Geophysical Research Abstracts
Vol. 12, EGU2010-7740, 2010
EGU General Assembly 2010
© Author(s) 2010

Influence of nonuniform solid concentration on surge occurrence of muddy debris flow and viscous debris flow

Muneyuki Arai
Meijo University, Civil Engineering, Nagoya, Japan (arai@ccmfs.meijo-u.ac.jp, +81 52-832 1178)

Debris flows are classified into some types by flow mechanism. Viscous debris flow and muddy debris flow have a common important characteristic that lots of surges flow intermittently. Authors have shown that surges are generated by flow instability as same as roll waves. This paper is reported the influence of nonuniform solid concentration in the flow into surge occurrence of muddy debris flow or viscous debris flow. It is difficult to discuss a general solution of any solid concentration form in the flow. Therefore it is simplified that the flow has two different concentration layers. The concentration of a lower layer is C_ℓ, thickness h_ℓ from bottom to h_ℓ, the concentration of an upper layer is C_u, thickness h_u from h_l to surface of the flow, and C_ℓ is greater than C_u. From the theoretical consideration, when the concentration is nonuniform, the flow is stable than uniform concentration. A theoretical result on muddy debris flow is as follows,

$$F_r \geq \frac{1}{\sqrt{\left\{\Phi + \left(\frac{3}{2} - \beta\right)\right\}^2 - \beta\left(\beta - 1\right)}} \tag{1}$$

here,

$$\Phi = \left[\sqrt{1+{\phi_m}^2} - \phi_u\right] \times \left[\sinh^{-1}\Big\{\frac{1}{\phi_m}\Big\} - \sinh^{-1}\Big\{\frac{1}{\phi_u}\Big\} - \sqrt{1+{\phi_m}^2} + \phi_m\right]^{-1}$$

$$\begin{aligned}
\beta \;=\; & \Bigg[a\Big\{2 + \Big\{\sinh^{-1}\Big(\frac{Y_0}{\phi_\ell}\Big)\Big\}^2\Big\} - 2\,\sinh^{-1}\Big(\frac{Y_0}{\phi_\ell}\Big)\,\phi_\ell + 2\,\sinh^{-1}\Big(\frac{Y_0}{\phi_\ell}\Big)\sqrt{{\phi_\ell}^2 + a^2} \\
& -2\left\{a\,\sinh^{-1}\Big(\frac{Y_0}{\phi_\ell}\Big) + \sqrt{{\phi_\ell}^2 + a^2}\right\}\cdot\sinh^{-1}\Big(\frac{a}{\phi_\ell}\Big) + a\left\{\sinh^{-1}\Big(\frac{a}{\phi_\ell}\Big)\right\}^2 \\
& +2 + \left\{\sinh^{-1}\Big(\frac{Y_0}{\phi_u}\Big)\right\}^2 - a\left\{2 + \Big\{\sinh^{-1}\Big(\frac{Y_0}{\phi_u}\Big)\Big\}^2\right\} + 2\,\sinh^{-1}\Big(\frac{Y_0}{\phi_u}\Big)\sqrt{{\phi_u}^2 + 1} \\
& -2\,\sinh^{-1}\Big(\frac{Y_0}{\phi_u}\Big)\sqrt{{\phi_u}^2 + a^2} - 2\left\{\sinh^{-1}\Big(\frac{Y_0}{\phi_u}\Big) + \sqrt{{\phi_u}^2 + 1}\right\}\cdot\sinh^{-1}\Big(\frac{1}{\phi_u}\Big) \\
& +\left\{\sinh^{-1}\Big(\frac{1}{\phi_u}\Big)\right\}^2 + 2\left\{a\,\sinh^{-1}\Big(\frac{Y_0}{\phi_u}\Big) + \sqrt{{\phi_u}^2 + a^2}\right\}\cdot\sinh^{-1}\Big(\frac{a}{\phi_u}\Big) \\
& -a\left\{\sinh^{-1}\Big(\frac{a}{\phi_u}\Big)\right\}^2\Bigg] \times \left[\sinh^{-1}\Big(\frac{1}{\phi_m}\Big) - \sinh^{-1}\Big(\frac{Y_0}{\phi_m}\Big) - \sqrt{1+{\phi_m}^2} + \phi_m\right]^{-2}
\end{aligned}$$

$\phi^2 = \left(\lambda^2 \frac{a_i \sin\alpha}{\kappa^2}\right)$, $\lambda = \left\{\left(\frac{C_*}{C}\right)^{\frac{1}{3}} - 1\right\}^{-1}$: linear concentration, $H = h_\ell + h_u$: depth of flow, $a = \frac{h_\ell}{H}$, 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, suffix m: mean of depth, ℓ: lower layer, u: upper layer.