

# 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 Brans (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 Pitter (1997) and Sweigard 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-

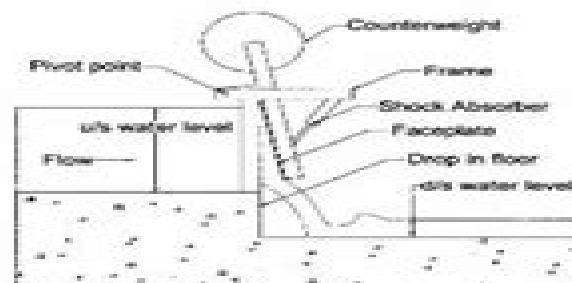


FIG. 1. Side View of Flap Gate

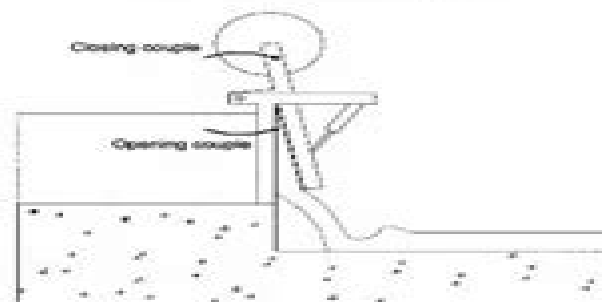


FIG. 2. Balance of Couples on Flap Gate

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**Wim Ravesteijn, Jan Kop**



## **Flap Gate Design For Automatic Upstream Canal Water Level:**

**Modeling and Control of Hydrosystems** Xavier Litrico, Vincent Fromion, 2009-09-17 Open channel hydraulics are described by hyperbolic equations derived from laws of conservation of mass and momentum called Saint Venant equations. In conjunction with hydraulic structure equations these are used to represent the dynamic behavior of water flowing in rivers, irrigation canals and sewers. Building on a detailed analysis of open channel flow modeling, this monograph constructs control design methodologies based on a frequency domain approach. In practice, many open channel systems are controlled with classical input output controllers that are usually poorly tuned. The approach of this book, fashioning pragmatic engineering solutions for the control of open channels, is given rigorous mathematical justification. Once the control objectives are clarified, a generic control design method is proposed, first for a canal pool and then for a whole canal. The methods developed in the book have been validated on several canals of various dimensions up to a large scale irrigation canal.

**Irrigation Systems** Adrian Laycock, 2011 Of all the confrontations man has engineered with nature, irrigation systems have had the most widespread and far reaching impact on the natural environment. Over a quarter of a billion hectares of the planet are irrigated and entire countries depend on irrigation for their survival and existence. Considering the importance of irrigation schemes, it is unfortunate that until recently the technology and principles of design applied to their construction has hardly changed in 4 000 years. Modern thinking on irrigation engineering has benefited from a cross fertilization of ideas from many other fields including social sciences, control theory, political economics and agriculture. However, these influences have been largely ignored by irrigation engineers. Drawing on almost 40 years of experience of irrigation in the developing world, Laycock introduces new ideas on the design of irrigation systems and combines important issues from the disciplines of social conflict management and political thinking.

**Hydraulic Engineering of Dams** Willi H. Hager, Anton J. Schleiss, Robert M. Boes, Michael Pfister, 2020-11-05 Hydraulic engineering of dams and their appurtenant structures counts among the essential tasks to successfully design safe water retaining reservoirs for hydroelectric power generation, flood retention and irrigation and water supply demands. In view of climate change, especially dams and reservoirs among other water infrastructure will and have to play an even more important role than in the past as part of necessary mitigation and adaptation measures to satisfy vital needs in water supply, renewable energy and food worldwide as expressed in the Sustainable Development Goals of the United Nations. This book deals with the major hydraulic aspects of dam engineering, considering recent developments in research and construction, namely overflow conveyance and dissipations, structures of spillways, river diversion facilities during construction, bottom and low level outlets as well as intake structures. Furthermore, the book covers reservoir sedimentation, impulse waves and dambreak waves which are relevant topics in view of sustainable and safe operation of reservoirs. The book is richly illustrated with photographs highlighting the various appurtenant structures of dams addressed in the book chapters as well as figures and diagrams showing important relations among the

governing parameters of a certain phenomenon An extensive literature review along with an updated bibliography complete this book     **Modern Water Control in Irrigation** Hervé L. Plusquellec, Charles Burt, Hans W. Wolter, 1994

**Proceedings of the International Forum on Water Resources Management and Irrigation Modernization in Shanxi Province, China**, 2007     **For Profit and Prosperity** Wim Ravesteijn, Jan Kop, 2008 Roads railway lines and bridges harbours and cities irrigation and drinking water supplies evidence of the presence of Dutch engineers in the former Dutch East Indies may be found everywhere in Indonesia For Profit and Prosperity places this legacy from the colonial past in its true perspective This publication provides a detailed description of some of the most important civil public works projects of the Dutch East Indian era while simultaneously outlining the contribution made by the Netherlands to the restoration modernisation and development of such works in the Republic of Indonesia The public works once constructed by Dutch engineers have greatly influenced the way in which Indonesia has become what it is today For Profit and Prosperity reveals just how all of that happened and it does not merely confine itself to the technological aspect The relevant social economic and cultural developments are also subjected to careful scrutiny This book therefore describes in a unique way just how technology and society can influence each other For Profit and Prosperity does not so much set out to provide a comprehensive catalogue style overview of all the public works structures created in the archipelago but rather to provide an insight into the way in which civil engineering evolved in the former colony At the same time an impression is inevitably given of the effect which all of that had upon Dutch civil engineering in general     **Design of Hydraulic Gates** Paulo C.F. Erbisti, 2003-01-01 Based on the author s extensive expertise and experience as an engineer of hydromechanical projects this book describes the principal aspects of the design manufacture installation and operation of hydraulic gates Specific topics are analysed in depth such as the selection of the gate type the limits of their use estimating their weight operative forces hoisting systems design of structure and support elements seals and hydrostatic and hydrodynamic forces The use of recent technological advances such as inflatable gates and fusegates is discussed The book can be used as a text book and manual for the design of gates It features a number of worked examples drawings and about 300 photographs to illustrate the concepts and methods involved and covers several different types of gate and their support elements from a variety of applications     CIGR Handbook of Agricultural Engineering: Land and water engineering International Commission of Agricultural Engineering, 1999     *Compte Rendu*, 1987 Vols for 2002 accompanied by CD ROM containing v 2 of the congress and another CD ROM containing the work of the 18th congress     **Bibliographie CIID**, 1991     Reclamation Era United States. Bureau of Reclamation, 1940     **Flexible Structures** Boris Ivanovich Sergeev, 1986     **Thomas Register of American Manufacturers and Thomas Register Catalog File**, 1955 Vols for 1970 71 includes manufacturers catalogs     **Annual Report of the Chief of Engineers on Civil Works Activities** United States. Army. Corps of Engineers. Civil Works Directorate, 1969     **Engineering Record, Building Record and Sanitary Engineer**, 1914     The Indian

Concrete Journal ,1955      **ASCE Combined Index** American Society of Civil Engineers,1990 Indexes materials appearing in the Society s Journals Transactions Manuals and reports Special publications and Civil engineering      The Engineer ,1954      **Hydraulic Gates and Valves** Jack Lewin,2001 Based on the author s extensive practical experience this new edition will act as a definitive reference work on gates and valves Hydraulic gates and valves in free surface flow and submerged outlets 2nd edition will provide you with a comprehensive overview of the subject and clearly describes the principle options available to engineers and designers and outlines the main advantages and disadvantages of all hydraulic gates and valves highlighting potential problems in their use This fully revised edition includes Information about new types of water operated automatic gates rolling weir gates fuse gates and an extended part on barrier gates and their details The sections on seals the trunnions of radial gates ice formation gate operation and structural design have all been expanded New sections on hazard and reliability of gates earthquake effects on gates and operating machinery environmental impact and aesthetics as well as maintenance An appendix on the calculation of hydrostatic loads on radial gates has been set out Hydraulic gates and valves in free surface flow and submerged outlets 2nd edition will be of great benefit to engineers who work or design project      Design of Hydraulic Gates, 2nd Edition Paulo C.F. Erbisti,2014-05-29 Revised and updated this second edition of Design of Hydraulic Gates maintains the same goal as the original to be used as a textbook and a manual of design of gates presenting the main aspects of design manufacture installation and operation of hydraulic gates while introducing new products technologies and calculation procedures This edition included new chapters on intake gates and trashrack design highlighting the aspects of safety operational and maintenance procedures To improve the strength against structural failure of intake trashracks the author proposes a series of rigid calculation assumptions design parameters and manufacturing procedures which will certainly result in safer trashracks Some 340 drawings and photographs 82 tables 107 references and 23 worked examples help the reader to understand the basic concepts and calculation methods presented

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