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ENERGY DISSIPATION DOWNSTREAM IRRIGATION STRUCTURES

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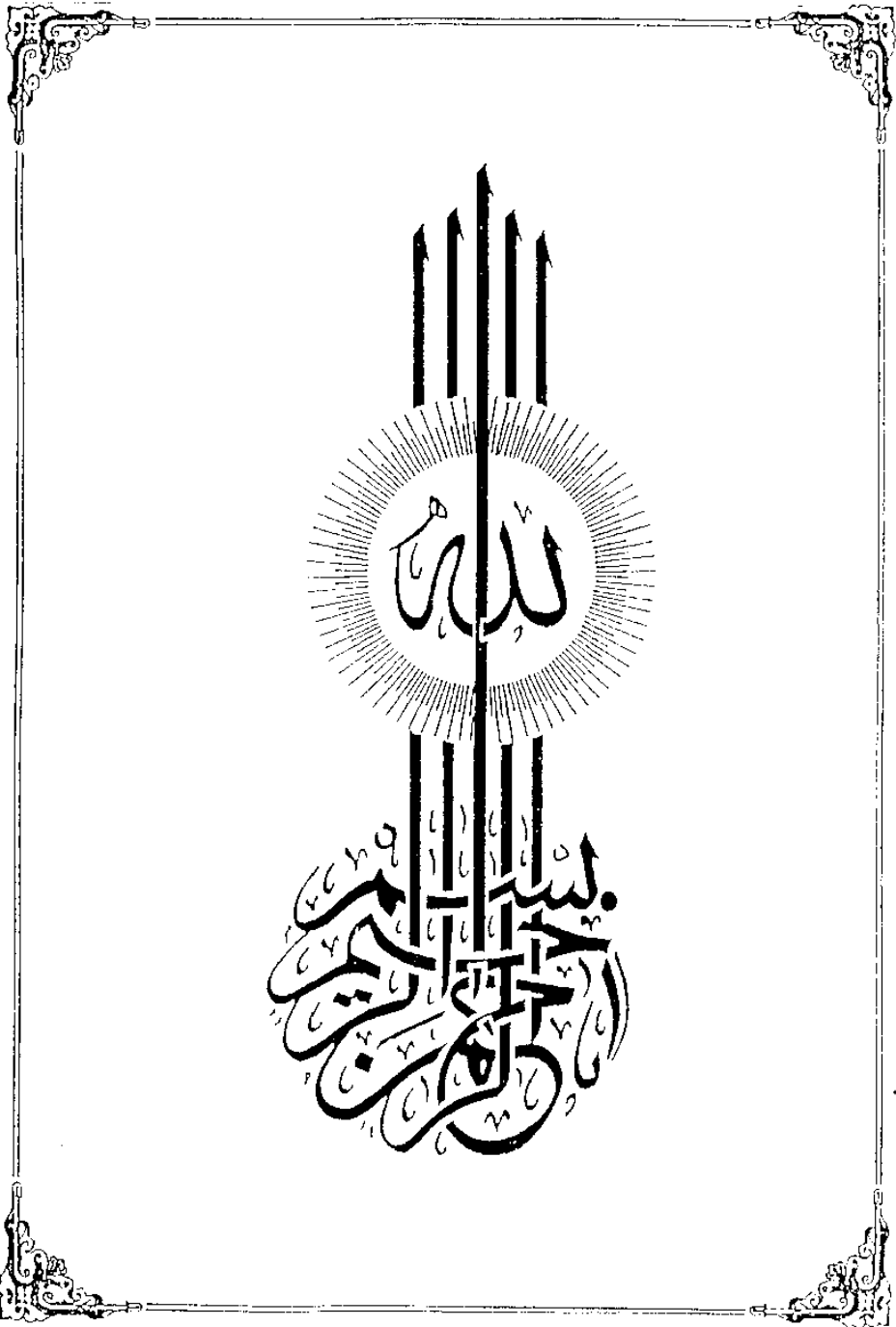
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NOTATIONS

General Symbols:

Subscripts (1) and (2) denote sections before and after the hydraulic jump, respectively.

Superscript numbers indicate works listed under References at the end of this thesis.

SYMBOL	DESCRIPTION
A	area of baffle piers faces.
b	bed width of channel.
b_1	width of each baffle pier.
c_D	coefficient of drag.
d	gate opening
d_s	max. depth of scour.
ΔE	energy lost.
f	function of.
F	force exerted by baffle piers.
F_1	Froude number.
g	acceleration due to gravity.
H	total head.
H_L	head lost.
h	height of baffle piers.
k	force coefficient.
L_f	total length of flow.

SYMBOL	DESCRIPTION
L_n	distance between sluice gate and appurtenances,
M	momentum
n	number of baffle piers
P	pressure force
Q	total discharge
q	discharge per unit width
v	velocity of flow.
v_p	velocity of flow just d.s. the blocks.
y	depth of flow
y_p	depth of flow just d.s. the blocks
α	height factor
β	width factor
γ	specific weight
λ_1	kinetic flow factor
μ	dynamic viscosity
ρ	mass density
ϕ	shape factor

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ENERGY DISSIPATION DOWNSTREAM IRRIGATION STRUCTURES

INTRODUCTION

Chapter (I)

INTRODUCTION

The phenomena of hydraulic jump, stilling basins and energy dissipating devices have been studied since 1819.

The hydraulic jump can be formed only when a stream flowing with supercritical velocity is transformed to a subcritical flow, during the velocity reduction, the stream loses a considerable amount of energy. Also when hydraulic jump is permitted to form on a concrete floor, it adds a weight to counterbalance the uplift pressure.

Many types of energy dissipators have been used throughout the world, and usually the design of each has varied to meet the problem at hand. The best types suited for protection against scour at a particular location depends largely upon the relationship between the existing tailwater depth and the depth required to form a hydraulic jump.

In many cases scour and erosion has led to the failure of irrigation structures. As a result, the study of energy dissipation and scour control has become one of increasing importance. This may be accomplished by constructing an energy dissipator downstream the gates of the structure. This will dissipate the excess energy and establish safe flow conditions in the outlet channel.

Operation of any hydraulic energy dissipator depends largely on expending a part of the energy of the high-velocity flow by the combinations of external friction between water and the channel, or between water and air, or by internal friction and turbulence, thus energy dissipators convert kinetic energy into turbulence and finally into heat.

By the addition of baffle piers or sills with suitable height, width, spacing and position, the satisfactory performance of downstream zone may be increased, stabilizing the flow, and distributing the velocities uniformly downstream the structure and, in many cases, a reduction in the required tailwater depth and length of apron may be possible.

A theoretical analysis involving the percentage of initial energy dissipation and the force exerted by baffle piers has been made.

The use of dimensional analysis aids in understanding the phenomenon of scour and its relation with the energy-dissipation percentage.

A one-vent regulator model representing Egyptian irrigation practice was chosen for this study to clarify the scour effect on bed of the alluvial channel.

REVIEW OF LITERATURE

Chapter (II)

REVIEW OF LITERATURE

In 1927, Von Kurt Safrane⁽¹⁴⁾ on studying the hydraulic Jump, proposed a formula for the length of Jump to be

$$L_j = 6 d_1 \sqrt{F_1}$$

Where d_1 is the depth u.s. the hydraulic Jump.

F_1 is Froude number of the incoming flow.

In 1932, Borris A. Bakhmateff and E.A. Matzke⁽¹⁾ obtained a comprehensive data of the hydraulic jump concerning the length of jump.

$$L_j = (4 \text{ to } 5) d_2$$

in case that Froude number does not exceed 9.

In 1934, Andria Ivanchenko⁽⁹⁾ proposed the following expression for the length of Jump which is

$$L_j = 10.6 (d_2 - d_1) F_1^{0.185}$$

Where d_2 is the conjugate depth d.s. hydraulic Jump.

F_1 is the Froude number of the incoming flow.

⁽²⁾
In 1948, Blaisdell have carried out a series of tests to compare the efficiencies of different types of stilling basins, he reached to the following results.

a, The introduction of floor blocks, and an end sill reduce the required tailwater depth to produce a perfect jump by 15%.

- b. The best height of end sill is $0.07 d_2$.
- c. The height of blocks may be made equal to d_1 .
- d. The length of the stilling basin is given by

$$L = \frac{4.5 d_2}{F_1^{0.38}}$$

- e. Deeply submerged sills of reasonable size produce a sufficient degree of turbulence to dissipate the excess energy.
- f. The floor blocks should occupy between 40 and 55 percent of the stilling - basin width.

In 1951, Weide⁽¹⁷⁾ suggested that when baffle piers are used, the conjugate depth can be found from the equation

$$y_2 = \frac{y_1}{2} \left(\sqrt{1 + 4 c_b + 8 \lambda_1} - 1 \right)$$

instead of the known equation

$$y_2 = \frac{y_1}{2} \left(\sqrt{1 + 8 \lambda_1} - 1 \right)$$

where c_b is the block coefficient. He found that gravitational, inertial and viscous forces affect the flow conditions and that the best performance results when there is an optimum balance between these forces.

A block coefficient dependent upon these forces can be determined by using the equation

$$C_b = \left(\frac{y_F}{y_1} \right)^2 - \left(\frac{y_F}{y_1} \right)^{-2} \lambda_1$$

where y_p is the depth of flow down-stream blocks.

In 1955, Harleman⁽⁶⁾ found that the percentage reduction in the length and the depth of the stilling basin at low Froude numbers were rather small as compared with higher Froude numbers.

He also indicated that the maximum force exerted by the baffle piers is 20% of the pressure force due to the downstream depth .i.e.

$$F_{\max} = 0.2 \frac{\gamma y_2^2}{2}$$

In 1957, Dr. Hassan M. Ismail & Mohamed S. Shalash⁽⁸⁾ on the scour below hydraulic structures reached the following results:

a. The worst condition of submergence which gave the max. scour hole was when the down-stream water depth nearly equal to half the upstream water depth

$$d_2 = \frac{1}{2} H$$

b. The max. floor length producing no scour without using

sills is equal to 5.35 the upstream depth

$$L_1 = 5.35 H.$$

c. It is recommended to extend the length of floor till the normal velocity distribution is reached.

$$L = 3.5 H$$

providing that a sill would be used in the suitable position.

d. The triangular toothed sill, gave the best effect in minimizing the scour hole. The teeth were equally divided and had a slope 1:1 in both sides.

e. The best position for a sill to produce minimum scour hole depends on the tailwater depth.

$$L_1 = 3.7 d_2, \quad L_1 = 1.85 H.$$

In the same year J.N. Bradley & A.J. Petorka⁽³⁾ have made some relations and curves for the ratio of conjugate depths, length of hydraulic jumps, type of jump expected and the losses involved, all have been related to Froude number.

In (1965, 1966), Walter Rand^(11,12,13) concluded that the flow over vortical and dentated sills can be described by a set of five dimensionless variables

$$\frac{V_1}{\sqrt{g D_1}}, \quad \frac{D}{D_1}, \quad \frac{S}{D_1}, \quad \frac{L_s}{D_1} \quad \text{and} \quad \frac{L_t}{D_1}$$

Where D is the tailwater depth, S is the height of sill, L_s is the distance between the position of D_1 and the sill,