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Theoretical occurrence condition of mud debris flow

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The debris flow is classified in three categories as the stony debris flow, mud turbulent debris flow and viscous debris flow from the different flow mechanism. The mud turbulent debris flow is discussed in this research. This debris flow ha some specific characteristics things. One is the high concentrated flow with sediment on the gentle slope channel, and some debris flow occur in short period. The occurrence condition of mud turbulent debris flow has been not studied clearly. In this research, the theoretical occurrence condition is obtained from the instability flow condition and Arai-Takahashi mud flow velocity equation. The result on the roughness bottom condition is as follows.

$$\left[\left(\frac{3}{2}-\beta\right)+\left\{\sinh^{-1}\left(\frac{1}{{\phi_0}^2}\frac{H}{d}\right)-\sinh^{-1}\left(\frac{1}{{\phi_0}^2}\frac{bk_s}{d}\right)-\sqrt{1+{\phi_0}^2\left(\frac{d}{H}\right)^2}+\phi_0\left(\frac{d}{H}\right)\right\}^{-1}\times\left\{1+{\phi_0}^2\left(\frac{d}{H}\right)^2-\phi_0\left(\frac{d}{H}\right)\sqrt{1+{\phi_0}^2\left(\frac{d}{H}\right)^2}\right\}\times\sqrt{1+{\phi_0}^2\left(\frac{d}{H}\right)^2}\right]^2-\beta(\beta-1)\quad\geq\quad\frac{1}{F_r^2}$$

here, ${\phi_0}^2=\left(\lambda^2\frac{a_i\sin\alpha}{\kappa^2}\right)$, $\lambda=\left\{\left(\frac{C_*}{C}\right)^{\frac{1}{3}}-1\right\}^{-1}$: linear concentration, H : depth of flow, d : particle size, k_s : equivalent roughness , b=1/30, β : momentum correction coefficient, F_r : Froude number, κ : Karman constant, σ : dencity of solid particle, ρ_m : mean density of flow, C_* : concentration of packed solid particles, C : mean concentration.

The result indicates that if the ratio of the flow dept and particle size is less, the occurrence is less Froude number, and if the concentration is higher, the occurrence is less Froude number.