PROBLEMS CONCERNING USE OF
LOW HEAD RADIAL GATES(a)

Closure by Thomas J. Rhone, M., ASCE

Messrs. Pariset and Michel have brought out some interesting facts in their discussion, and their extension of the coefficient of discharge curves is indeed a valuable addition. None of the crest profiles used in obtaining the curves presented in the writer's paper was as thin as the Edgard de Sonza Dam crest profile; in fact, the highest free-flow coefficient was only 3.84. The larger values of the controlled flow coefficients, and the fact that for a given H the coefficient becomes essentially constant when θ is greater than 70 degrees, rather than increasing, as shown on Figure 6, indicates that other variables should possibly be considered in an analysis. The use of the cavitation coefficient presented on page 152 is a very good measure for potential cavitation damage. A similar equation 1/ has been used as a means of determining cavitation potential in conduits and entrances, and in the case of gate slots, has been proved with model prototype comparisons.2/ The writer assumes that the statement (on page 152) made by Messrs. Pariset and Michel "To determine the maximum allowable pressure on the profile of a spillway, * * *," is a typographical error, and should read either "minimum allowable pressure," or "maximum allowable subatmospheric pressure," as stated later (on page 154).

(a) Proceedings Paper 1935, February 1959, by Thomas J. Rhone.

1/ Engineering Hydraulics, edited by Hunter Rouse, John Wiley and Sons, page 30.

2/ Ball, J. W., "Hydraulic Characteristics of Gate Slots," Journal of the Hydraulic Division, Proceedings, ASCE, Volume 85, No. Hy 10, October 1953, pages 81-114.

Mr. Bowman's awareness of the problems presented in the paper and his subsequent comprehensive discussion are very gratifying. The increasing number of papers that are appearing in technical publications seem to indicate a favorable trend in "sharing the knowledge gained from basic research." It is hoped that this policy will continue, and will be as well received as in this instance.

Mr. Bowman's discussion of the various discharge quantity equations provides a clear, concise analysis of the advantages and disadvantages of each. He also provides a guide for the selection of the best combination of equations to use under various conditions of gate design, gate opening, and head above gate seal. His own method of obtaining an approximate rating curve is an excellent "short-cut" system, and is probably as accurate as any of the methods provided by the writer. The corrections for velocity of approach and contractions, etc., are, for the most part, a matter of judgment, and will vary according to the practice of each design office.

The datum profiles used in the series of tests described in the paper were based on the hydraulic model investigations of the Hoover Dam spillway. The results are reported in Boulder Canyon Projects, Final Reports, Part VI--Hydraulic Investigations, Bulletin 3, "Studies of Crests for Overfall Dams."

Mr. Bowman's discussion on gate seals is very informative. His observations on prototype installations broden the scope of the information provided in the paper, which, as he stated, was principally derived from Bureau of Reclamation practices. The writer cannot answer the question as to how the L-seal negotiates the bottom corners of a radial gate. In most of the structures investigated, the side seals were of the molded angle type, and the bottom seals were usually of the rectangular type, with a tightly fitted butt joint at the corners.

In his discussion, Mr. Cox has brought forth an unfortunate omission; namely, that the writer did not identify the source of Figure 6. The curves were obtained from the Waterways Experiment Station chart, as he stated. The discharge quantity that he questioned was given as 4,880 in the table, but should have been 4,580 cfs, which is within 4 percent of the measured quantity. The author's figures in arriving at this quantity were as follows:

Net gate opening	2.96 feet
Effective head	30.77 feet
	72.7 degrees
Discharge coefficient	0.681

The small discrepancies between Mr. Cox's values and the writer's can easily be attributed to different interpretations of the graphical portions of the solution, and either could be accepted. Mr. Cox's explanation for the larger values for the computed discharges at bigger gate openings is entirely feasible. A steeper crest would permit higher flow quantities, other conditions being equal, than a flat crest. This is particularly true for the larger gate openings, as shown in the Pariset and Michel, and Bowman discussions. The writer agrees with Mr. Cox's statement concerning the standardization of some of the geometrical design. The use of the design head as a basis of obtaining dimensionless ratios is successfully used in other phases of spillway design, and should be equally satisfactory in radial gate design.

Mr. Toch implies that the discharge formulas presented in the paper are also recommended by the author; this was not the intent. The four methods presented in the paper are in more or less common use, and the purpose in analyzing and discussing them was to show that each method is inadequate to some degree. The similarity between the first two formulas is in the form of the equation only.

It should be obvious that the coefficient of discharge values in the first equation are average values obtained from numerous model studies, irrespective of gate geometry. In the second equation, the coefficients are related to the geometrical configuration of the gate. Apparently, the originator of the third method believed that the use of any gate on a crest would affect the coefficient of discharge to the extent shown in the lower graph on Figure 5, and that the gate geometry would further modify the coefficient in the manner shown in the upper graph. The writer cannot agree that the upper graph "---merely relates the cosecant and cosine of any given angle," as stated by Mr. Toch. It seems equally apparent that the graph presents a simplified method for obtaining the value of $\frac{1}{\sin \Pi}$ by using the readily available values of the gate radius trunnion height, and gate opening above crest. Mr. Toch is correct in believing that the coefficient of discharge is also a function of the crest shape. Previous discussions have vividly demonstrated this to be true, and it should be an important consideration in generalizing a radial gate discharge equation. The two references listed by Mr. Toch are appreciated. The thesis by Mr. Glowiak has recently been reviewed by the author, and it is a competent piece of research work that adds considerably to the knowledge of radial gate discharge characteristics.