USE OF BED ROUGHNESS IN ENERGY DISSIPATION DOWNSTREAM IRRIGATION STRUCTURES

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ABSTRACT

The free rectangular hydraulic jump phenomenon were investigated on rough and smooth channel beds under different flow conditions and different roughness heights. The free surface, bed pressure, initial depth, sequent depth, and jump length, were measured. The study also includes observations of the entrained air. Statistical methods were used to analyze the experimental data and to generate the necessary characteristic design charts for the free rectangular hydraulic jump formed on different bed roughness height.

A macroscopic momentum balance was applied to the hydraulic jump section to derive the general equation for the free rectangular hydraulic jump on rough bed. The energy equation was used to obtain the jump energy loss.

The dimensional analysis approach was applied to develop the relation between the variables involved in the hydraulic jump formed on rough beds.

The theoretical results are compared with the experimental data from the present study for the free rectangular hydraulic jump formed on different bed roughness height.

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List of Symbols

The following symbols are used in this thesis

A = area ;

b = width ;

E1 = Specific energy at the beginning of the jump ;

E2 = Specific energy at the end of the jump ;

EL = Energy loss ;

F1 = Froude number at the beginning of the jump ;

Fr = Bed force resistance ;

Frr = Relative bed force resistance ;

g = Acceleration due to gravity ;

G = Gate opening ;

H = Head above sluice gate ;

h = Manometer Reading ;

I = Intensity of roughness ;

Lb = Distance from the beginning of the jump to the beginning of roughness ;

LJ = Length of jump ;

m = Mean hydraulic radius ;

n = Manning's roughness coeff ;

P = wetted perimeter ;

P1 = Pressure force at the beginning of the jump ;

P2 = Pressure force at the end of the jump ;

q = Discharge/unit width ;

Q = Discharge ;

R = Correlation coefficient ;

r = Height of roughness ;

RN = Reynolds number ;

V1 = Average velocity at the beginning of the jump

V2 = Average velocity at the end of the jump ;

X = Distance downstream of the sluice gate ;

Y1 = Water depth at the beginning of the jump ; initial depth

Y2 = Water depth at the end of the jump ; sequent depth

Y21 = The relative depth ;

γ = Specific weight of water ;

ρ = Mass density of water ;

μ = Coefficient of dynamic viscosity ;

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INTRODUCTION

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INTRODUCTION

Irrigation structures have been built in various regions of the world, for controlling open channel flow from natural streams for use in irrigation, navigation and other purposes. These irrigation structures may be classified according to the working head, into two distinctive types, high head and low head structures. Spillways are considered high head. While barrages, canal intake structures, and weirs are considered low head structures.

The excess energy existing immediately downstream from most irrigation structures requires a device to reduce and dissipate the energy to prevent downstream scour and to minimize erosion. This may be accomplished by constructing an energy dissipator to establish a safe flow regime in the downstream channel.

From practical point of view, hydraulic jump is a useful means of dissipating the excess energy that exists in a supercritical flow downstream a hydraulic structure. A hydraulic jump quickly reduces the velocity of flow on a paved apron to a point where the flow becomes incapable of scouring the downstream channel.

A free hydraulic jump can be separated into two portions, the principal stream and the roller. Transitory movement of the water particles is confined chiefly to the principal stream, while in the roller, the movement is essentially rotational. In addition the principal stream is composed primarily of clear water, whereas the roller is composed of a mixture of air and water. A viscous shear is created along the transition region between the top roller and the high velocity stream underneath it. It has been found that most of the energy is dissipated mainly in the transition region between the roller and the principal stream. The increased viscous shear produces a rapid conversion of energy to heat. In other words, the energy loss in the jump depends to a great extent on created shear stresses. Thus, the roller is an indispensable part of the phenomenon, since without it, the formation of turbulence, and hence energy dissipation, would be minimal.

The length of the stilling basin of a hydraulic jump energy dissipator should be long enough for the velocity distribution to regain its normal distribution. Thus, minimizing the length of the floor of a dissipator is one of the important considerations from the economic point of view.

To improve the performance efficiency of a stilling basin, an addition of appurtenances is necessary. The main purposes of such appurtenances are to dissipate addition of energy by increasing the turbulence, to help in stabilizing the flow, and to distribute the velocities more evenly throughout the basin by reducing the high bed velocities formed in the region of the hydraulic jump.

The purpose of this research is to obtain the