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CALIBRATION OF FREE FLOW MEASURING DEVICES FOR FLAT GRADIENT CHANNELS

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Water measuring structures/devices generally used in Pakistan are subject to the availability of standard tables, graphs, or charts. These tables and charts are developed for some standard measuring structures. Alteration in the standard dimensions during construction of the structure may introduce considerable error in estimating the available discharge. A study was conducted for calibrating the locally constructed devices and for comparing their coefficients of calibration with the standard. The study revealed that the value of calibration coefficient differed significantly from their standard value, emphasizing thereby the need for calibrating the measuring devices before use under local field conditions.

INTRODUCTION

An essential aspect of water resources management is the measuring of flow rates in open channels so as to determine the amount received from a source, to control the amounts distributed to various users in conformity with legal requirements or water supply contracts, and to apply water to the crops according to their consumptive use requirements ensuring maximum water use efficiency. The discharge of water flowing through most of the devices is estimated from depth-discharge rating curves developed by calibrating the given device in the laboratory. Alteration in the standard dimensions during construction and/or operation may cause considerable error in estimating the available discharge. The head-discharge relationships may not be completely developed and related by the theory for many flumes and weirs. This study was undertaken to calibrate the broad crest weir, parshall flume and cutthroat flume having equal throat width of 30.28 cm for the best fit under local conditions.

MATERIAL AND METHODS

Data for this study were collected from the hydraulic laboratory of the Agricultural Engineering Workshop, University of Agriculture, Faisalabad. A rectangular test channel, 100 cm wide, 60 cm deep and 15 m long, with a flat gradient was constructed in brick masonry. The water was supplied from a sump located at the upstream of the channel. A weighing tank was installed at the end of the channel to measure different rate of flow passing through the measuring device. The tank was 1.83 m in length 0.91 m in width and had a capacity of 1000 gallons. A circulatory pipe system was also installed on the side of the channel to convey the flow back to the sump. The depth of flow and discharge rate were recorded over the flow range of each device. The head readings were recorded from the stilling wells at the inlet and outlet sections of the devices when the flow was in steady state condition.

RESULTS AND DISCUSSION

If circumstances allow it is always preferable to install a flow measuring device under free flow conditions. The obvious advantage is that only upstream flow depth needs to be measured to determine the discharge.

a. **Free flow operation of cutthroat flume:** Under free flow conditions, the discharge Q, through a cutthroat flume depends only upon the upstream depth of flow. The general relationship for cutthroat flume is given by:

$$Q = C\,h_a^n$$

Analysis of the free flow data collected for cutthroat flumes yields the value of c and n, as 3.851 and 1.690 respectively when the h_a value would be in cm and Q in 1/sec. The results are not identical with the values given by Skogerboe and Hyatt (1967). The variability is due to the changes in the operating conditions. It clearly indicates that the cutthroat flume must be calibrated before use under local conditions. The rating curve is shown in Fig. 2a. Head-discharge of different devices is given in Table 1.

Table 1. Head-discharge of different devices

Head (cm)	Discharge (1/s)			
	Cutthroat flume	Parshall flume	Broad-crested	
			Case-I	Case-II
4	3.60	4.31	3.48	5.34
12	23.06	27.59	28.68	27.73
20	54.68	65.42	76.49	59.66
28	96.55	115.53	145.93	98.82
36	147.65	176.67	236.43	144.07
44	207.26	247.99	347.56	194.67
52	274.87	328.89	479.00	250.11
60	350.07	418.87	630.46	309.99
68	432.53	517.54	801.72	374.02
76	521.98	624.56	992.59	441.92

b. **Parshall flume:** For free flow condition, the general form of the equation for the flume is:

$$Q = C\,h_a^n$$

The values of c and n for Parshall flume were found to be 0.414 and 1.69 respectively for a throat width of 30.48 cm. The equation thus becomes:

$$Q = 0.414\,h_a^{1.69}$$

in which h_a and Q are in cm and 1/s respectively. This equation is not identical to the equation reported by Bos (1989) because of the fact that conditions of flow were not identical with the original calibrating conditions. The rating curve for Parshall flume is shown in Fig. 2b.

c. **Broad-crested weir:** The general form of discharge equation for broad-crested weir is:

$$Q = C_d C_v \frac{2}{3}\sqrt{\frac{2}{3}\,g}\,b h_a^{1.5}$$

which can be written as

$$Q = c\,h_a^n$$

Where,

$$C = C_d C_v \frac{2}{3}\sqrt{\frac{2}{3}\,g}\,b = \text{constant}$$

$$n = 1.5$$

In equation 2, h_a and Q are known and the parameter to be estimated is only c and n. For BCW two cases were considered i.e. assuming n as unknown and n equal to 1.5. In the case of unknown n, the values of c and n were found to be 0.243 and 1.923 respectively with coefficient of determinant equal to 0.9. In this case the equation gives good agreement with the ob-

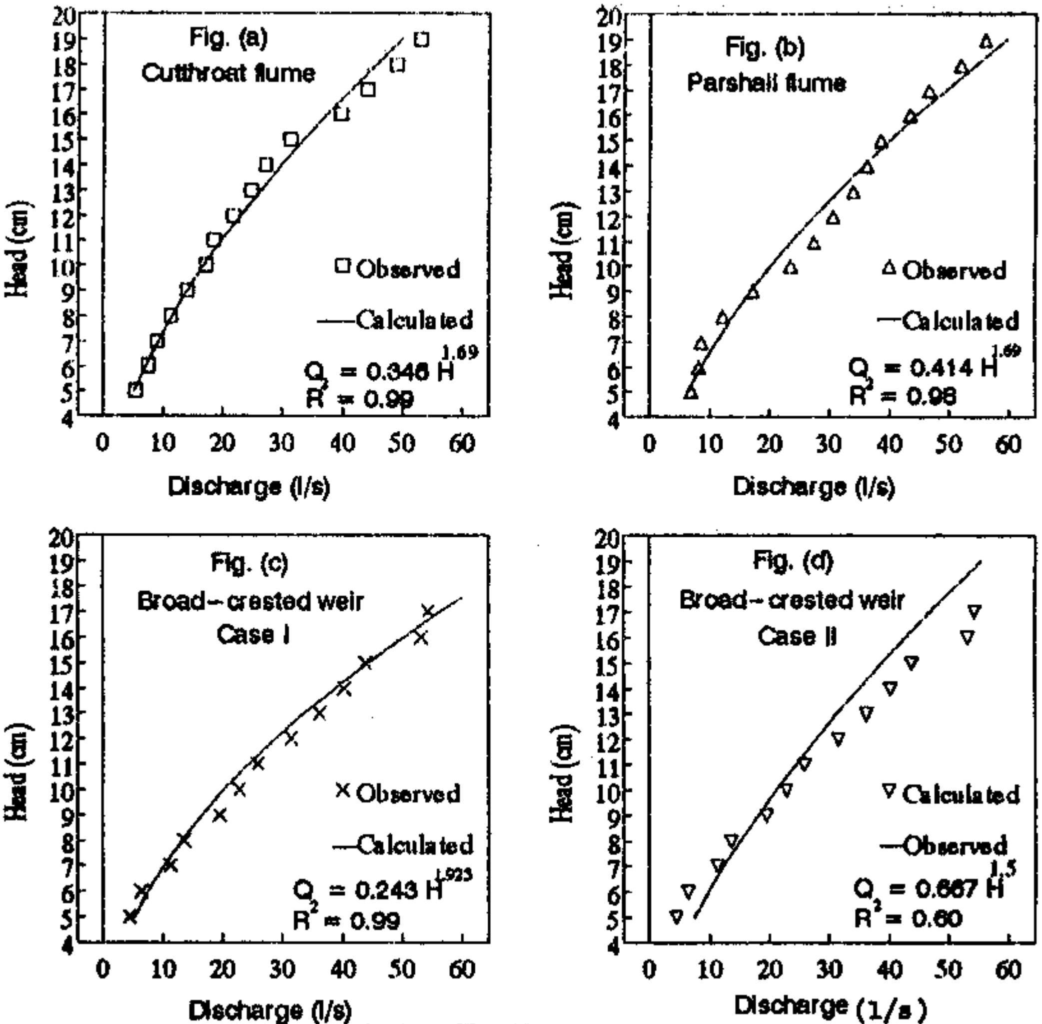

Figure 1. Free flow calibration curves for tested devices

of determinant equal to 0.9. In this case the equation gives good agreement with the observed value as shown in Fig. 2c. But in case when n was taken equal to 1.5, the value of c was found to be 0.667 with coefficient of determinant equal to 0.60. The predicted value of discharge did not show good agreement with that of the observed as in case of unknown n (Fig. 2d). This is so because field conditions cannot be simulated by theoretical equation, thus a calibration chart for any flow measuring device should be established.

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