COMPARATIVE ANALYSIS OF ALGORITHMS BEING USED FOR MEASUREMENT OF DISCHARGE THROUGH RADIAL GATES OF CANAL CONVEYANCE SYSTEM

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Abstract: **The efficiency at field level is in large part measured in terms of the evenness of depth of moisture of the soil, which is directly related to the constant delivery of discharge. The deficiency in operation of networks may be due to incorrect measurement of discharge passing through the Check Structure. For measuring the discharge through gate, the value of Coefficient of Discharge C_d is one of the important factors. The value of C_d for any gate can be assessed either by continuous observation at site for long duration or by regression analysis or by developing a laboratory model.**
The discharge algorithms accurately represent the complete discharge characteristics for the range of water levels and radial gate geometry normally encountered at canal radial gate check structures. The primary disadvantage of the discharge algorithms is their complexity

Keywords: **gate algorithm, coefficient of discharge, radial gate**

I.   INTRODUCTION

In many parts of the World, irrigation systems are normally performing well below their potential and it is mainly attributed to the improper or ineffective operation of control structure. One measure used for assessing the performance of an irrigation system is based on the ratio of water volume released from the sources to that actually applied to the crop at field. Many of the problems associated with these irrigation schemes are linked at least partially to ineffective operation of the water distribution systems. The efficiency of the Major network depends on the operation of the input gate and the check gates, which are along the main canals. The efficiency of the Minor network depends upon the accuracy of the discharge delivered by the main canal as well as the operation of the regulation structures within the minor network itself. The efficiency at field level is in large part measured in terms of the evenness of depth of moisture of the soil, which is directly related to the constant delivery of discharge. The deficiency in operation of networks may be due to incorrect measurement of discharge passing through the Check Structure. Thus the one of the objective of the control system is how to operate the canal to maintain the prescribed discharge in pools of canal. The automatic control can greatly enhance the efficiency of the operation of open channel water conveyance system due to greater flexibility, reliability and safety and will have a minimum operational waste reducing cost of operation when compared to manual operation. In the canal automation system, accurate gate head discharge equation to assess the discharge passing below each gate of the check structure i.e., the check structure to serve as a flow measuring device or to set the appropriate gate opening for a desired discharge by knowing the water level on upstream and downstream of the check structure i.e. the check structure to serve as a flow control structure.

For measuring the discharge through gate, the value of Coefficient of Discharge C_d is one of the important factors. The value of C_d for any gate can be assessed either by continuous observation at site for long duration or by regression analysis or by developing a laboratory model.

II.   GATE STROKING ALGORITHM

The change from one discharge to another in open channel flow always creates a disturbance in water surface elevation. Since pool boundaries are usually gates, the technique of water surface control is called Gate Stroking. Gate stroking is series of continuous or discontinuous gate motions which produce a desired water surface profile in a canal. The Coefficient of Discharge C_d is calculated based on regression analysis. For calculation of required opening to pass the required discharge through gate

the difference of depth at the upstream and downstream of the check structure is used along with the value of C_d based on regression analysis.

III. DISCHARGE ALGORITHM OF CANAL RADIAL GATE

In Discharge Algorithm of Canal Radial Gate i.e. RADGATE, the value of C_d is based on a 1:6 canal radial gate model. For calculation of required gate opening to pass the required discharge the Metzler's equation is used. In Metzler's equation only depth at the upstream of the check structure is used along with the value of C_d to calculate required gate opening. The value of C_d is calculated for two different flow condition i.e. free flow condition and submerged flow condition but the effect of downstream depth is already considered in calculation of C_d.

For comparative study of these two discharge algorithms, two canal pools with three check structures of canal is selected and schematic is shown vide Fig.1.
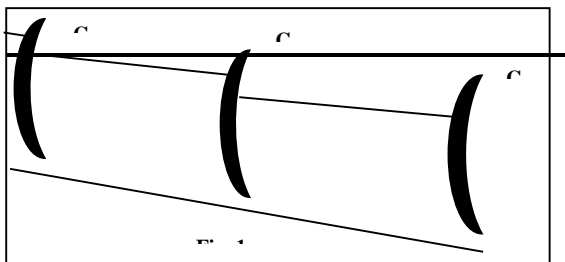
The middle check structure i.e. CR-2 is selected to compare the results because on upstream and downstream of this check structure, the conditions are fully controlled.

For analysis, the variation of discharge in pools is taken from 75 cumecs to 900 cumecs. The transient analysis in these pools is done with the help of Unsteady State Model [Acharya (1994)]. The depths at the upstream and downstream of these check structures are based on transient analysis and the same are used for calculation of required gate openings in both the discharge algorithm of gates as per the concept of mass conservation.

Sr. No.	Discharge (Cumecs)	Option "A" (Gate Stroking Algorithm)	
		Gate Opening (cm)	C_d
1	75	23.20	0.699
2	100	31.10	0.696
3	150	47.10	0.689
4	200	63.50	0.683
5	300	97.30	0.671
6	400	133.00	0.659
7	500	171.00	0.650
8	600	211.70	0.644
9	700	255.00	0.643
10	800	301.00	0.647
11	900	349.20	0.657

Sr. No.	Discharge (Cumecs)	Option "B" (RADGATE)	
		Gate Opening (cm)	C_d
1	75	15.90	0.665
2	100	20.10	0.702
3	150	31.20	0.679
4	200	43.30	0.653
5	300	67.60	0.627
6	400	91.20	0.621
7	500	113.30	0.626
8	600	133.60	0.638
9	700	151.80	0.656
10	800	167.50	0.681
11	900	180.00	0.715

Sr. No.	Discharge (Cumecs)	Difference	
		GO (cm)	C_d
1	75	7.30	0. 034
2	100	11.00	-0.006
3	150	15.90	0.010
4	200	20.20	0.030
5	300	29.70	0.044
6	400	41.80	0.038
7	500	57.70	0.024
8	600	78.10	0.006
9	700	103.20	-0.013
10	800	133.50	-0.034
11	900	169.20	-0.058

The results of these analysis is presented graphically vide Figure-2.
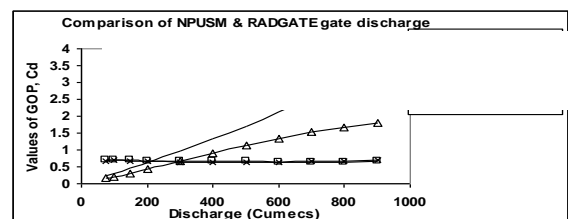
Figure-2 Comparison of Gate Stroking Algorithm and RADGATE Algorithm

IV. CONCLUSION

From the results it is clear that the calculation of C_d values in both the algorithm does not differ significantly. For all the variation of discharges the values of C_d in both the gate discharge algorithm remains almost same. But it is observed that the required gate openings (GOP) in both the algorithm differs for all discharge variations. The gate opening GOP varies from 7.3cm to 169.2cm and C_d varies from 0.005 to 0.04. The variation of GOP increases as discharge increases. But the difference of Cd value increases upto 40% variation of Maximum discharge i.e. 900 cumecs and for greater variation i.e. more than 40% variation of maximum discharge again it decreases. These result shows that initially at the design stage the value of C_d can be based on regression analysis or can be based on laboratory model. After the construction of gate, the C_d values should be fine tuned with the observation at the site. The discharge algorithms accurately represent the complete discharge characteristics for the range of water levels and radial gate geometry normally encountered at canal radial gate check structures. The primary disadvantage of the discharge algorithms is their complexity. Many equations are necessary to achieve the high degree of accuracy. The discharge algorithms listed above are based on the standard hard-rubber-bar gate lip seal design. The algorithms, correctly applied, have the capability of being as accurate as any measuring device or procedure available to measure the discharge in small or large canal systems. As a result, a direct benefit is provided for canal operators who control canal systems manually or by remote manual/automatic control systems. The installation of costly Parshall flumes, weirs, acoustic velocity meters, and many canalside turnout meters could be eliminated providing an economic benefit to the project.

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