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Analysis of Small Water Management Structures in Irrigation Distribution Systems

Gaylord V. Skogerboe

Wynn R. Walker

Brent B. Hacking

Lloyd H. Austin

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by

Gaylord V. Skogerboe
Wynn R. Walker
Brent B. Hacking
Lloyd H. Austin

Utah Water Research Laboratory
College of Engineering
Utah State University
Logan, Utah 84321

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Bifurcations and convergences--The principles for separating flow into two or more branches, each carrying some percentage of the original stream, should be determined. Converging flows pose similar problems especially when the flows are at different velocities and head losses must be held to a minimum.

Inlet and outlet transitions--Information is needed concerning the design of transitions to obtain both maximum and minimum head losses.

High velocity canals--More information is needed to predict flow at turnouts, transitions, siphons, curves and other structures when the flow velocity is supercritical.

Canal bank erosion by wind-generated waves--Methods for determining the stable slope of various soil materials when subjected to wave action requires study. Relationships between various exposures, climate, site conditions, and the size of the waves generated need investigation.

Wave suppressors--New and more effective methods should be developed for the elimination of surges and waves in canals.

Seepage meters--Devices are needed to locate seepage areas in canals and to determine the amount of the seepage loss.

Canal sealants--New, low-cost, effective, and durable sealants to prevent seepage losses need development.

Underdrains--Jam-proof flap valves to relieve pressure under linings are needed. New types of valves should be considered.

Sediment control devices--Devices for excluding sediment from canals and pipelines or to keep sediment in suspension throughout the system, should be investigated.

Moss and/or weed elimination devices--Self-cleaning devices for moss and weed elimination are needed.

Riprap--The sizes needed for protection from high velocities and waves should be determined. The most effective way to place riprap should be studied.

Rescue and safety devices--High velocity inlets and steep sided canals can provide hazards for humans and animals. Consideration should be given to rescue and safety devices which will effectively save lives and yet not interfere with the conveyance of the water.

Automatic flow controls--Devices to automatically control flows should be developed. Hydraulic and operational characteristics of both presently available and new equipment must be determined.

In discussing possible means of having the recommended research accomplished, it was suggested by some panel members that a considerable portion of the research material could be undertaken by graduate students, particularly at the Master of Science level. Much of the research suggested at the conference could be more readily accomplished if the topics were identified with specific details and separated into segments in order that an individual graduate student could investigate a single segment.

Considerable literature exists throughout the world regarding small water management structures; however, much of the literature is concerned with particular structures for special uses rather than information of a general nature. The material of a general nature is scattered in numerous laboratory and project reports or design manuals. Because of the cost of an individual small structure, general rules-of-thumb and large factors of safety have been used in design and construction rather than to develop

Examples of such structures are the broken-back transition, manifold stilling basin, USBR stilling basin VI, and USU stilling basin. There is still room for additional thinking regarding such structures. A number of possibilities exist for dissipating energy in the vertical direction, wherein the jet issuing from the closed conduit is either moving vertically upward or vertically downward. In either case, ideas can be borrowed from overflow stands, alfalfa valves, energy dissipator pipe as used in the USU stilling basin deflector plates, slotted plates, slotted caps (e.g. well screens), blocks, and wave suppressors. The design should vary with the amount of excess energy that must be dissipated.

Trapezoidal Baffled Aprons

The U.S. Bureau of Reclamation (Peterka, 1964) has developed design criteria for baffled aprons in rectangular channels. For small structures, it is frequently desirable to use trapezoidal cross-sections. Therefore, design criteria should be developed for trapezoidal baffled aprons. In particular, emphasis should be given to smaller drops, say less than 10 feet. The slope of the trapezoidal walls should be varied from 1:1 to 3:1 (3 horizontal to 1 vertical).

Outlet Transitions

In most cases, the design of outlet transitions in irrigation distribution systems involves reducing the velocity of flow in a short distance and protection against scour if discharging into an unlined geometry of the approach channel, must be taken into account in these studies.

Debris and Sediment Controls

The removal of objectionable debris and silt from irrigation flows has in the past been largely a problem of devising a mechanical system that will serve the purpose. As a result of this work, several useful designs have been developed, however, they do not meet all the requirements for certain important situations.

Silt and sediment removal techniques for removing bed load from flows have been illustrated by Carlson and Enger (1963) and Dominy (1964). To add to existing design information, a study of the most effective location for positioning the canal turnout as a method to lowering sediment content would be useful. Since the concentration of silt or sediment in the flow increases with depth, positioning the turnout higher up in the flow would serve to lower the concentration in the lateral and add grade to the farmers lateral system.

Debris such as weeds often cause damage to canal and lateral systems in the spring when water is first turned in because of such problems as plugged culverts, fence line obstructions, or clogged headgates. Design information on a portable trash collector could be very beneficial to farmers and ditch riders.

The small trash screens reported by Pugh and Evans (1964) have worked well in most instances, but work could be done to add design data to allow proper design and construction. For example, the discharge characteristics of these screens for conditions of clogging could be studied, or the effect that certain types of debris such as moss or leaves have on the amount of water passing through the screen. Answers to questions such as these would provide helpful information to individuals designing and building this type of structure.

Tilted Flumes

A very common problem with field installations of flow measuring flumes is that settlement occurs on the downstream end. For such a condition, the value of discharge obtained from the rating curves or tables is less than the true discharge. The only satisfactory solutions, to date, for this problem include: raising the lower end of the flume so it is again level; placing a new level floor in the flume; or placing a liner in the existing flume and then grouting it into place. Normally, when settlement occurs it is not corrected. Therefore, a more satisfactory solution to the problem would be in determining corrections to the rating curves or tables.

Studies are needed to evaluate the effect of slope on the discharge ratings of various types of flow measuring devices. The effect of slope on both the free flow and submerged flow ratings of Parshall flumes, trapezoidal flumes, and cutthroat flumes should be determined.

Also, the effect of sideways tilt on the discharge ratings should be evaluated for each of these flumes.

Approach Velocity

Very little quantitative information is available regarding the effect of approach velocity on discharge ratings of flow measurement structures. Usually, the effect of approach velocity is considered negligible. Yet, numerous examples can be found in the field where high approach velocities are affecting the discharge passing through a rated constriction. If very high approach velocities were encountered, it is not difficult to visualize a profound effect on a rated structure. Consequently, although low approach velocities may have very little influence, there is a quantitative effect as the approach velocity is increased. Therefore, a quantitative evaluation of the relationship between approach velocity and the discharge rating of any particular flow measure device is very important.

Initial studies should determine the effect of approach velocity on a sluice gate, weir, and flow measuring flume. The results from these studies would then show which structures should be fully evaluated for all sizes of the particular structure. Any studies regarding flow measuring flumes should be correlated with the effects of downstream settlement for such flumes.

Siphons

Most siphons consist only of a curved length of constant diameter tubing. Although a few accessories are presently available for alleviating debris and erosion problems, there are undoubtedly a number of improvements which could be made. For example, modifications to the inlet, such as a bell-mouthed shape or hood inlet, might materially improve the hydraulic characteristics of a siphon. Any modifications to siphon inlets should incorporate some form of screening to prevent debris from entering the siphon. Also, there is considerable opportunity for adding various appurtenances to the siphon outlet to prevent erosion.

Prefabricated Structures

Small irrigation structures constructed of concrete and used for water measurement or control are usually cast-in-place. Prefabrication of multiple parts for assembly in the field would be advantageous in the following ways: (1) The unit cost of each installation would be reduced because of savings in time, equipment transport, and materials; (2) Maintenance and replacement would be simpler and longer lasting; and (3) The prefabrication would provide year-round employment for irrigation company personnel.

The information regarding the structural design and methods of assembly must be obtained before a prefabrication operation can be effective. The structural design should include determinations on adequate thicknesses and reinforcing requirements for the different components of various structures. The assembly techniques for construction of the numerous types of structures that lend themselves to prefabrication should be studied, and the possibility of interchangable parts in multiple-structure types should be considered.

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