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UNIFORM AERATED CHUTE FLOW[a]

Discussion by Hubert CHANSON[2]

The author provided interesting simple correlations on uniform aerated flows. The writer would like to add some information on the average air concentration and to discuss specific points concerning the bottom air concentration and the mixture flow depth.

BOTTOM AIR CONCENTRATION C_o

CAIN (1978) and CHANSON (1988) performed air concentration measurements on prototype (Aviemore dam) and model (Clyde dam model) using similar conductivity probes. Their data consistently showed that the air concentration next to the spillway floor tends to zero at the spillway floor (CHANSON 1989) and an example is shown on figure A1 where the data are compared with the computed equilibrium profile (WOOD 1985). Zero bottom air concentration suggests the presence of an air concentration boundary layer that does not coincide with the velocity boundary layer (CHANSON 1989). At the spillway floor, the high velocity gradient (i.e. $\delta V = 9.6$ m/s for $\delta y = 3$ mm on figure A1) and the resulting shear stress would split air pockets in micro bubbles of negligible volume.

It is believed that the reduction of drag force (i.e. friction factor) observed in aerated flow is caused by the presence of air bubbles across the velocity boundary layer that tend to reduce the shear stress between flow layers, and hence the total drag force.

AVERAGE AIR CONCENTRATION C_e

AIVAZYAN (1986) reported on-site data with slopes in the range 16 to 31 degree and proposed two correlations :

$$C_e' = \sin\Theta \qquad \text{(A1)}$$

and $$C_e' = 0.17 + 0.35 * \sin\Theta \qquad \text{(A2)}$$

where C_e' is the average air concentration defined with reference to the depth y_{98}:

$$(1 - C_e') * y_{98} = d$$

The mean air concentration tends to zero for a horizontal channel and the equation (A1) seems to be more appropriate. The writer uses a similar correlation in term of C_e defined with reference to the depth y_{90} :

$$C_e = 0.9 * \sin\Theta (\Theta < 50 \text{ degree}) \qquad \text{(A3)}$$

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MIXTURE FLOW DEPTH

GANGADHARAIAH et al. (1970) deduced the equation (5) with data obtained in gradually varied flow region (figure 8, GANGADHARAIAH et al. 1970). In this region the continuity equation for air and the energy equation provide two differential equations that can be integrated using numerical method (WOOD 1985).

For uniform flow the re-analysis of STRAUB and ANDERSON's data by WOOD (1983) shows without ambiguity that the uniform mean air concentration C_e is function of the slope only. For a given slope, C_e is independent of the discharge, the Froude number and the relative roughness.

However the characteristic depths y_w and y_{90}, and hence the flow bulk, depend on the chute slope and the roughness (WOOD 1983) :

$$y_w = \left(\frac{q_w^2 * f_e}{8 * g * \sin\Theta} \right)^{1/3} \qquad \text{(A4)}$$

$$y_{90} = \frac{1}{1 - C_e} * y_w \qquad \text{(A5)}$$

where f_e is the friction factor of aerated flow, function of the mean air concentration.

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Fig. A1 - Air concentration distribution next to the channel bottom - CAIN (1978)