

FLAP GATE DESIGN FOR AUTOMATIC UPSTREAM CANAL WATER LEVEL CONTROL

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ABSTRACT: The EXCEL design procedure for a simple hydraulic flap gate for automatic upstream canal water level control is provided. Basic configurations were developed in The Netherlands in the 1920s and have recently been used in Indonesia, the Dominican Republic, and Nigeria. Four irrigation districts in the San Joaquin Valley of California have constructed and installed over 60 properly functioning flap gates. The gates can be installed within 2 h, but require free discharge conditions and in practice are limited to controlling water depths of about 1 m or less.

INTRODUCTION

The flap gate is a simple hydraulic automatic upstream water level control gate. Its simplicity is derived from ease of construction and maintenance—construction only requires flat plate and tubing fabrication, rather than curved surfaces as for other types of hydraulic automatic gates. The basic design of a flap gate is shown in Fig. 1. If designed properly, it will automatically maintain the upstream water level within a few centimeters. The gate must be installed in a free-flow condition. The proper operation of a flap gate requires that the gate-closing couple around the pivot point be exactly balanced by the gate-opening couple around that point, while maintaining the same upstream water level at all flow rates (e.g., all angles of opening). Fig. 2 illustrates these two couples. The gate-closing couple is formed by the mass of the gate and counterweight, and the gate-opening couple is formed by the pressure of the water against the faceplate.

Most work on flap gates originated in The Netherlands. Vlugter (1940) investigated various configurations such as the Begemann and Doell. Brouwer (1987) summarizes important design principles, including key dimension ratios. Raemy and Hager (1997) examined the opening and closing moments at various angles of opening, and Brants (1995) documented the use of such gates in Indonesia. Burt and Styles (1999) observed poorly maintained flap gates in an irrigation project in the Dominican Republic. Modrano and Pittor (1997) and Swicgard and Dudley (1995) worked on prototype flap gates (commonly known as Begemann gates) at the Water Delivery Facility of the Irrigation Training and Research Center (ITRC) at Cal Poly.

Since 1997, about 40 gates have been installed at the Chowchilla Water District (CWD) of California. The construction of the first CWD gates was based on the early Cal Poly prototypes, which were developed with support of the Mid-Pacific Region of the U.S. Bureau of Reclamation. Although many of the CWD gates performed well, some of the controlled water levels were different from those predicted by the early design

procedure. As a result of the discrepancies, ITRC developed the new design procedure explained in this paper. Gates based on the new design have also been installed in the Turlock Irrigation District (ID), Alta ID, and Broadview WD of California.

PROCEDURES AND METHODS

Pressure Distribution—General

The ITRC design program (an EXCEL spreadsheet) estimates the closing and opening couples of the gate at a variety of angles with a desired upstream water level. If one knows the mass and relative locations of all the steel members, the centroid of the mass can be determined from basic statics equations to compute the gate-closing couple.

The opening couple on a flap gate is more complex to com-

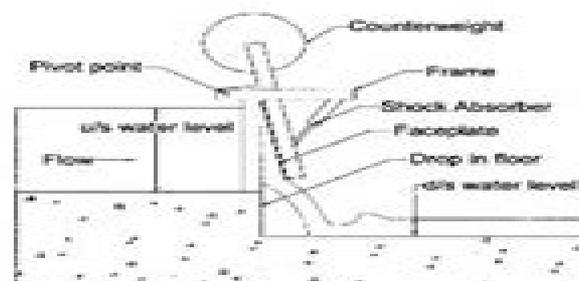


FIG. 1. Side View of Flap Gate

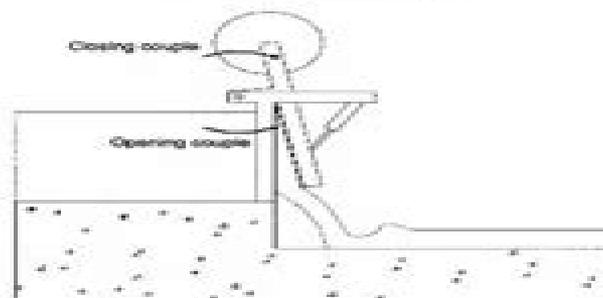


FIG. 2. Balance of Couples on Flap Gate

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