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# Design of RBC Flume for Water Measurement in Field Channels of Low Discharges

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**ABSTRACT**

Water is the most valuable asset of irrigated agriculture. Accurate measurement of irrigation water permits more intelligent use of this valuable natural resource. A new style of portable flow measuring flume (RBC) is designed for furrows and unlined canals. These flumes are relatively easy to install and operate. They are long throated flumes and broad crested weirs requiring very little head loss for satisfactory operation. This article presents the design procedure of a RBC flume using advanced software model namely Winflume based on trial and error procedure till the design requirement is attained. Once the design is made, the fabrication could be done with the help of local workshops using low cost materials either by GI sheets or fiber plates. For the study, the design was made for a discharge range of 3-8 lps.

**Key words :** Field channels, RBC flume, Water measurement

Water is the most valuable asset of irrigated agriculture. Accurate measurement of irrigation water permits more intelligent use of this valuable natural resource. Hence water measurement is very much essential at every point of irrigation process right from the head reach to the tail end of any project.

Stream flow measurement techniques may be broadly grouped as direct determination and indirect determination. Considerable advances have been made during the last decade in the design and use long throated flumes and the related modified broad crested weirs in lined canals. This type of structures is very easy to construct since it partially utilize the existing canal lining (Clemmens and Replogle,1980) and are named as RBC flumes named after the scientists. Construction of flumes in unlined canals is more complicated. One must construct more parts of the flume than in a lined canal, and also consider foundation problems since there is no existing canal lining to support the structure in an earthen canal. One alternative is to use temporary or portable structures, constructed in a machine shop, of sheet metal, fiber glass or some other light weight materials. The present study is taken with a view to design a RBC flume with low cost material as described above to measure low discharge range of 3 to 8 lps for some experiments to be taken up at College of Agricultural Engineering, Bapatla in the field channels.

Replogle and clemmens(1979) developed a portable flume to measure flow in crest standard concrete slip from the irrigation channels. The flume resembled a board crested weir with only two finished surfaces of long and flat weir crust and rounded approach ramp. The calibration was derived from a mathematical model that had been verified by laboratory testing. This portable model with a sill height of .035m operated successfully without a change in discharge rating at approximately 90 percent submergence. The flume capable of measuring discharges varying from 2.6 to 36.2 lit $sec^{-1}$ could be installed to give a stable reading in less than 10 min with ±2 percent accuracy.

Replogle and Clemmens (1979) stated that modified broad -crested weirs are economical and effective metering flow devices for lined irrigation canals. Required head losses are low so that a device can usually be retrofitted into most existing canal systems. Standard flumes are presented based on flume width that can be constructed in canals wit diff. bottom widths.

Clemmens at al (1984) presented a design procedure and series of rating tables for rectangular broad crested weir with rectangular approach channels for a wide range of flow conditions. For real fluids, the discharge relationship was developed introducing an empirical discharge,$c_d$. Equation $Q = C_d\ 2/3\ (2/3g)^{0.5}\ b\ H_1^{1.5}$

Table 1. Input parameters fed to Winflume.

| | |
|---|---|
| 1. | Discharge range to be measured = 3-8 lps (General Range) |
| 2. | Bed slope of the Canal = 0 % slope ( flat) |
| 3. | Sill level = 0.1 m |
| 4. | Channel depth = 0.6 m ( maximum assumed) |
| 5. | Shape of the flume = Trapezoidal |
| 6. | Tail water depth = 0.75. |

## MATERIAL AND METHODS

### Design of RBC Flume

At first, the data pertaining to the field and irrigation source were arrived at near the pipe outlet available at College workshop and were given as input parameters for the software 'Winflume'. The input parameters are arrived at and are as listed.

### Use of software 'Winflume'

'Win flume' is the software for designing and calibration of long throated flumes and broad crested weirs for open channel water flow measurements. Win flume is latest in a series of long throated flume design tools originally developed through cooperative research efforts of the agricultural services and the international; Institute for Land Reclamations and Improvement (ILRI). The main purposes of Win flume software are 1) Calibration of existing flow measurements structure fitting the criteria for analysis as long throated flumes - Win flume can generate rating tables, Q vs. h data loggers, and wall gage data and plots Win flume can also compare field –measure d Q vs. h data theoretical rating curve of a structure. Win flume can be used as a design review tool to identify design deficiencies in existing structures.

2) Design of new structures – win flume can used to design new flow measurement structure for new and existing canal systems. Design can be developed manually by the user and analyzed using win flume to ensure proper operation, or win flumes design module can be used to developed design that have desired head loss characteristics and meet other requirements.

### Design considerations

The theory of long throated flumes is based on energy balance between the upstream gauge location and the control section within the flume throat, where the flow is critical. For critical flow the flow rate and energy head have one known functional relationship. Thus, the water level at the gauging station is related to the rate of flow. We can mathematically predict the relations ship since:

a) The flume throat is long, which ensure that stream line flow at the control section is nearly straight and parallel.

b) The flume is constructed with gradual conversing transitions which eliminates flow at the throat entrance,

c) Boundary layer drag theory is used such that energy loss due to wall friction can be determined.

d) Relationships'd' from velocity distribution coefficient which affect the energy relationships,

e) Empirical coefficients have been for turbulent energy losses in the downstream diverging transition.

A mathematical method was developed which can determine the flume rating (head versus discharge) to with in + or-2% and the maximum allowable tail water level for maintain modular limit. Modular flow exists when there is critical flow in the flume throat, resulting in a unique head discharge relationship for the flume.

### Theoretical Considerations

Several theoretical and practical considerations limit the dimensions of these flumes First, to maintain nearly parallel flow in the flume throat ,the upstream (sill referenced) energy head H1 (where $H1=h_1+v_1^2/2g$) is limited by the $H_1/L = 1.0$ ,where L is the throat length ,v = flow velocity ,$h_1$ = sill referenced water level (head ),and g = acceleration due to gravity. Second the gauging station must be located atleast two times the maximum energy head, $H_{1max}$, upstream from the flume throat and atleast $H_{1max}$ upstream from the converging transition or ramp. Third, a reasonable length of approach is required to stabilize the flow profile at the gauging station .A gradual transition from the earth channel to the flume is also necessary to minimize the formation of standing waves that might affect the head reading. Flow at high Froude numbers (ratio of inertia to gravity) in the approach channel can also cause standing waves. Thus, the

Fig.1 Side elevation view of different components in RBC flume.

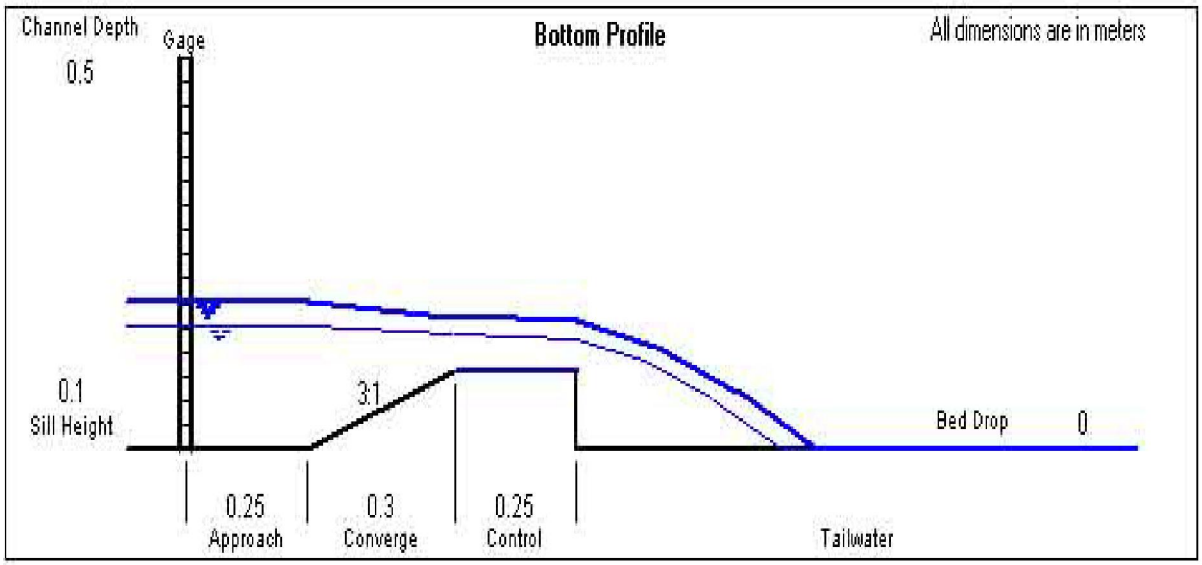



Fig. 2 Various views of different sections of designed RBC flume.

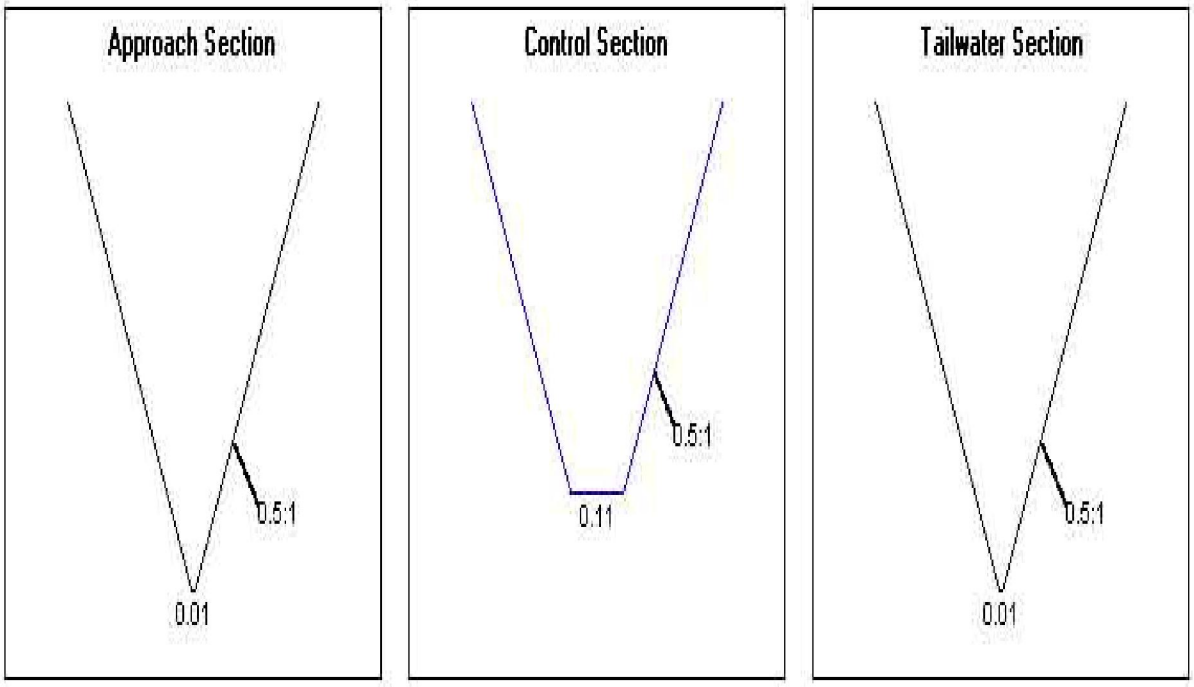


Fig.3 Upstream and downstream views of designed RBC flume .

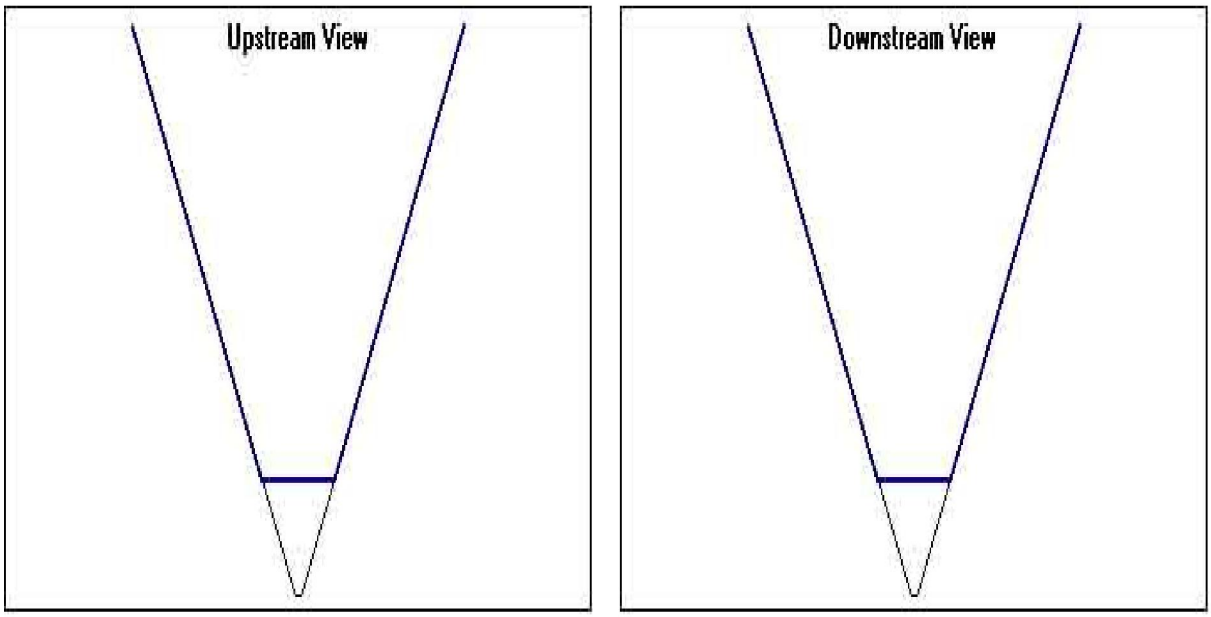



Fig. 4.a and b Isometric view and top view of designed RBC flume .

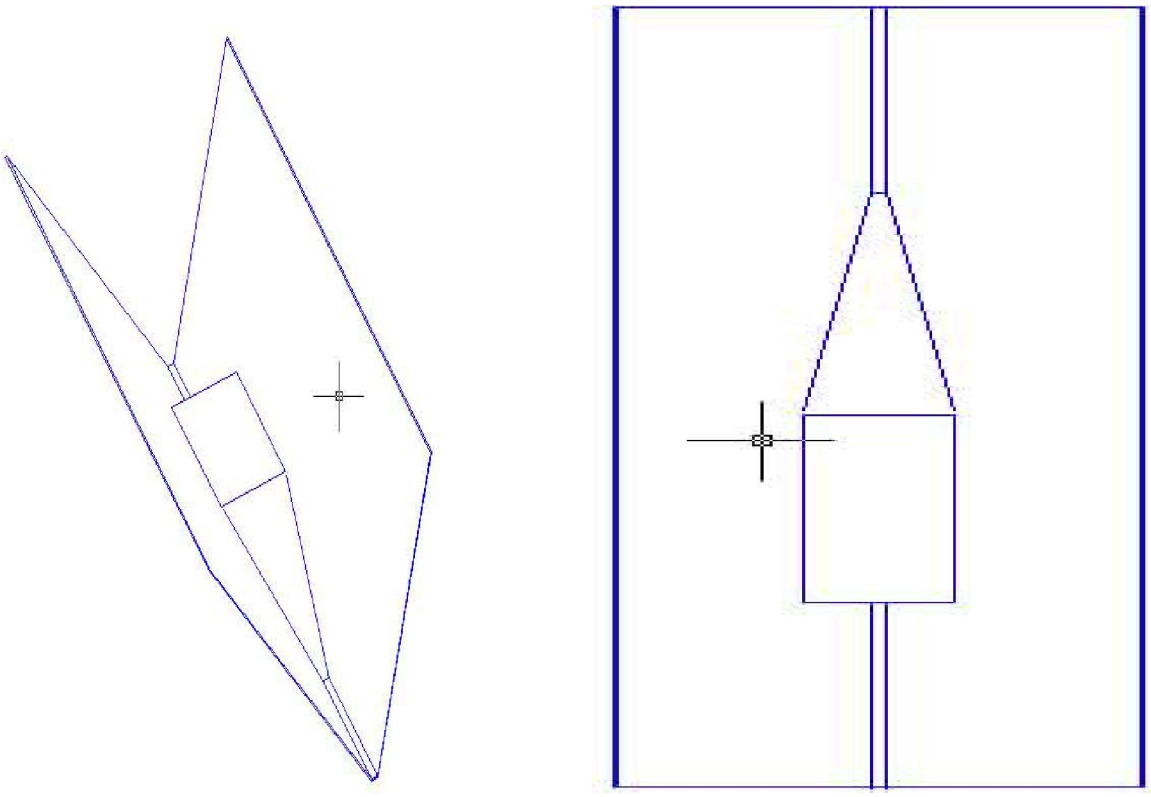
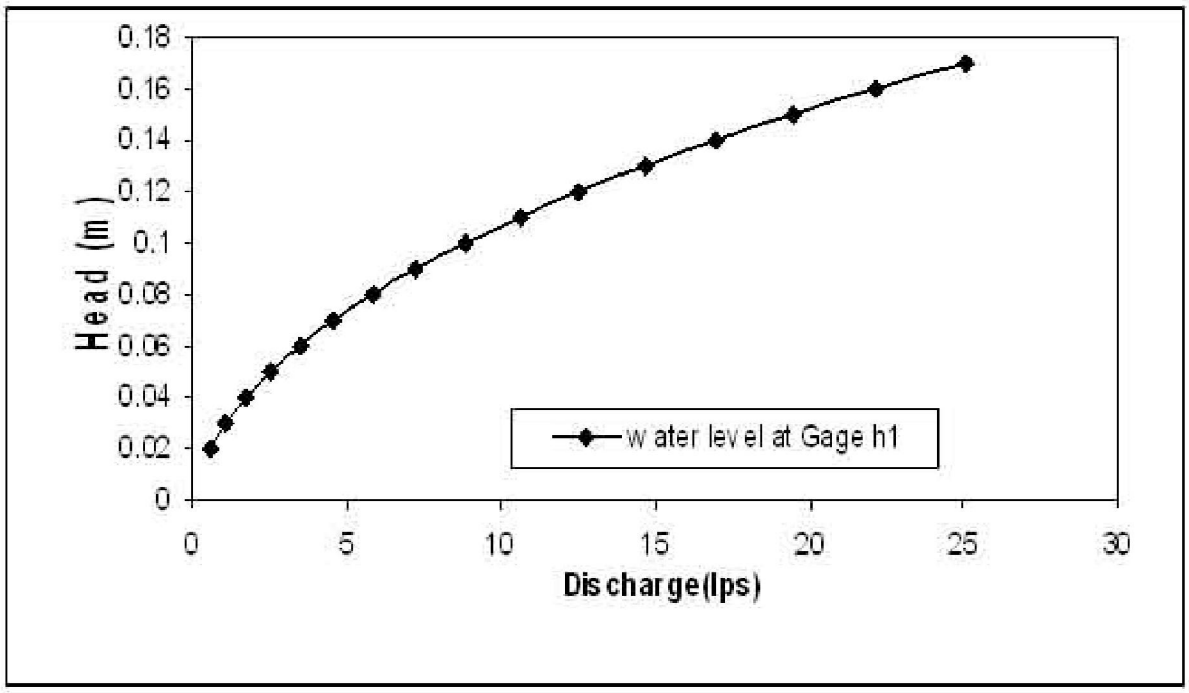


Fig.5 Head versus discharge rating curve for the designed RBC flume.




Froude numbers for these flumes was limited to 0.48.

**Winflume Menu options**

The main menu options and sub options are self explanatory. The structure/Flow Chart of major menu options, displayed in the main window of Win flume and their sub options are as listed under.

**File**

New Flume
Open Existing flume file
Load Flume 3.0 Database
Review Data for Current Flume using the Flume Wizard
Save Flume
Save Flume as
Printer Setup
Print Flume Drawing
Copy Flume Drawing to clipboard
Close
Exit

**Flume and Canal Design**

Flume properties and Canal Data (flume crest type, construction material, equired discharge and associated tail water levels)
Dimensions
Undo

**Design Menu**

Site Selection Tips
Flume Wizard
Flume Properties, Canal Data and Design Requirements
i. Flume construction material and associated roughness height
ii. Flume discharge range and associated tail water levels
iii. Head measurement method and allowable discharge measurement error
iv. Required freeboard

Review Current Design (It displays all the output parameters and also give certain suggestions to improve the design for making it accepted)

Performs a review of the current design based on six design criteria:

1 Upstream Froude number < 0.5
2 Upstream freeboard >= user-specified limit
3 Allowable tail water > actual tail level at minimum flow
4 Allowable tail water > actual tail water at maximum flow
5 Expected discharge measurement error meets design requirement at minimum flow
6 Expected discharge measurement error meets design requirements at maximum flow

**Reports/Graphs**

Rating Tables and Graphs
Rating Equation
Measured Data Comparison
Wall gages
Flume Data Record
Flume Drawing Printout
Copy Flume Drawing to Clipboard

**Options**

Units
User Name
Calibrate Screen for Wall gage preview
Calibrate Printer for Wall Gage Output
Show Maximum Water Surface Profile
Show Minimum Water Surface Profile
Explorer File Open-Dialogue
File open Dialog with Flume Summary
Save Current Settings as Default
Save Settings and Exit

**Help**

**Output from 'Winflume'**

For the input parameters given in Table 1 as arrived enlisted and fed in Winflume thereafter, the results are obtained by Trail and Error Procedure to suit the design discharge range. The drawings of different sections of the flume designed by the software are presented in fig.1 and fig.2. The isometric and top views of designed RBC water measuring flume is drafted in auto cad. Dimensions of the flume are input values of Winflume such as bed slope, converging length, throat width etc as shown in fig.4. Different trails were conducted in the water channel at different discharges and different heads measured at the throat section of fabricated flume. A graphical representation of head versus discharge is given in fig.5.

**Conclusions**

RBC flume is proved to be accurate in water measurement for various ranges of discharges. Which were adopted already in western countries like USA and Netherlands etc. A software model namely Win flume, developed by Netherlands Scientists was used and the design dimensions are arrived for a discharge range of 3-8 lps. Head discharge relationship is established for calibration of the flume. This concept is useful for the design of RBC flume for any desired discharge range despite the construction materials.

**LITERATURE CITED**

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