NOTULE HYDRAULIQUE

A new method of predicting the flow in a 90° branch channel

(FLOW IN THE MAIN CHANNEL IS SUBCRITICAL AND THE BRANCH CHANNEL IS SUPERCRITICAL)

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Based on dimensional analysis, an experimental relation for predicting the flow in a 90-degree branch channel, with subcritical flow in the main and supercritical flow in the branch, has been developed. The discharge distribution Q_b/Q_1, where Q_b is the discharge in the branch channel and Q_1 is the discharge in the main channel, varies linearly with the F_0, the Froude number in the main channel upstream of the branch, for a constant L/B ratio in the range $L/B = 1/4$ to 1 and $F_0 = 0.2$ to 0.8, where L is the width of the branch and B is the width of the main channel. The discharge distribution decreases as the Froude number increases.

INTRODUCTION

The problem of branch channel flow is defined as predicting the flow in a branch channel for a given discharge in the main channel, knowing the flow condition and features of the main channel and the features of the branch channel (like slope, roughness coefficient, angle of off take, etc.). This is a problem of spatially varied flow in open channel hydraulics. It can also be considered as a particular case of the well-known problem of side weir flow, when the height of the weir is reduced to zero [1].

Considering the number of variables that are involved, it would not be possible for any single investigation to give a complete solution of this problem.

This problem can be solved by the well-known method of conformal representation [2]. In this case the level of the fluid both along the main channel and the branch is assumed to be the same. As such, when applied to practical problems, this introduces considerable error.

Solution given by Taylor [3] for rectangular channel junctions is only for a particular case of equal widths of channel and subcritical conditions of flow in both the main and the branch channels. The solution is a graphical one involving a laborious trial and error process.

K. Pattabhiramiah and N. Rajaratnam [1] have solved this problem for supercritical flows

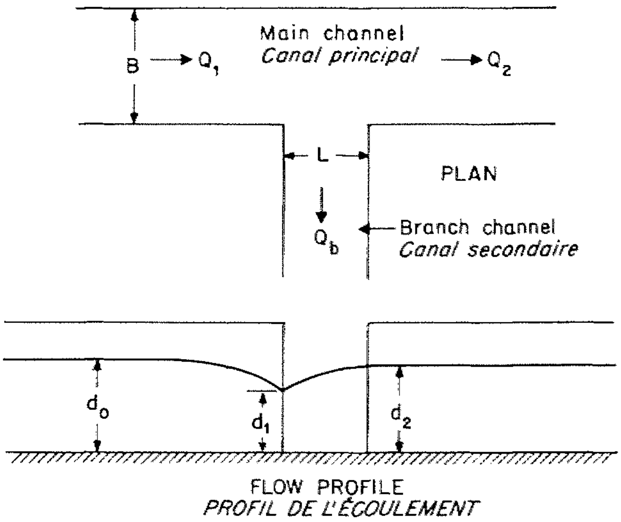

FIG. 1

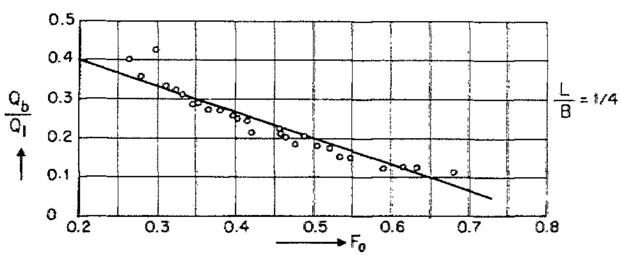

FIG. 2

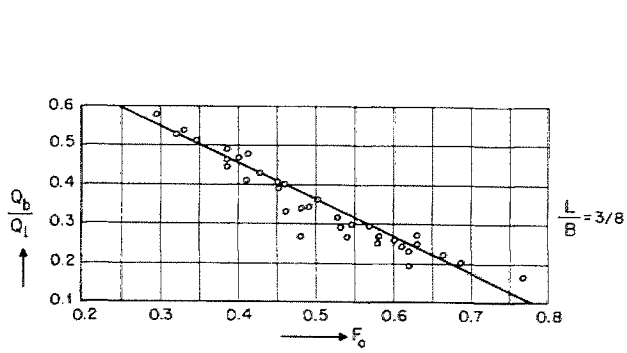

FIG. 3

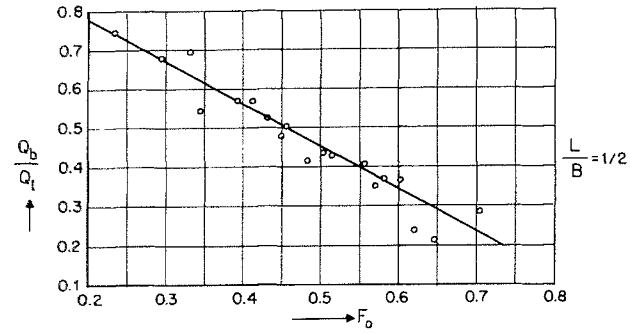

FIG. 4

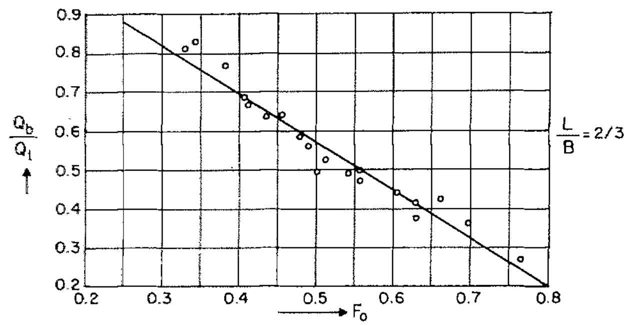

FIG. 5

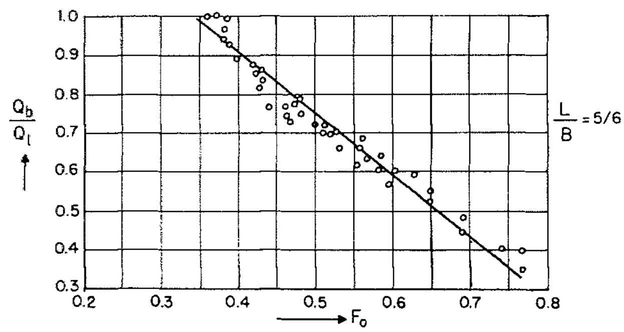

FIG. 6

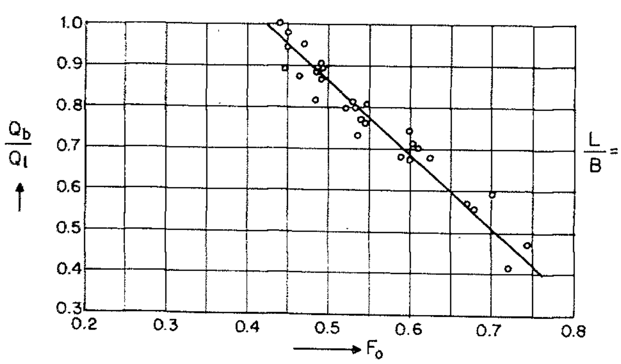

FIG. 7

by the concept of constant specific energy. Hence, the present investigation maintaining subcritical flow in the main and supercritical flow in the branch channel has been taken up.

THEORETICAL ANALYSIS OF THE PROBLEM

In case of subcritical flow in the main channel and supercritical flow in the branch channel, the profile along the main channel is shown in Figure 1. This is similar to the case of side weirs, when the flow in the main channel is subcritical as given by de Marchi [4].

The discharge in the branch channel Q_b depends on d_0, V_0, B, L, θ, g, γ.

where

d_0 = depth at the uniform flow in the main channel;

V_0 = velocity at the uniform flow in the main channel;

θ = angle of off take of the branch to the main;

g = acceleration due to gravity;

γ = specific weight of water.

Expressing in functional relationship:

$$f_2\,(Q_b, d_0, V_0, B, L, \theta, g, \gamma) = 0 \qquad (1)$$

By dimensional analysis:

$$Q_b/Q_1 = f_3\,(F_0, L/B, d_0/B, \theta) \qquad (2)$$

where:

$$Q_1 = d_0 V_0 B \qquad \text{and } F_0 = V_0\sqrt{gy_0}$$

From experiments it has been found that d_0/B is not a significant parameter (in the range $0{,}1 \leqslant d_0/B \leqslant 0{,}5$). So, for a particular value of $\theta = 90°$:

$$Q_b/Q_1 = f_4\,(F_0, L/B) \qquad (3)$$

EXPERIMENTAL DETAILS

In the experimental set-up, the main channel is of 2 ft wide, 2 ½ ft deep and 50 ft long. The branch channel is of variable width and 10 ft long. The longitudinal slope of the branch channel was kept to maintain supercritical flow for the maximum discharge (1/30).

The discharge in the main channel was varied from 0.5 to 3 cusecs. Experiments were conducted for the 90° branch. The width of the branch channel was kept at 1/2′, 3/4′, 1′, 1 1/3′, and 1 2/3′ and 2′ so as to give a L/B ratio ranging from 1/4 to 1. The depth and velocity in the main channel were varied by means of baffles.

DISCUSSION OF THE EXPERIMENTAL RESULTS

In the theoretical analysis, the depth considered is the depth at the uniform flow instead of the depth, d_1 at the upstream end of the branch (Fig. 1). This is in order to facilitate the prediction of flow to the branch knowing the uniform depth of flow in the main channel upstream of the branch. The results that are plotted in Figures 2 to 7 show, in each case the discharge distribution Q_b/Q_1 varies linearly with F_0 for any constant L/B ratio and the discharge distribution decreases as Froude number increases. When F_0 was increased to beyond 0.8, the depth d_1 in the main channel at the upstream end of the branch approached to critical causing fluctuating flow.

The discharge distribution equation can be given as $Q_b/Q_1 = mF_0 + C$.

The values of m and C being plotted with L/B ratio, the equations of m and C are:

$$m = -(1.45\ \ L/B + 0.32)$$
$$C = \quad (1.575\,L/B + 0.16)$$

Therefore, equation (3) becomes:

$$\frac{Q_b}{Q_1} = (1{,}545 - 1{,}45\,F_0)\,\frac{L}{B} + 0{,}16\,(1 - 2\,F_0) \qquad (4)$$

CONCLUSIONS

In case of 90° branch channel, in the range L/B = 1/4 to 1 and F_0 = 0.2 to 0.8.

1. The discharge distribution Q_b/Q_1 is a linear function of F_0 for a constant L/B ratio.

2. The discharge distribution decreases as the Froude number increases.

Acknowledgements

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RÉSUMÉ

Nouvelle méthode pour la détermination du débit dans un branchement à 90° sur un canal

(l'écoulement est fluvial dans le canal principal et torrentiel dans le branchement)

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Les auteurs présentent des résultats expérimentaux valables dans le domaine suivant :

L/B compris entre 0,25 et 1 $\quad F_0 = V_0 \sqrt{g y_0}$ compris entre 0,2 et 0,8

(L est la largeur de la dérivation, B celle du canal principal, V_0 la vitesse et y_0 le tirant d'eau à l'amont du canal principal).

Les figures 2 à 7 montrent les résultats obtenus, qui peuvent être représentés avec une approximation suffisante par la formule :

$$\frac{Q_b}{Q_1} = (1{,}545 - 1{,}45\,F_0)\,\frac{L}{B} + 0{,}16\,(1 - 2\,F_0)$$

où Q_b et Q_1 sont les débits dans la dérivation et dans le canal principal.

Il faut noter que, dans le domaine des expériences, le rapport d_0/B (qui a varié entre 0,1 et 0,5) n'avait aucune influence sensible sur le débit dérivé.