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Comparative Study of Flow Measuring Devices for Low Discharge

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Abstract - The wide range of flow measuring devices are available for use in Open Channels. In absence of guide line and recommendations, it is difficult for the field staff to s elect a particular type of measuring device. It is particularly more true in the case of measuring small discharge (upto 40 lit/sec.) Therefore, a comparative study for evaluating different types of devices for measuring discharge upto 40 lit/sec. (lps) was undertaken as adaptive research. Partial flume, cut-throat flume, Board creasted Weir RBC (Portable) flume s tanding Wave flume and 90° - V Notch were selected for the study as these are commonly used in construction, use and maintenance, experiments were carried out in the Open Channel. Broad Creasted Weir (replogle) of 20 cm sill height tops the list followed by 90° V- n otch and portable standing wave Flume.

Keywords - *Low discharge, Partial flume, cut-throat flume, Board creasted Weir RBC (Portable) flume standing Wave flume and 90° - V Notch ,field channel.*

1. Introduction

In gravity Irrigation System discharge measurement is very important for proper control and application of water. For this purpose flow measuring devices are to be installed at various location starting from main canal and upto field channels., The study deals with the flow measurement in small canals mainly field channels. With this objective in view, different flow measuring devices used for measuring small discharges are comparatively studied s o as to arrived at recommendations regarding selections. This study has been carried out in open channel hydraulics laboratory by considering different range of discharge .The criteria to be fulfilled while selecting a particular measuring device can be as follows.

i] Simple in design.
ii] Simple in construction and use.
iii] Accuracy ind discharge measurement
iv] Less afflux.
v] Easy to maintain.
vi] Facility of discharge measurement from rating tables,
vii] Less expensive.

The measuring devices that are available for use are notches, weirs and flumes. As stated earlier the objective or this study is to compare the hydraulic performance infield use and socio economics of different flow measuring devices based on actual experiments & to suggest the suitable one for measuring conditions. Following commonly devices are considered for the purpose of this comparative study:

1. Partial flume (15.2 cm)
2. Cut - throat flume 20 * 90 cm
3. Broad crested weir sill height 20 cm (Replogle)
4. RBC (Portable) flume throat v idth 25 cm
5. Standing Wave Flume SWF), throat width 20 cm and sill height10 cm. 90^{-0} V-Notch.

2. Methodology

The study was carried out in the open channel hydraulics laboratory. The measuring devices are tested for the discharge of 10, 20, 30 and 40 lps. The discharge in the channel is controlled by valves provided in the constant head tank. The volume of water collected in the tail tank, in a given time is considered for direct measurement of discharge and this is taken as the reference discharge for comparison.

The tail tank is provided with a gauge fitted in a separate gauge chamber. Stop watch is used to note down this time. Seepage losses in the channel, is very insignificant and hence neglected.

3. Results and Discussions

Table (1) gives the discharge measured by the different measuring devices under considerations on the basic of the observations in the tail tank. The percentage variation in the discharge measured by flume or notch with respect to actual discharge is also given in the table.

Table (2) gives the afflux (U/S water depth-normal) causes due to installation of various measuring devices. For this purpose setting sill height in case of 15.20cm Partial flume and cut throat flume were calculated for the discharge of 40 lps. The cost of each measuring devices, considering cost of material, fabrication, supply on site, installation and lining of 5 m. on U/S and D/S side etc. is shown in table (3)

For the comparison and ranking of various flow measuring devices under study, following parameters were considered:

a] Discharge accuracy
b] Ease in design
c] Ease in construction
d] Use and maintenance
e] Afflux
f] Location specificity
g] Cost

Weightage of ten points given in each parameter and comparative rating tables is prepared which appears in table (4) the discharge measured by a particular device was compared with the actual discharge measured in the tail tank. Maximum marks were given to the devices having less deviation in the discharge and vice versa. The device which is simple to design, easy to construct , easy for day to day use and maintenance, creating less affiux was given maximum marks and vice versa. Location specificity i.e. whether a particular device requires a specific location for installation was also considered while rating e.g. V notch requires free flow condition i.e. fall and hence rated low as location specificity is concerned.

The ranking on the basis of score is as below :

i] Broad crested weir Replogle) with 20 cm sill height
ii] 90- degree V-notch.
iii] Standing wave flume, (SWF) with 20 ems throat width and 10 cmSill height.
iv] RBC (portable flume with 25 ems throat width.
v] 20 x 90 ems. Cut-throat flume.
vi] 15.2 cm Partial flume.

The cornparative study is carried out of different flume measurement devices from wide range of a ailable devices, suitable under field conditions. The devices for measuring small discharge is generally used by lower level staff and hence it is necessary to select a device which is easy to design, construct and use under field conditions. Considering large number of devices to be constructed, the cost aspect also needs to be considered.

The study indicates the following results :

1] Prashall flume :
It is very accurate device and easy to design. However, it is not easy to construct as exact shape and dimensions are necessary to be achieved. It needs frequent maintenance to retains dimension , cause more afflux and cost is high. Hence it is not very suitable under field conditions. It is recommended to use this device in laboratories rather than in the field.

2] Cut Throat Flume :
This flume is simple to design and construct. However it is not very accurate and hence not recommended.

3) Board crested Weir (Replogle) :
This is a device which almost satisfies all the criteria under field condition and second maximum points. This device can be constructed in situ without much modifications to existing channel section. Discharge table can be prepared using actual dimension after construction, even if they are repairable. Its cost is also less. It is therefore recommended to use this device in the field on large scale.

4] 90 degree V-Notch :
It is accurate, easy to design and construction and very cheap. As it require clear overall and cause more afflux, it is not recommended for all locations. However, if conditions favorable to V notch are available it is recommended to use this device.

5] Standing Wave Flume (S.W.F.) :
It is accurate. However its construction is not very simple. Simple broad crested weir (replogle) is simplified from the SWF and instead of SWF broad crested weir (Replogle) may be used. However SWF can be fabricated out of metal sheets and accurate dimensions can be maintained. It has advantage of portability over the Replogle flume. Whenever measurement are to be temporary it is recommended to use this flume.

6] RBC Flume (Portable) :
It is easy in design and causes less afflux. It is portable. However because of low accuracy, sensitive to gauge reading, high in cost, it is not recommended to use this flume on large scale.

Based on this study, it can be concluded that Board Crested Weir (Replogle) of 20 cm sill height

constructed in situ is more suitable to measure small discharge under field conditions. If fall is available and afflux is no constraint, 90 degree V-notch is recommended. Portable standing wave flume made out of metal sheet with accurate dimension can be used to measure discharge temporarily.

Table No.1 Discharge Accuracy

Measuring Device	Discharge in l.p.s., tail tan k discharge				
	40	30	20	10	Av & Variation
	Discharge variation %				
1.Parshall flume (6") 15.2 cm	1.7	2.9	0.70	-0.7	1.5
2.Cut throat flume 20 x 90 cm	4.2	-2.2	- 6.8	- 19	8.0
. 3 Broad crested Weir- sill ht. 20 cm	-1.2	1.2	0.90	1.50	1.2
4. 90° V **notch**	1.1	4.2	-1.9	-1.8	2.8
5. Standing wave flume (SMF) TW=20 crns Sill Ht. 10 cm	-4.8	-1.58	-4.4	-11.4	5.3
6. RBC (Portable) flume sill with 25 cm	12.0	10.20	-3.4	-0.80	6.4
% variation in actual discharge versus discharge measured by the device.					

Table - 2 Comparative Afflux For Different Flumes Under Free Flow Conditions

Measuring Device	Discharge in l.p.s., tail tan k discharge			
	40	30	20	10
1.Parshall flume (6") 15.2 cm	24	20	15.5	10
2.Cut throat flume 20 x 90 cm	20.5	17.5	14	9.5
. 3 Broad crested Weir- sill ht. 20 cm	8.4	7.0	5.5	3.5
4. 90° V **notch**	24.3	21.5	18.5	14.0

5. Standing wave flume (SMF) TW=20 crns Sill Ht. 10 cm	24.6	20.3	15.5	9.8
6. RBC (Portable) flume sill with 25 cm	16.8	14.4	11.5	7.8

Table – 3 comparative Cost Of Flumes/Weirs

Discharge in l.p.s., tail tan k discharge	Cost of fabrication (ExFactory) Rs	Installation Lining Rs	Contingencenci es Rs	Total Cost Rs
1.Parshall flume 15.2 cm	9600	2500	500	12600
2.Cut throat flume 20 x 90 cm	4400	2500	400	7300
3 Broad crested Weir-sill ht. 20 cm	3000	1500	250	4750
4. 90° V **notch**	2000	800	150	2950
5. Standing wave flume (SMF) TW=20 crns Sill Ht. 10 cm	4900	1500	400	6800
6. RBC (Portable) flume sill with 25 cm	9300	1500	450	11250

Table - 4 Comparison Of Various Flow Measuring Devices

Measuring Device	Accuracy	Ease in Design	Ease in Const	Use & Maintenance	Afflux	Location Specificity	Cost	Total	Ranking
	(10)	(10)	(10)	(10)	(10)	(10)	(10)	Out of (70)	
1.Parshall flume (6") 15.2 cm	10	8	2	4	4	8	2	38	VI
2.Cut throat flume 20 x 90 cm	3	8	8	4	6	8	4	41	IV
3 Broad cre.sted Weir-sill ht. 20 cm	10	8	10	7	8	8	8	59	I
4. 90° V **notch**	10	8	10	8	2	2	10	50	II

5.Standing wave flume (SMF) TW=20 48crnsSill Ht. 10 cm	8	8	6	4	4	8	6	44	III
6. RBC (Portable)flume sill with 25 cm	6	8	4	4	8	8	2	40	V

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