Part 650 – Engineering Field Handbook

Chapter 6 – Structures

IA650.0602 Straight Drop Spillways

A. Design Procedures for Drop Spillways

(1) General Guidance

(i) Follow Iowa Conservation Practice Standard 410, Grade Stabilization Structure (IA CPS 410) to plan, design, and install drop spillway structures. The following procedures and information supplement IA CPS 410.

(ii) Design drop spillways with adequate hydraulic capacity to pass the peak flows from the design discharges, less any reduction from detention storage, if needed. Peak discharges may be determined using procedures in Title 210, National Engineering Handbook (NEH) Part 650, Engineering Field Handbook (EFH) Chapter 2, Estimating Runoff; or 210-NEH, Part 630, Chapter 10, Estimation of Direct Runoff from Storm Rainfall. The effect of detention storage on the design peak discharge may be evaluated, if desired, by means of flood routing programs such as WinPond or SITES.

(iii) Auxiliary spillways are not required for drop spillways if the structural spillway capacity is adequate to pass the maximum flow from the total capacity storm as specified in IA CPS 410 without overtopping the headwall.

(iv) The downstream channel must be stable after the structure is installed. As a general rule of thumb, any grade steeper than 0.5% should be carefully evaluated. If stability cannot be ascertained by visual inspection, estimate channel velocity using the Manning equation for flows at bank-full stage or at design peak flow, whichever is less. Channel velocities may be computed for trapezoidal or parabolic channels using the Hydraulic Formulas found under Utilities within the NRCS Engineering Field Tools software. Compare to permissible bare channel velocity for the soil materials found in the downstream channel. See 210-NEH, Part 650, EFH Chapter 14, Water Management, Figure 14-16 (Permissible Bare Earth Velocities) for permissible velocities. If the downstream channel is not stable, adjust the outlet elevation of the structure downward to allow for the depth of downcutting expected, or provide additional stabilization measures downstream of the structure.

(v) Drop spillway structures tend to scour in the area upstream of the weir, and in some cases immediately downstream of the outlet. Provide loose or grouted rock riprap protection as shown on the standard drawing, or as required to prevent erosion for non-standard structure designs. For information on riprap sizing see 210-NEH, Part 654, Technical Supplement 14C, Stone Sizing Criteria.

(vi) In the past, NRCS has developed a variety of standard drawings and designs for concrete drop structures. Design standards have changed since then, and not all loading conditions were accounted for in the original designs. No NRCS standard concrete drop designs or standard drawings will be used unless a full analysis of the loading conditions and concrete design is completed.

(2) Island Type Structures

(i) If a drop spillway is planned as an island type structure, the capacity of the weir or headwall opening must be equal to the capacity of the downstream channel at the point where the auxiliary spillway (AS) flow will re-enter the channel. This design practice is set so that the ditch will be full before the overflow around the structure enters the ditch. This eliminates the possibility of erosion from flow over the ditch bank. To accomplish this, the crest of the weir must be set below the bottom elevation of the AS sufficiently to provide weir capacity between these two points equal to the bank-full capacity of the channel. Generally, a portion of the weir will be submerged, and this must be considered in the design for any structure with a vertical drop greater than 4 feet. No submergence calculations or increase in weir size are required for island type structures with a vertical drop of 4 feet or less.

(ii) When flow occurs through the AS, the depth of flow over the weir may be higher than the weir design depth of flow. This will require extending the height of the weir notch (top of headwall) above the design depth of flow in AS so that flood flows will not overtop the headwall and erode the earthfill. In other words, the depth of the weir notch must be equal to the depth necessary to carry ditch capacity plus the design depth of flow of the AS.

(iii) The AS will often be located on cultivated land, and the velocity of flow must be kept low so that scouring will not develop. The depth of flow affects the height of the structure; therefore, as flow depth increases, the cost of the structure will increase. An AS flow depth of 0.5 foot is about the maximum that should be considered, providing this depth will not create erosive velocities.

(iv) The upstream waterway must have the same capacity as the channel below the structure. This means that the discharge from the waterway must fill the channel before the banks of the waterway are overtopped and flow is directed to the AS. It should also be proportioned so that its banks will overflow near the structure as soon as channel capacity flow has been reached. Above this point of overflow it should be designed under IA CPS 412, Grassed Waterway.

(v) In order to force overflow water away from the structure, the earth fill should extend at least 40 feet from the edge of the weir notch. The top of the settled earth fill should be at least 1.0 foot higher than the top of the structure headwall. A dike should extend downstream from the earth fill to prevent auxiliary spillway flow from entering the channel within 15 feet of the structure.