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PERFORMANCE ASSESSMENT OF BROAD CRESTED WEIR FLUME IN THE FIELD

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The reported study presents testing and evaluation of a modified BCW flume. Using this flume, the discharge of four lined watercourses was measured and compared with the flow rate estimate by Manning's equation. The discharge of the flume was found to deviate by ± 2% from the estimate. This deviation could be considered negligible. Under the given hydraulic and boundary conditions, BCW flume was found to operate satisfactorily. It is simple to construct and economical as compared to other measuring devices under similar conditions.

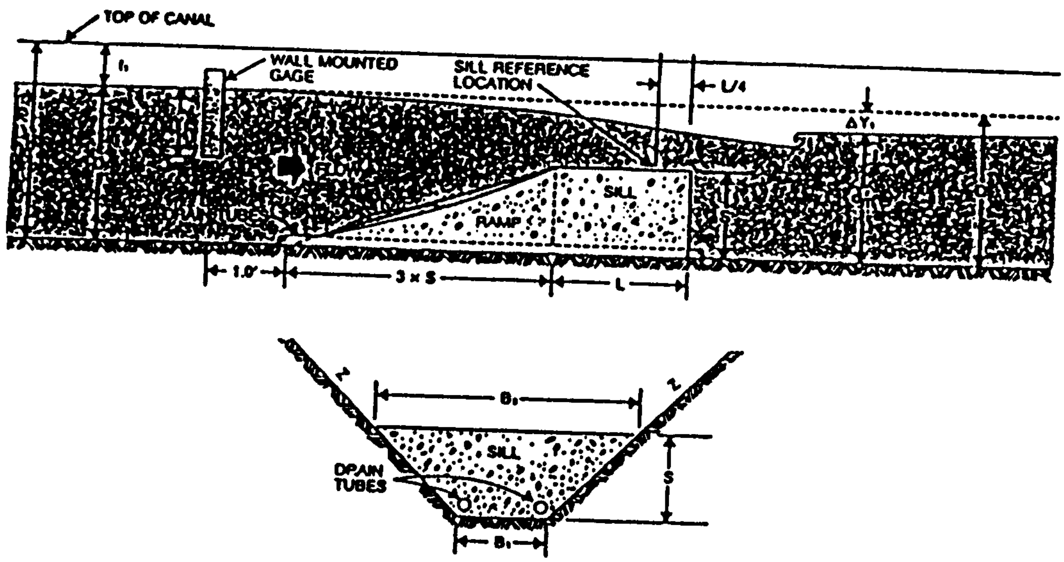
INTRODUCTION

Typical water measuring devices such as weirs and flumes that are used to measure discharge in open channels or ditches are expensive and cumbersome. Most of the said measuring devices demand laboratory calibrations. Flumes used in the field are limited to specific shapes and sizes for which these calibrations are made. Any deviation in construction from the design specification/dimensions as calibrated, results in a change of depth-discharge relationship. These dimensional requirements make most flumes difficult and costly to construct. Moreover, they require relatively larger head loss to measure flow rate (Stutler, 1984).

A Broad Crested Weir Flume (BCWF) that resembles a Long-Throated Flume (LTF) was designed and constructed as shown in Figure 1. The difference between BCWF and LTF is that BCW flume has a throat bottom which is higher than the bottom of the approach channel whereas the throat of the LTF flume is formed by narrowing the channel width only (Bos, 1975). It was planned to design and construct a BCWF for testing its performance under Pakistan's field irrigation channel conditions and to suggest modifications if any to improve its workability. The mathematical model which has been derived and tested both in the laboratory and field allows design of BCWF for any particular size and shape of canal. The BCW flumes were designed under expert advice of Dr. Gowin (Advisor to OFWM, Ministry of Food and Agriculture) and Dr. Replogle (Research Leader of the USDA Agriculture Research Service, Water Conservation Laboratory, Phoenix, Arizona).

METHODOLOGY

Broad crested weir flumes were constructed on four lined watercourses at different sites. The flumes were located in about 50 to 100 m downstream of the channels far enough from the canal outlet so that backwater curve does not affect out flow from the canal. A flume has two sections, still and ramp. Width of the still should be as close to the calculated value as possible for accurate measurement, as the error in width is directly proportional to the error in flow



Flume dimensions in profile (top) and cross section (bottom).
Abbreviations used in the profile are as follows: d = constructed depth; D_1 = upstream water depth; f_1 = actual freeboard; Y_1 = sill-referenced flow depth; L = sill length; ΔY_1 = actual increase in water depth caused by the flume; S = sill height; d_m = flow depth; 3 X S = three times the sill height (ramp length)..
Abbreviations used in the cross section (bottom) are as follows: B_3 = sill width; B_1 = canal bottom width; Z = sideslopes; S = sill height.

Fig. 1. Broad crested weir flume.

discharge. The still must be high enough so that it obstructs the usual flow in the ditch. Flume will operate satisfactorily at or below 85% submergence (Stutler, 1984). Thus design criterion is that the required minimum depth change caused by the flume at maximum flow should be 15% of the still reference depth.

The upper edge of ramp should join the still in a way that it does not protrude above it. To allow drainage of upstream channel, the flume can be constructed with an opening at its bottom in the shape of a hole. For unlined channels, BCWF comprises the following parts: entrance to approach channel, approach channel, ramp, sill, diverging section, tail water channel and downstream protection shown in Figure 2. If sufficient head is available the diverging section can be eliminated and if froude number is less than 1.7 then the tail water channel can be eliminated.

Flow measurements were made relative to the depth of flow just upstream of the flume. This depth was measured relative to the top of sill height. A point on the sill at about L/4 from the downstream end and at centre line of flow was used as reference. Using the collected data, a depth discharge relationship was developed for the given BCW flume. Vertical depth of flow must be converted into sloping distance because of trapezoidal shape. A convenient type of gauge was used which gives discharge in ls^{-1} and depth in cm. A plastic sheet gauge protected by a plastic cover was considered

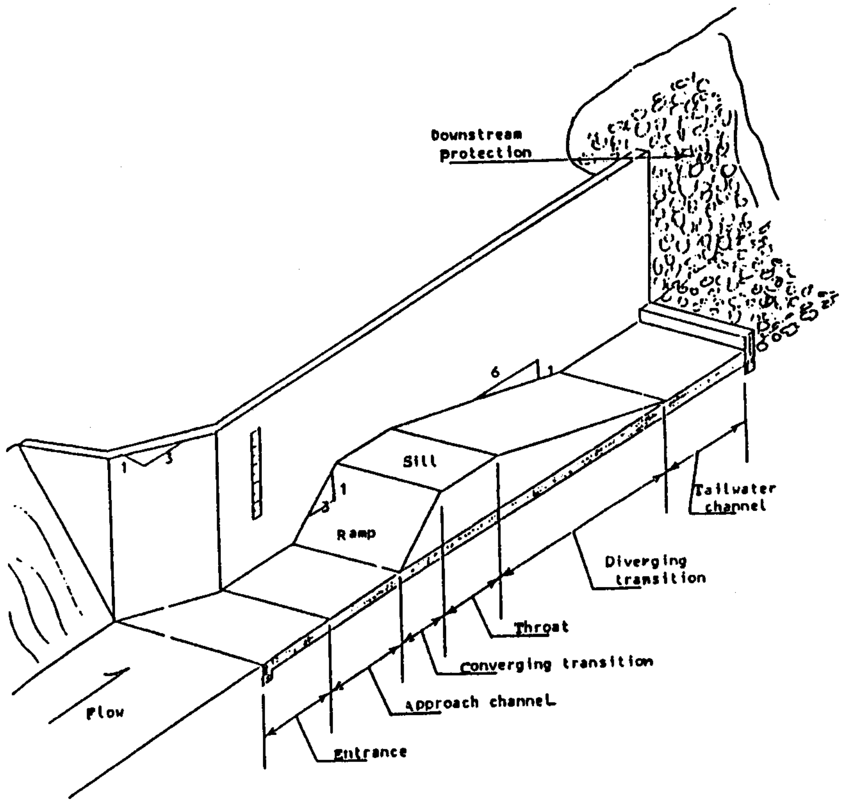


Fig. 2. Rectangular BCW structure in an unlined channel.

more feasible in our watercourses. A computer model is also available to provide depth discharge relationship for this purpose.

In using staff gauge, the gauge must be carefully surveyed into place with a surveyor's level and rod. The reference elevation for mounting the gauge is along the centre line of the watercourse on top of the sill at about L/4 from the downstream end of the flume. This eliminates chances of error caused by a non-level sill.

RESULTS AND DISCUSSION

The discharge data were collected from four lined watercourses with the help of BCW flumes and also by Manning's equation. Table 1 shows that discharge measured with BCW flume almost agrees with Manning's equation at all four sites. As critical flow occurs in the throat section, a rating table of the gauge developed in BCW flume works effectively with error of about ± 2% with Manning's equation which agrees with the results of Replogle and Bos (1982). It was concluded that under similar hydraulic and other boundary conditions, BCW flume is simple to construct, most economical, easy to make flow measurement as compared to other structure for accurate measurement of flow. Also sediments may move over the crest without causing any problem.

Table 1. Watercourse discharge as measured with Manning's equation and Broad Crested Weir (BCW) (lps)

	Manning's equation	BCW
Mogha No. 52810/L		
i.	48.6	47.20
ii.	49.0	47.50
iii.	47.9	47.00
iv.	119.25*	118.00*
Mogha No. 47850/L		
i.	74.5*	73.00*
ii.	74.75*	75.30*
iii.	35.00	34.25
iv.	34.85	34.00
Mogha No. 43441/L		
i.	103.7*	101.50*
ii.	77.0	71.50
iii.	76.8	73.50
iv.	104.0*	102.40*
Mogha No. 20740/L		
i.	73.58**	72.40**
ii.	73.00**	71.50**
iii.	73.90**	72.60**
iv.	74.00**	73.00**

* Includes canal discharge as well as water coming from SCARP tubewell.

** Includes canal discharge as well as water coming from Postgraduate Agriculture Research Station (PARS) tubewell.

Another advantage of the BCW flume is that if the constructed dimensions are much different from design, a new rating table can be derived to measure discharge.

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