding stability of the wall is made dependent on a tie to the apron. This can cause an additional sliding force to be brought to the spillway proper - for which the spillway was not designed (pages 6.47-6.48).

Interim Procedures. Until the new revised edition is completed and available, structural design procedures given in TR-63, "Structural Design of Monolithic Straight Drop Spillways" should be followed rather than those given in NEH-11. Some portions of TR-63 could be improved. This will be accomplished at the time it is rewritten for inclusion in the revised NEH-11.

Filing Instructions. Place this circular immediately behind the front cover of NEH-11, Drop Spillways. Additional copies may be obtained from Central Supply by ordering Form Catalog Order No. NEH-011A.

ACTING Donald I Basy

EDWARD E. THOMAS
Deputy Chief for Technology