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NEW TYPE WEIR CONSTRUCTION FOR SMALL WATERSHEDS

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SYNOPSIS

Wet foundation conditions are frequently encountered in constructing runoff measuring weirs on small watersheds in deeply incised waterways. In case of very fine silts and clays, the conventional well point system is not suitable for dewatering the foundation and cutoff trenches. A new type of weir construction was developed to circumvent the need for dewatering these foundations. Details of the construction are outlined. The weirs consist of (1) a main supporting wall of steel sheet piling, which is capped with a prefabricated steel crest, and (2) the stilling basin outlined by driven corrugated steel sheeting and backfilled with large boulders.

INTRODUCTION

Precalibrated flumes and weirs are commonly used to measure runoff from experimental agricultural areas. H-type flumes have capacities for discharges expected from watersheds of less than 20 acres. Broad-crested V-notch concrete weirs are used for larger areas.[3] Both of these normally require excavation for forming and pouring a concrete cutoff wall. Frequently, these excavations are in wet areas and are difficult to dewater. Many man hours of labor have been spent fighting mud and trench caving on these jobs. To eliminate this difficulty, a new type of weir was designed and installed on four small watersheds of 80 to 120 acres in the deep loess of western Iowa.

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3 Holtan, H. N., Minshall, N. E., and Harrold, L. L., "Field Manual for Research in Agricultural Hydrology," Agricultural Handbook No. 224, U. S. Dept. of Agriculture, Washington, D. C., 1962.

These watersheds were established in connection with a study on the effect of level terraces and other conservation practices on the rate of gully advancement, sediment yield, and streamflow characteristics. Much of this deep loess is dissected by gullies 20 ft deep, or more. Permanent gully control or floodwater-retarding structures are generally uneconomical on areas draining less than 160 acres. Most of the land in this soil area can remain productive if level terraces and other conservation practices are effective in controlling the advance of gullies.

THE PROBLEM

Engineers constructing a broad-crested V-notch concrete weir in one of these deep gullies encountered several severe problems. The soils were fine, wind-blown material with layers high in silt or clay content that inhibited the downward movement of infiltrating water. In addition to water seeping out along the banks, the bottom of the gully was always wet.

Dewatering these wet areas for construction of concrete foundations was quite difficult because conventional-type well point systems were not suitable for use on these fine soils. Pumping water from the excavation caused the banks to slough. Also, because of the soft foundation existing under these conditions, the labor force had very poor footing. Furthermore, it was necessary to pour a concrete subbase or footing on which to support the weir forms.

Another problem was to install a gaging device that would measure the complete flow in the gully without disrupting the normal underground flow out of the basin. An impervious cutoff wall for the measuring weir would present a watertight barrier to such underground flow. Streamflow leaking into the gully bottom and bypassing the gaging site, being unmeasured, was also unacceptable. The ideal condition was deemed to be one in which the ground-water profile remained essentially unaffected, and yet any base flow appearing upstream from the gaging station would flow over the weir.

SOLUTION

Some of the difficulties encountered with this work on wet foundations were eliminated by using a new type of installation that did not require excavation for footings or cutoffs. This consisted of a main wall, across the gully, of 10-ft interlocking steel sheet piling, supporting a prefabricated stainless steel crest. Stainless steel was available from surplus. A cheaper material might have been selected if it had to be purchased. A stilling pool outlined with 7-ft corrugated steel sheeting and partly backfilled with rock was provided. Some of the design details of the crest are shown in Fig. 1.

This type of construction is less watertight than a concrete cutoff and therefore has less effect on the natural ground-water profile. A waterproof membrane was attached to the upstream face of the weir to assure that all the base flow discharged over the weir crest. This membrane was carried down approximately 2 ft below the crest and then extended upstream from 2 ft to 3 ft. A sheet metal cutoff was used in place of the plastic membrane for the fourth weir. Sheet metal was used because it is less susceptible to damage by rodents and debris. It was found to be easier to install in wet locations. The galvanized sheet metal cutoff was bolted to the face of the stainless steel weir crest and formed to rest against the upstream face of the piling. This cutoff wall extended 4 ft below the weir crest.

A stilling pool at the downstream face of the weir was formed in the area outlined by the steel sheet piling and the corrugated steel sheeting. The soil was removed from this area to a depth of approximately 4 ft and this excavation backfilled with layers of gravel and coarse rock. No special studies were made to determine the depth of the scour hole, but investigations at Colorado State University[4] indicate the feasibility of this method in lieu of a permanent stilling basin and energy dissipator. Fig. 2 is a photograph of a completed installation.

CONSTRUCTION METHODS

The first step was to slope the steep gully banks, in the vicinity of the weir, to near the finished grade called for on the plans. Next, the 10-ft inter-

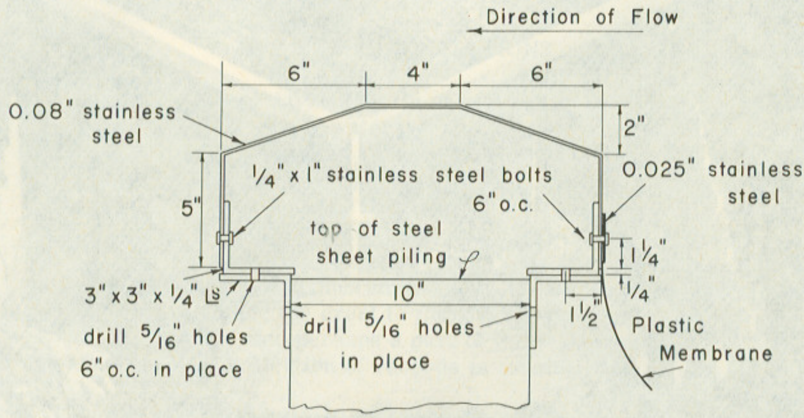

FIG. 1.—SECTION OF WEIR CREST

locking steel sheet piling was driven approximately 7 ft into the soil across the gully to the lines and grades shown on the plans. Allowance was made for a maximum deviation from a straight line of 1 in. A greater deviation could perhaps be tolerated, and the variation could be taken up by the pairs of angles in attaching the weir crest. The 8-ft corrugated steel sheeting was driven into the gully bottom around the stilling pool area designated to contain the gravel and rock backfill. The scour hole was excavated to a depth of approximately 4 ft and backfilled with three layers of gravel and rock. The bottom 6 in. layer was gravel; the top layer was one-man rock. Experience gained from several small runoff events indicates that rip-rap material or "blast

4 Smith, George L., "Scour and Energy Dissipation Below Culvert Outlets," CER No. 57GLS16, Dept. of Civ. Engrg., Colorado Agric. and Mechanical Coll., Fort Collins, Colo., 1957.

material" from limestone quarries may be more satisfactory for lining the scour hole. This material contains rocks weighing several hundred pounds as well as graded material down to fines. The larger rock is necessary to dissipate the energy created by the overfall at the weir without being transported out of the stilling pool.

The interlocking sheet piling was cut off with a torch on a grade line approximately 8 in. below the design elevation of the weir crest. The lower pair of 3 in. by 3 in. by 1/4 in. angles was clamped to the steel sheet piling at the proper slope, then drilled and bolted. Care must be exercised to keep the proper grade while attaching the lower 3 in. by 3 in. by 1/4 in. angles, as experience revealed that regularly stocked angles are not uniformly straight.

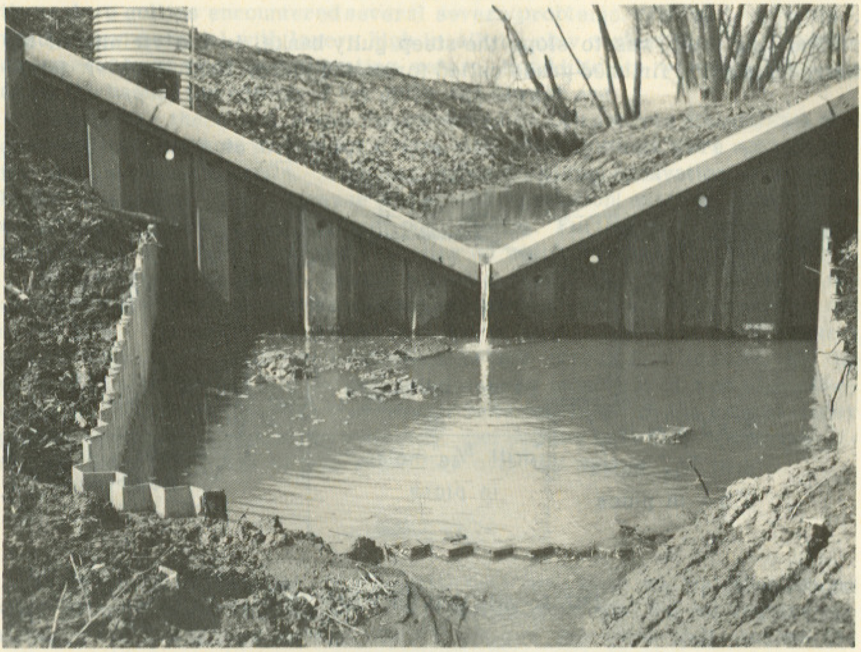

FIG. 2.—VIEW OF COMPLETED WEIR

It was necessary to drill and attach the angles at the notch and then to aline the angles at each attachment to succeeding pilings. The original plans were to use shims between the sheet piling and these angles. In these loess soils, pilings were brought into near-perfect alinement with a minimum of effort by jacking or clamping. This eliminated the need for shims. The upper pair of angles was clamped in place to obtain the proper alinement and then drilled and bolted. Finally, the stainless steel crest was attached to the upper pair of angles with stainless steel bolts and, at the same time, the waterproof membrane was attached to the upstream face. Pilings were held in alinement until the weir crest attachment was completed. The pilings remained in good alinement when released, and no significant distortion of the weir crests could be found.

To obtain year-round records of runoff from any small agricultural watershed, it is necessary to keep the weir and well free of ice. This was accomplished by placing thermostatically operated electric heating cables under a 4-ft section in the center of the weir crest and on the intake pipe. These were designed to provide more than the minimum 40 watts per sq. ft recomended for melting ice at this latitude. A 150-watt flood lamp, also thermostatically operated, was installed in the shelter house to prevent frost accumulation on the float wheel and float tape of the recorder.

The concrete weir cost $4884. The average cost of the first three of these steel-crested weirs, using all new materials, was approximately 15% less. Used piling and sheeting and favorable construction conditions for the fourth weir resulted in a 40% saving. Additional savings will result from the salvaging of these metal crests when the stations are discontinued. These savings will be somewhat offset by higher maintenance costs, because it will occasionally be necessary to replace some of the rock in the stilling pool.

CONCLUSIONS

There are several advantages in using steel rather than concrete for construction of weirs on small watersheds in areas having wet foundations. They are as follows:

1. a savings in the cost of installation;
2. simplicity of construction—dewatering the site is unnecessary;
3. ease of removal in case of short duration experiments;
4. closer adherence to lines and grades is possible through use of the pairs of angles for attaching the crest to the sheet piling; and
5. the weir crest and perhaps a part of the steel piling and sheeting can be salvaged when the collection of records is terminated.

One disadvantage of this type of installation may be the difficulty of obtaining a sharp bend in the crest plate. The minimum possible outside radius of the bend was 5/32 in. plus the thickness of the material. The hydraulic characteristics of the board-crested V-notch concrete weir have been determined with laboratory calibrations.[3] Field check and laboratory calibration will be required to determine the effect of rounding the corners and using a different material.

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KEY WORDS: construction; dewatering; foundations; irrigation; runoff; watersheds; weirs

ABSTRACT: An alternative to the necessity of dewatering wet foundations for construction of small runoff measuring weirs is presented. The method is particularly adapted to soils so fine that conventional well point systems are unsatisfactory. Details of construction are outlined. The main wall consisted of a row of steel sheet piling capped with a prefabricated steel crest. The stilling basin was outlined with corrugated steel sheeting and filled with large boulders.

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