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HEADING-UP IN IRRIGATION WORKS

by

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LIST OF SYMBOLS

The following symbols have been adopted in this thesis and are defined wherever they first appear :

Symbol		Definition	Dimensions
A	=	Cross-sectional area of channel	L^2
A_1	=	Area at section upstream from constriction	L^2
A_2	=	Area at the tailwater section	L^2
A_3	=	Area at the section of maximum contraction	L^2
B	=	Width of flume vent	L
b	=	Width of the vent	L
b/B	=	Contraction ratio	–
C	=	Coefficient, coefficient of discharge	–
E_1	=	Specific energy [illegible] upstream [illegible] from constriction	L
E_2	=	Specific energy [illegible] tailwater section	L
E_3	=	Specific energy [illegible] of maximum contraction	L
ΔE	=	The total [illegible] = $E_1 - E_2$	L
F	=	Froude number	–
F_1	=	Froude number of the upstream [illegible] from constriction	–
F_2	=	Froude number at the tailwater section	–
F_3	=	Froude number at the section of maximum contraction	–
g	=	Acceleration due to gravity	LT^{-2}

			Dimensions
h_2	=	Difference in water surface elevation between the upstream section and the downstream section, heading up	L
h_3	=	Difference in water surface elevation between the upstream section and the section of maximum contraction	L
Δh	=	Difference between the upstream water depth and the water depth at maximum contraction section	L
K	=	Coefficient defined elsewhere	–
L	=	Length of the constriction measured parallel to flow	L
Q	=	Total discharge	$L^3 T^{-1}$
q	=	Discharge intensity	$L^2 T^{-1}$
R_e	=	Reynold's number	–
v	=	Point velocity in the x direction	$L T^{-1}$
V_1	=	Mean velocity at a section upstream from constriction	$L T^{-1}$
V_2	=	Mean tailwater velocity	$L T^{-1}$
V_3	=	Mean velocity at section of maximum contraction	$L T^{-1}$
x	=	Linear horizontal distance, distance from the beginning of the vent to sill position	L

			Dimensions
y	=	Depth of water referred to average bottom elevation	L
y_1	=	Upstream water depth	L
y_2	=	Tailwater depth	L
y_3	=	Water depth at section of maximum contraction	L
α	=	Coefficient, heading up coefficient	-
$\beta, \eta, \delta \omega$	=	Coefficients defined elsewhere	-
θ	=	Angle of diversion of expansion wall	-
ρ	=	Mass density	$M\ L^{-3}$
μ	=	Dynamic viscosity coefficient	$ML^{-1}\ T^{-1}$

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INTRODUCTION

INTRODUCTION

Barrages, regulators, bridges and other irrigation works have been built in various regions of the world from time immemorial for the diversion of water from natural streams, for use on agricultural lands, for providing means of communication from one tract of land to another, and for protecting life, property and land from the danger of floods. The abutments of these works represent some obstruction and constriction to the flow which will induce a certain rise in the upstream water level by a certain distance called "heading-up" or "afflux" corresponding to a certain discharge.

In regulators and barrages, the discharge is adjusted by using gates and timbers, but this discharge can never be greater than that which would pass if the regulator were fully open, while in bridges the discharge is not controlled. The maximum discharge is therefore the significant one which must be taken as a basis when the project of irrigation is prepared. It follows that the most important case in the calculation of the heading-up in regulators and bridges is the case when the maximum discharge passes. It is always desirable to keep the heading-up as small as possible because relatively large values of heading-up may cause a dangerous rise of the adjacent water table, resulting in the clogging of the land. Also, the extended backwater may cause a corresponding rise in the water table, which may endanger some buildings far away from the constriction. Therefore, it is advisable to estimate reasonably the amount of heading-up produced by any irrigation structures.

The study presented herein involves a trial to :

1) Develop a practical method for estimating the heading-up for sub-critical flow of water through open channel constrictions.

2) Combine the important flow, fluid and channel variables in a functional relationship to be used in carrying out laboratory experiments.

3) Study the main characteristics of flow through constrictions that have an importance to the designer of such works.

The dimensional analysis was used in finding an expression for the heading-up coefficient as a function of flow, fluid, and geometry of the constrictions.

The study was limited to an investigation of single-opening constrictions composed of vertical walls of various widths, and different outlet diverging angles. A study of the effect of introducing a sill on the heading-up is also included. Five vent widths of constriction have been tried ([illegible] cm). For each vent width, the diverging angles were [illegible] 12.5°, 20°, [illegible] & 90°. The sill used was of the rectangular type. Five positions of sill were chosen to study its effect. In each experiment complete surface profile records were taken for different tail-water depths.

This research work may be considered as the first part of a complete study involving the combined effect of constrictions and obstructions, i.e. the effect of abutments and piers as well.

CHAPTER I

REVIEW OF LITERATURE

1- Heading-up due to variation of vent width.

2- Heading-up due to variation of outlet angle.

3- Heading-up due to variation of sill position.

CHAPTER I

REVIEW OF LITERATURE

1.1. Heading-Up due to Variation of Vent Width

The previous analyses to obtain an expression for either the discharge or backwater effect (heading-up) through an open channel contraction have inevitably considered an upstream flow section and another section further downstream. A combination of either the energy and continuity equations, or the momentum and continuity equations, could be written between the two sections, and thus the discharge or backwater equation could be obtained.

The different formulas yielding the estimated value of the heading-up are here reviewed. As reported in (12)*, the formula for estimating the heading-up is developed by equating the loss in potential energy with the gain in kinetic energy. The loss of potential energy between section 1.1 and section 2.2 (Fig. 1) is equivalent to the difference of water levels between the two sections. This difference is commonly described as the heading-up h_2. The resulting equation is expressed in the following form :

$$h_2 = \frac{\alpha \; V_1^2}{2g \; K^2} \left[\left(\frac{A_1}{\mu \; A_3} \right)^2 - 1 \right] \qquad \ldots\ldots (1)$$

where α = a coefficient as the velocity varies from point to point of the section.

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* Numerals in parentheses refer to corresponding references.