ENERGY HEAD OF AERATED FLOWS IN STEPPED CHANNELS

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For the hydraulic design of a stepped channel, it is important to predict the energy head of aerated flows in skimming flows.

Recently, the air-concentration ratio C of skimming flows was measured, and a clear-water depth d was determined. By using the clear-water depth d, the energy head E_w of skimming flows was estimated as $E_w = d\cos\theta + V_w^2/2g$ [e.g. Ohtsu et al.(2000), Chanson et al.(2002), and Boes and Hager (2003)], where V_w = averaged velocity ($V_w = q_w / d$; q_w = discharge per unit width of clear water) and θ = angle of channel slope.

But, a method for estimating the energy head of aerated flows E has not been established.

In this paper, a new method for estimating the energy head of aerated flows E is presented by using the air-concentration ratio C and the aerated flow velocity u. If the energy head E is expressed by the clear-water depth d and the averaged velocity V_w, E is represented by the following equation with correction coefficients C_p and C_v [Ohtsu et al. (2004)]:

$$E = C_p d\cos\theta + C_v \frac{V_w^2}{2g}$$

The expression of C_p and C_v is developed by using the air-concentration ratio C from an air-bubble diffusion model [Chanson (2001)] and the aerated flow velocity from the $1/N$-th power velocity distribution law, and the values of C_p and C_v are determined (Figs.1 and 2). In Figs.1 and 2, C_m is the averaged air-concentration ratio. Also, the relationship between E and E_w is clarified for given relative step height S / d_c [S = step height and d_c = critical flow depth] and angle of channel slope θ.(Fig.3). Further, the relationship between the actual aerated flow velocity V_{ave} and the velocity from clear water depth V_w ($= q_w / d$) is shown.

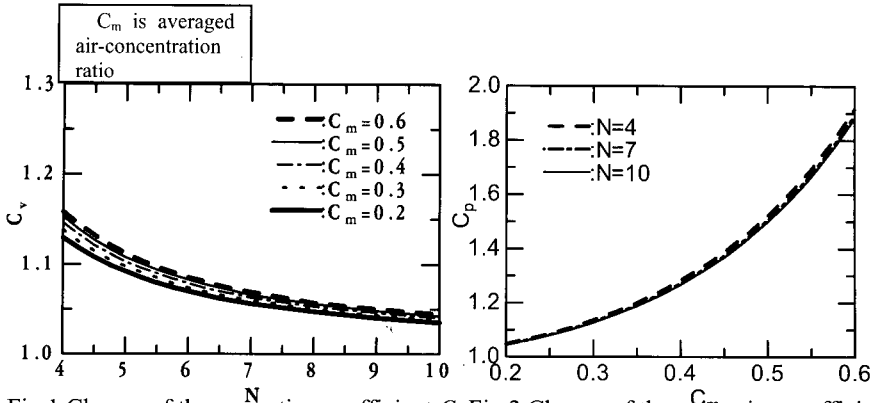
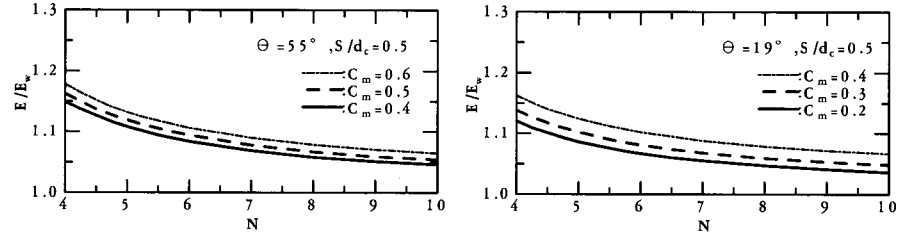


Fig.1 Change of the correction coefficient C_v with N and C_m

Fig.2 Change of the correction coefficient C_p with C_m and N



(a) (b)

Fig.3 Change of E / E_w with N and C_m

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