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FLOW THROUGH CRUMP WEIR

ECOULEMENT A TRAVERS LE DEVERSOIR DE CRUMP

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ABSTRACT

The determination of the rates of discharge in natural and artificial channels is a hydrometric parameter of utmost importance. However, the complexity of the measurement requires hydraulics to use the techniques of weirs. The type of spillway, its shape and size is a problem, since such a system must provide a permanent flow and a negligible error in the flow calculation. This article presents an experimental study a flow over a weir with a triangular profile. It consists in determining a constant coefficient of discharge in specific areas of head variations and flows.

Keywords: Discharge, Weir, Triangular profile, Flow, Discharge coefficient

RESUME

La détermination des débits dans les canaux naturels et artificiels est un paramètre hydrométrique de la plus haute importance. Cependant, la complexité de la mesure oblige l'hydraulique à utiliser les techniques de déversoirs. Le type d'évacuateur de crue, sa forme et sa taille posent problème, car un tel système doit fournir un écoulement permanent et une erreur négligeable dans le calcul de l'écoulement. Cet article présente une étude expérimentale de l'écoulement sur un déversoir avec un profil triangulaire appelé déversoir Crump. Elle consiste à déterminer un coefficient de débit constant dans des zones spécifiques de variations de charge et de flux.

Mots clés : Débit, Déversoir, Profil triangulaire, Ecoulement, Coefficient de débit.

INTRODUCTION

Due to the increasing demand on water resources and costs, water engineer has always been the objective of mobilization, good use of this resource development. One of the major means of rational use of water is to control the flow to consumers in a rational manner and without waste. The means for flow measurement are currently numerous, but the choice of such a problem remains. Authors such as Horton, Bazin, Crump, and Filippov were interested in these types of weirs to define the best profiles. A triangular weir is unique in comparison with other weirs have a constant coefficient of flow in specific areas of head variations and velocity, and it is for this reason they are widely used as literature hydrometric. For practical use, it is recommended to take an asymmetric triangular sill profile with the slopes of the upstream and downstream facings respectively $m_l = m_2 = 2$ and 5.

The beginning of the utilization of the first flow meters' weir relates toward the end 19 century (Karacaev,1985). The study of the capacity of the triangular spillways of practical profile was assumed to the Bazin and is proposed as far as Horton (Bakhmeteff, 1934) and Raften (Horton,1907). They prove that these spillways have sufficiently stable hydraulic characteristics in the specific range of a change in the hydraulic parameters and therefore can be applied as the hydrometric development.

Specifically, the requirements of hydrometry brought to the investigations by Crump (Crump,1952) of the particular case of triangular spillway with S_{upstream} = of 2.0 $S_{\text{downstream}}$ =5.0. After a while this spillway has been given the name " Crump's weir " and, as the measured, obtained wide spread before Great Britain and India. Before the full-scale situation the factual characteristics of the capacity of weirs differ from calibration (cup- laboratory) frequently by 10....20%. However, from the interference of measurements - sediment deposit and increase velocity of the flow before spillway (Karacaev, 1985).

In order to exclude these complications, weirs were used with the insertable or lifting thin wall, which they set only at the moment of measurement.

However, hydraulic structures and equipment, and also the exploitation of weirs with the sharp-crested weir on the rivers and the channels proved to be sufficiently complex. Therefore, hydrometric practice has reached the wide practical profile with large sill and small height which do not retain solid matter.

According to the information, given in (Karacaev, 1985), hydrometric weir are the sufficiently reliable means of measurement. Their average quadratic erroneously composes 2....4%, that beside 1, 5....2 times less than with the determination of expenditure by the method “velocity area”. The utilization of triangular weir of a practical profile (of Crump type) as the water-gauge devices is calibrated to be produced on the basis of the following documents (Burges and White, 1966), (White et Whitehead, 1974). (Hershey, White 1977), and (Filippov, 1988).

The latter fact served as by the reason for the carrying-out of further investigations for refining the capacity of Crump weir (Hershey and al, 1985), (Engel., Stainsby 1958), (Filippov,1986), (Filippov,1987), (ISO " 4360-1984"), (ISO 4360-1982 ».), (PNFR,1995), and (White et Whitehead, 1974). This work deals with the study the flow through the triangular profile weirs with different slopes to know the characteristics of each flow (free and submerged), i.e. the discharge coefficient, velocity of flow for free and submersion flow, and errors made on these variants (GOST R 51657-4, 2002). The economic factor is also essential in any development hydrotechnical, in this context to determine the optimal geometry for this type of work is required. (Achour et al., 2003). Four weirs be tested, namely Crump weir (slope 2: 5) and three triangular profile weirs slope (2: 2) (2: 3) in order to know the physical and hydrodynamic characteristics of the different flow regime, to determine the discharge coefficients of flow rates and submersion coefficient, to establish characteristic curves of each weir and the error rate or the discharge determination.

DESCRIPTION AND EXPERIMENTAL METHODOLOGY

Facilities used includes a channel length of 5 m, a width of 0.245 m and a height 0.70m, an axial flow of 24.5 l/s pump (fig. 1). Experimental studies of weirs with three profiles of sills were conducted in the laboratory of the Department of Hydraulics of the Moscow State University of Environmental Engineering. The patch had a width of b = 0.245 m and a height of 0.3 m. Sill profiles studied were respectively, 1: 2 and 1: 5, 1: 2 and 1: 3, 1: 2 and 1: 2. The height of all three sills was the same P = 0.15 m.

Flow ranges were taken from 0.010 to 0.024 m^3 / s of measured heads from 5,3 cm to 12,25cm. Water levels were measured at 21 points, which were located at the following distances la from the upper edge of the weirs: 0.95 (6.33 P); 0.85 (5.67 P); 0.75 (5.0 P); 0.65 (4.33 P); 0.55 (3.67 P); 0.45 (3.0 P); 0.25 (1.67 P); 0.15 (1.0 P); and 0.00.

Studies have shown that the most stable constant values of flow rates have two profiles of triangular sill with slopes in the upstream and downstream, respectively: 1: 2 and 1: 5; as well as 1: 2 and 1: 2.

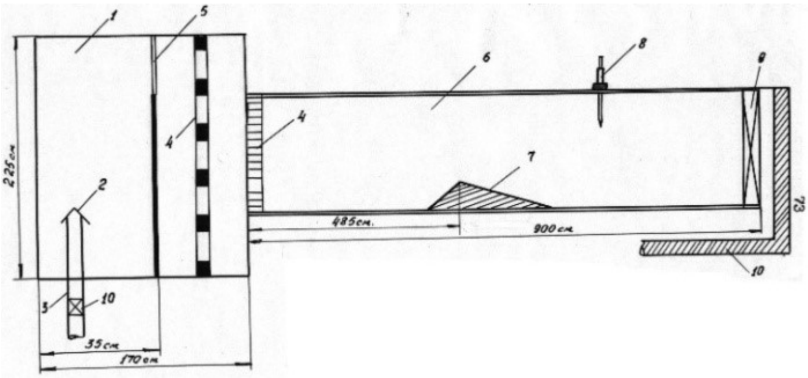

Figure 1 : Experimental installation

1. Reservoir, 2. Sink, 3. Water feed, 4. Stabilizer, 5. Measuring weir, 6. Experimental channel, 7. Crump weir, 8. Limnimétre, 9. Ecluse flow centrl, 10. Drain line

To calculate the flow in the channel, we evaluate the mass flow through the weir during a time T, the measurement of the height of the nape is made using a point-gauge. Three steps for each flow of time T is carried out, the height of the overflowing water to free and submerged flow. Once the flow rate Q, the time T and the nape is known a calculation of the discharge coefficients, velocity, and submersion and for two flow regimes by the following formulas:

According to regulatory documents (Crump, 1952) equations for flow weirs triangular profiles are:

- $$Q = \left[\frac{2}{3}\right]^{3/2} \sqrt{g} C_d b H^{1,5} \qquad (1)$$
- $$Q = \left[\frac{2}{3}\right]^{3/2} \sqrt{g} C_d C_v b (h)^{1,5} \qquad (2)$$

Where; h-upstream water level above the sill

H- total head over the sill, equal $H = h + \propto \frac{V^2}{2g}$, ($\alpha = 1, 0$)

g- acceleration of gravity, m/s^2

C_d- coefficient of discharge

C_V- velocity coefficient, given by

- $$C_V = \left[\frac{H}{h}\right]^{1,5} . \qquad . \qquad (3)$$

b- Width of the weir, m

In carrying out for experimental study, an experimental coefficient was determined in the flow equation, equal to

- $$C_E = C_v C_d . \qquad (4)$$

and then the velocity coefficient is calculated by (3) and the desired discharge coefficient

- $$Cd = \frac{C_E}{C_v} . \qquad (5)$$

For a correct use of the experimental results, we compare results with the existing data obtained for a symmetrical sill, that is to say with 1:2 slopes.

As a natural measure we accept the overflow studied by Bazin (Horton, 1907), which was established in a rectangular channel with a width b = 1.99... 2.0 m, and a sill height P = 0, 5 m, range of flow measurement is 0.0864 to 1.1863 m^3/s, the measured height - 0.07 to 0.405 m and the measuring section is located on a distance l_a of 5.0 m (10 P).

Figure 2 illustrates some models used in the experiment. The results obtained show that the development of regulatory documents for hydrometric constructions and especially for weirs with bottom sills, require a more accurate determination of the measurement sections. Because existing guidelines contain unacceptable limits of available measurement sections, for example, $l_a \geq 2hmax$. this distance measure in our study is l_a = 0.245 m = 1.63 P. By measuring the height of fall for the section

l_a = 1.63 P, not l_a = 4P additional error rate determination would be 3.34% for Q/b = 0.098, which knowing the allowable error of 5%.

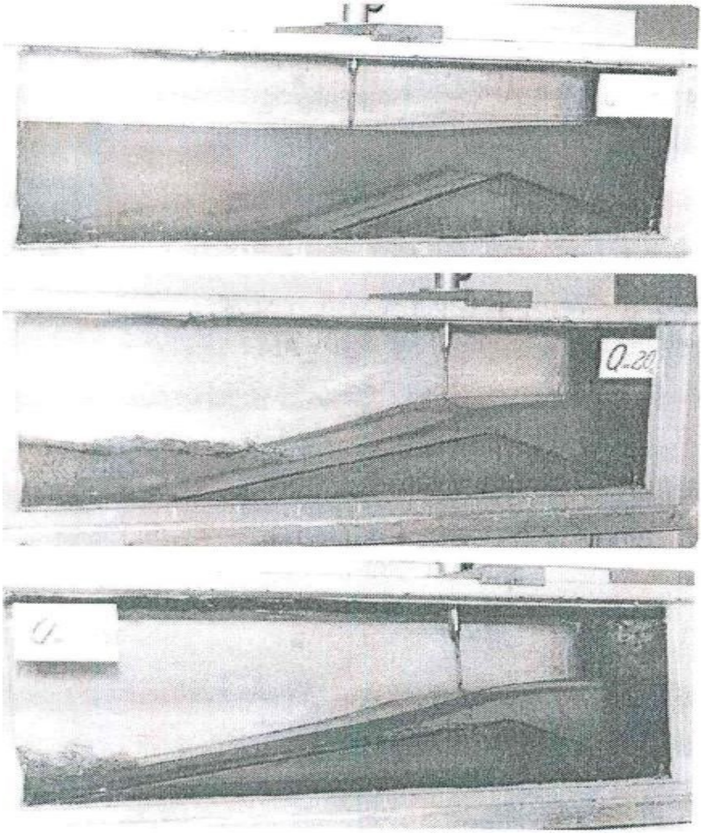

Figure 2: Some weirs used in the experiment

RESULT AND DISCUSSION

Figure 3 shows the experimental and natural characteristics of weirs. From this figure we see that the two characteristics coincide with a difference that does not exceed 0.5%. This shows that the geometric parameters accepted in experimental studies of the spillway sill and ranges of hydraulic characteristics Froude give genuine results for modeling in kind. The width of the channel studied (0.245), although slightly less than that recommended 0.3 m by regulatory documents (Agroskin, Dmitriev, Pikalov,1964), (Bakhmeteff, 1934), (Horton,1907), is quite sufficient to study the characteristics of flow weirs. The relationship between the flow coefficient Cd with full height relative shows the constancy of flow coefficient (Cd = 1.245) and good compatibility of experimental results and data. Although the measurement section was a distance 6.3 P and the natural weir on 10 P, the results gives us the possibility to conclude that there's a significant change in pressure of 6P to 10 P. On the other hand, it should be noted that the arrangement of sections measuring the distance least 6 P has a vital importance for the determination of flow characteristics of weirs.

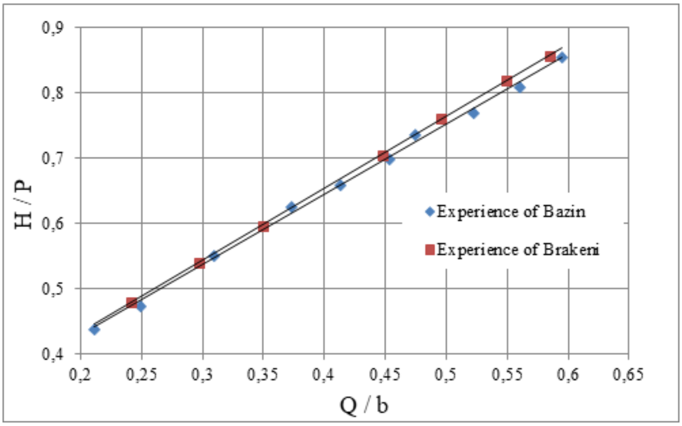

Figure 3: Calibration curve characteristics of experimental and natural spillway, Q/b=*f* (H/P)

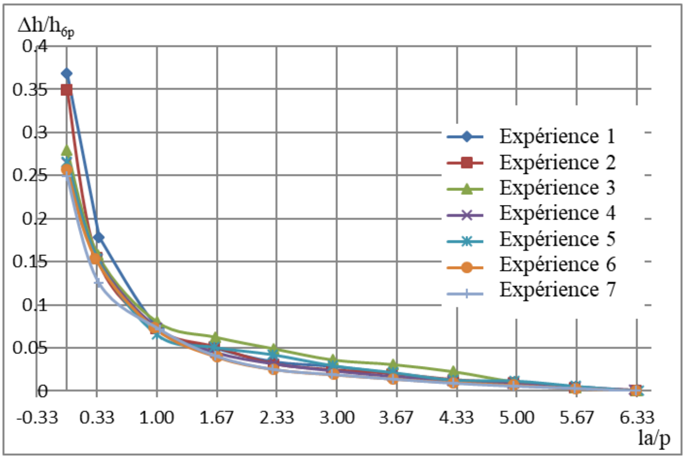

Figure 4: Change the drop height and the measuring section, $\Delta h/h_{6p} = f(l_a/P)$

Figure 4 shows the relationship of the relative change of the height of fall in accordance with the relative distance of the measuring section. Note that the reduction of the distance of 6 P to 0 causes the change of drop heights up to 37% and the total height drops to 20% at an estimated distance 6P.

The figure 5 shows the relationship of change of the flow coefficient Cd depending on the relative arrangement of the measuring section. It was found that the most stable values of flow coefficients, corresponding to the linear interpolation, settled in the range of 6 P (P 10) up to 3 P and a small additional error up to 2 P, available to the measuring close to 2 P is useless, because there is a sudden change of the values of flow coefficients which implies an increase in the error rate calculation. The discharge coefficient for measuring weir on the distance equals 4 P, Cd = 1.255.

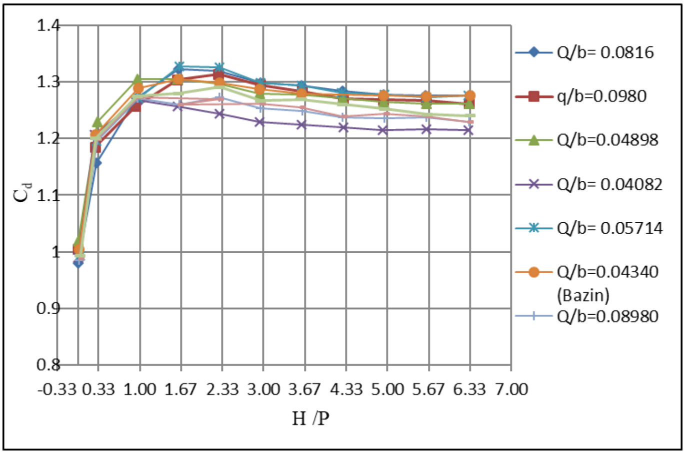

Figure 5: Discharge coefficient Cd depending on the measuring section; C_d=*f* (H/P)

For the same crest height and flow rate, Cd value decrease by increasing upstream angle value and increase by decreasing the same angle. For the same flow rate and upstream angle, the coefficient of discharge inversely proportional to the crest height. (Abdul-Hassan K. *et al*, 2017).

CONCLUSION

For the accuracy of documents and country regulations by revising the international standard for triangular profile weirs it is recommended:

- Insert these documents in the practical application of control systems in beds and open channels the symmetrical triangular profile weirs upstream and downstream slopes equal to 1:2
- For recommended weirs, use the discharge coefficient in the equation of flow equal to 1.255 with the location of the measuring section at a distance equal to 4P the top edge of the sill, knowing that the relative error is equal to 0.5 ... 1 0%;
- The measuring section may be disposed on the distance 2 h_{max} provided that h_{max} = P, while taking the relative error of the flow coefficient equal to 2%;
- For other sections measuring the flow coefficients are calculated from Figure 4.

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