FLOW THROUGH A POROUS RUBBLE MOUND WEIR

EVAN KOUTANDOS [1] and PANAYOTIS PRINOS [2]

[1] Post Doctoral Fellow, Hydraulics Lab., Dept. of Civil Engineering,
Aristotle University of Thessaloniki, Thessaloniki 54124, Greece,
(Tel: +30-2310-995856, Fax: +30-2310-995672, e-mail: ekoutant@civil.auth.gr)
[2] Professor, Hydraulics Lab., Dept. of Civil Engineering,
Aristotle University of Thessaloniki, Thessaloniki 54124, Greece,
(Tel: +30-2310-995856, Fax: +30-2310-995672, e-mail: prinosp@civil.auth.gr

In the present study the hydrodynamic characteristics of porous rubble mound weirs are examined experimentally. The effect of the governing parameters ((a) Reynolds number: Re=q/ν, (b) Porosity of the rubble mound: n, (c) Rubble grain diameter in dimensionless form: d_m/h_0, (d) River bed slope: i) that determine the flow rate is examined. Results in dimensionless diagrams are presented. In addition, results are compared with those for an impermeable weir. The destruction mechanism of the structure is also investigated and some basic characteristics are presented.

The experiments were organized into three different sets according to the construction material of the structure. The height of the structure was 10 cm, the length of the base 138 cm, the length of the crest 84 cm and the width of the weir 40 cm. The weir in the first set was impermeable made of plywood. In the second set the weir was made of natural gravel with a mean diameter, d_m =0.51 cm and porosity, n=0.42 while in the third set the mean diameter was d_m =4.05 cm and porosity, n=0.55. In each set three different bed slopes i were examined (0.008, 0.009 and 0.01) in a wide range of Reynolds and Froude numbers, 10 experiments (only overflow) in the first set and 20 in the second and third set. A simple computation leads us to the total number of experiments, 150. The total length of the experimental flume was 12 m, the width 0.4 m and its height 0.6 m. The structure was placed at 6 m from the channel inlet. The water was recirculated stably and the channel bed was hydraulically smooth. The discharge was measured using a V notch weir. Measurements of depth 0.5 m before (h_0) and 0.5 m after the structure (h_1) were extracted from digital pictures with the aid of known measured reference points of adequate accuracy (0.1 mm). In the second and third set of experiments a wire net was used in order to ensure stability. The net was removed only in the third set of experiments in order to investigate the stages of the weir destruction.

In fig. 1 (A) the variation of the dimensionless discharge F_0 with the dimensionless ratio $\Delta h/B$ ($=(h_0-h_1)/B$) is shown for I equal to 0.009 while variation of the dimensionless discharge F_0 with the Re number of the flow is presented in fig. 1 (B), for the examined weir porosities. It is clear that, for the impermeable weir case, $F_0=q/(gh_0^3)^{1/2}$ and thus the discharge, Q=q*b, is directly proportional to the $\Delta h/B$ ratio and the Re number of the flow. In the other two cases where the structure is permeable this fact is only clear in the part of the figure where overflow occurs ($\Delta h/B>0.072$). In the parts of the figures where subsurface or transient flow is depicted ($\Delta h/B<0.072$), non-linearities appear which are mainly due to the interaction of the flow with the porous body of the weir. These non-linearities are more evident in the case of the greater porosity (n=0.55). For the specific hydraulic conditions examined the greater discharge is observed in the case of the impermeable structure. It is evident that the role of the porosity is predominant in the specific flow. Discharge is shown to be greater with higher porosity due to bigger voids and higher through flow. It is also clear that the effect of the Re number is significant for any permeability of the structure.

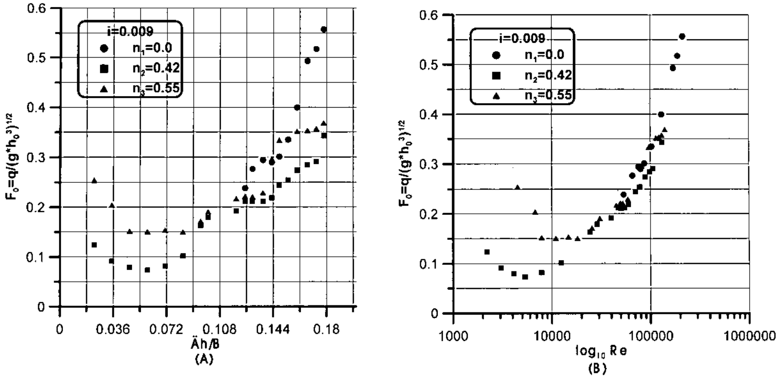

Fig. 1 (A, B) Variation of the dimensionless discharge F_0 with the dimensionless ratio Δh/B and the Re number of the flow (A and B respectively).

In fig. 2 (A) the variation of the dimensionless discharge F_0 with the dimensionless ratio Δh/B is shown for n equal to 0.55 while the variation of the dimensionless discharge F_0 over the dimensionless ratio d_m/h_0 for the examined channel bed slopes is presented in figure 2 (B). It is again clear that, for the impermeable weir case, F_0 and thus the discharge, Q is directly proportional to the Δh/B ratio. On the opposite, F_0 decreases with increasing d_m/h_0 ratio for flow through the permeable structure (Δh/B <0.072) while it increases with increasing dm/h_0 for flow over the structure. This is logical since higher values of d_m lead to smaller values of porosity. The effect of the channel bed slope in the discharge appears to be of lesser importance than the porosity, the Re number and the mean grain diameter. Abnormalities appear again in the part of the diagrams where subsurface or transient flow is depicted (Δh/B < 0.072).

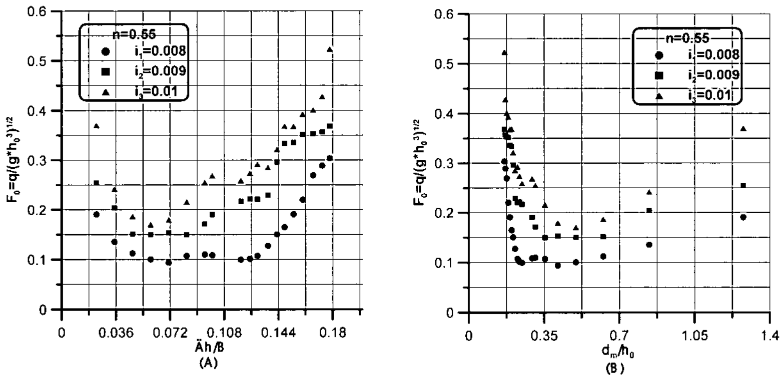

Fig. (A, B) Variation of the dimensionless discharge F_0 with the dimensionless ratio Δh/B and the dimensionless d_m/h_0 ratio (A and B respectively)