SHEET 312

VERTICAL LIFT GATES ON SPILLWAYS

DISCHARGE COEFFICIENTS

1. Purpose. Vertical lift gates have been used on high-overflow-dam spillways. However, they are more commonly found on low-ogee-crest dams and navigation dams with low sills where reservoir pool control normally requires gate operation at partial openings. Hydraulic Design Chart 312 provides a method for computing discharge for partly opened, vertical lift gates.

2. Background. Discharge under high head, vertical lift gates can be computed using the standard orifice equation given in Sheets 311-1 to 311-5. The equation recommended by King[1] for discharge through low head orifices involves the head to the three-halves power. For flow under a low head gate, this equation can be expressed as

$$Q_G = C_{d1}\sqrt{2g}\,L\left(H_2^{3/2} - H_1^{3/2}\right) \qquad (1)$$

where Q_G is the gate controlled discharge, C_{d1} the discharge coefficient, g the acceleration of gravity, L the gate width, and H_1 and H_2 are the heads on the gate lip and gate seat, respectively.

3. A recent U. S. Army Engineers Waterways Experiment Station[2] study of discharge data from four laboratory investigations[3-6] failed to indicate correlation of discharge coefficients computed using equation 1 above or the equation given in Sheets 311-1 to 311-5. However, the concept of relating gate-controlled discharge to free discharge was developed in that study. The free discharge equation is

$$Q = C_d\sqrt{2g}\,LH^{3/2} \qquad (2)$$

where H is the head on the crest. The relation of controlled to free discharge was obtained by dividing equation 1 by equation 2.

$$\frac{Q_G}{Q} = \frac{C_{d1}}{C_d}\left(\frac{H_2^{3/2} - H_1^{3/2}}{H^{3/2}}\right) \qquad (3)$$

4. Analysis. The analysis of data taken from references 3 through 7 indicated reasonable correlation between free and controlled discharge. The results are shown in Chart 312. This study indicated that the relation C_{d1}/C_d varied slightly with the discharge ratio but could be assumed

as unity. Data from studies[6,7] with the gate seat located appreciably downstream from the crest showed good correlation with data for on-crest gate seat locations.

5. Application. Application of Chart 312 to the gate-discharge problem requires information on the head-discharge relation for free overflow for the crest under consideration. These data are usually available from spillway rating curves. Chart 312 should be a useful tool for the development of rating curves for vertical lift gates.

6. References.

(1) King, H. W., Handbook of Hydraulics for the Solution of Hydraulic Problems, revised by E. F. Brater, 4th ed. McGraw-Hill Book Co., Inc., New York, N. Y., 1954, pp 3-9.

(2) U. S. Army Engineer Waterways Experiment Station, CE, Discharge Rating Curves for Vertical Lift Gates on Spillway Crests, by R. H. Multer. Miscellaneous Paper No. 2-606, Vicksburg, Miss., October 1963.

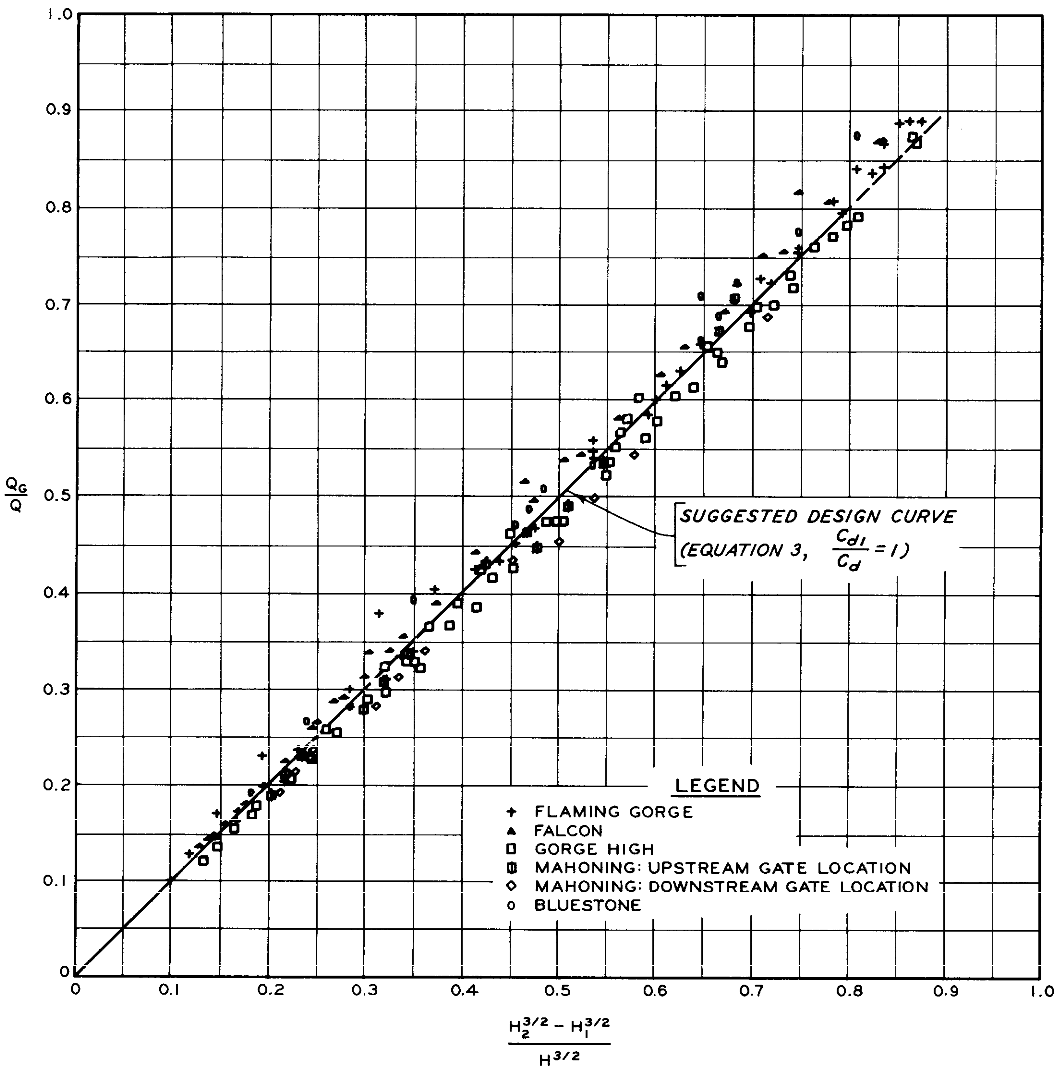
(3) U. S. Bureau of Reclamation, Hydraulic Model Studies of Falcon Dam, by A. S. Reinhart. Hydraulic Laboratory Report No. HYD-276, July 1950.

(4) __________, Hydraulic Model Studies of Gorge High Dam Spillway and Outlet Works, by W. E. Wagner. Hydraulic Laboratory Report No. HYD-403, September 1955.

(5) Carnegie Institute of Technology, Laboratory Tests on Hydraulic Models of Bluestone Dam, New River, Hinton, W. Va. Final report, prepared for the U. S. Army Engineer District, Huntington, W. Va., February 1937.

(6) Case School of Applied Science, A Report on Hydraulic Model Studies for the Spillway and Outlet Works of Mahoning Dam on Mahoning Creek, Near Punxsutawney, Pa., by G. E. Barnes. Prepared for the U. S. Army Engineer District, Pittsburgh, Pa., May 1938.

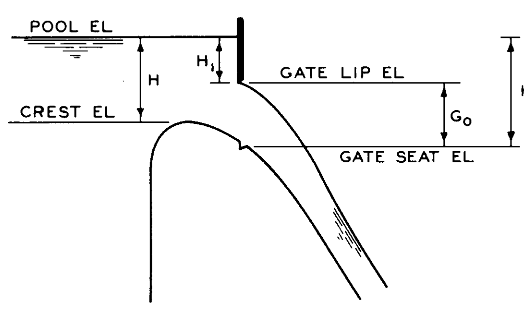
(7) U. S. Bureau of Reclamation, Hydraulic Model Studies of Flaming Gorge Dam Spillway and Outlet Works, by T. J. Rhone. Hydraulic Laboratory Report No. HYD-531, May 1964.



NOTE: Q = FREE-FLOW DISCHARGE AT HEAD H

Q_G = DISCHARGE AT HEAD H AND GATE OPENING G_O

$H_1 = H_2 - G_O$



DEFINITION SKETCH

VERTICAL LIFT GATES ON SPILLWAYS

DISCHARGE COEFFICIENTS

HYDRAULIC DESIGN CHART 312

REV 1-68 WES 1-66

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