

6. Landforms made by direct action of gravity

6.2 Debris cone

Two-dimensional simulation of debris flow flooding has been conducted using the following equations.

Debris flow:

$$\frac{\partial(uh)}{\partial t} = -gh \frac{\partial(Z+h)}{\partial x} - \frac{\mu(\sigma - \rho)gh \cos \theta_x}{\gamma} \quad (6.14)$$

$$\frac{\partial(vh)}{\partial t} = -gh \frac{\partial(Z+h)}{\partial y} - \frac{\mu(\sigma - \rho)gh \cos \theta_y}{\gamma} \quad (6.15)$$

$$\frac{\partial h}{\partial t} + \frac{\partial(uh)}{\partial x} + \frac{\partial(vh)}{\partial y} + \frac{\partial Z}{\partial t} = 0 \quad (6.16)$$

$$\frac{\partial(C_d h)}{\partial t} + \frac{\partial(C_d uh)}{\partial x} + \frac{\partial(C_d vh)}{\partial y} + C_* \frac{\partial Z}{\partial t} = 0 \quad (6.17)$$

$$C_d = \frac{\rho \tan \theta}{(\sigma - \rho)(\tan \varphi - \tan \theta)} \quad (6.18)$$

Flood flow succeeding debris flow:

$$\frac{\partial M}{\partial t} = -gh \frac{\partial(h+Z)}{\partial x} - \frac{gn^2 u \sqrt{u^2 + v^2}}{h^{4/3}} \quad (6.20)$$

$$\frac{\partial N}{\partial t} = -gh \frac{\partial(h+Z)}{\partial y} - \frac{gn^2 v \sqrt{u^2 + v^2}}{h^{4/3}} \quad (6.21)$$

$$\frac{\partial h}{\partial t} + \frac{\partial M}{\partial x} + \frac{\partial N}{\partial y} = 0 \quad (6.22)$$

Example of simulation:

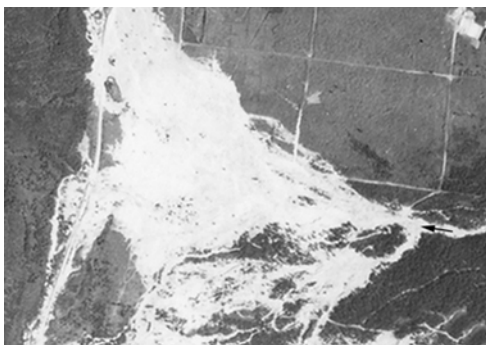


Fig.6.5
Flooding of debris on fan
surface
Dainichi Fan, Niigata

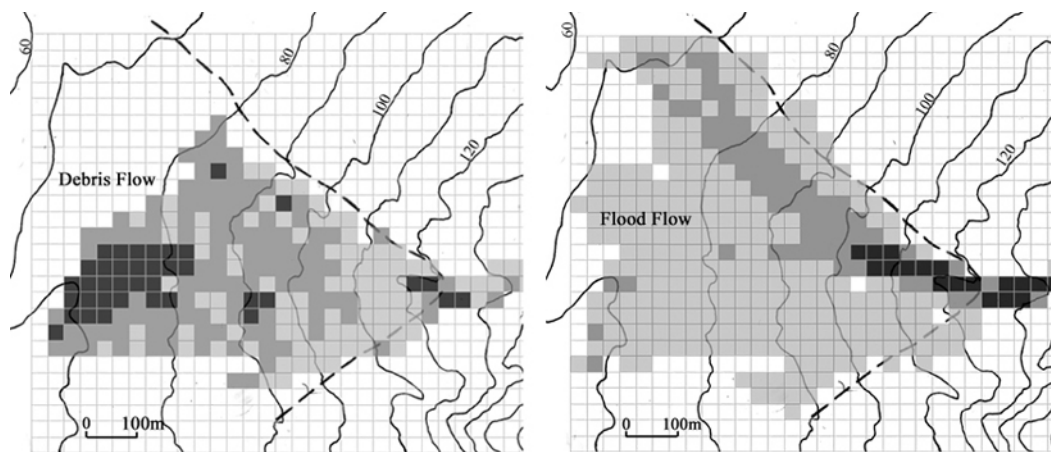


Fig.6.6 Two dimensional digital simulation of debris flow flooding –Dainichi Fan
Left: Debris flow, right: flood flow succeeding debris flow , mesh width: 30m

6.3 Deformation due to dead load

Deformation of mountain body due to dead load has been calculated by using finite element method

Shear stress is maximum just below the summit. Fracture and gravitational spreading is liable to occur there.

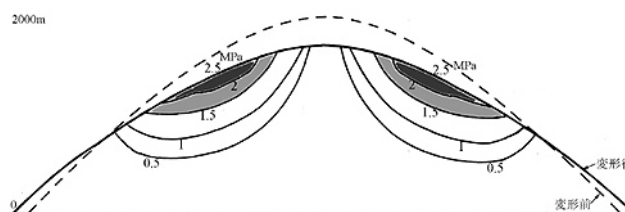


Fig.6.12 Distribution of shear stress due to dead weight

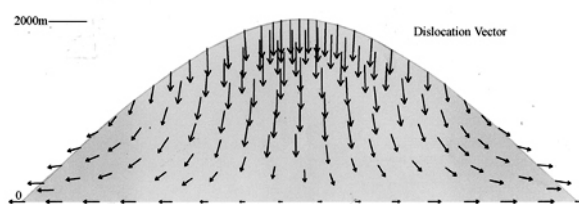


Fig.6.13 Distribution of dislocation vector

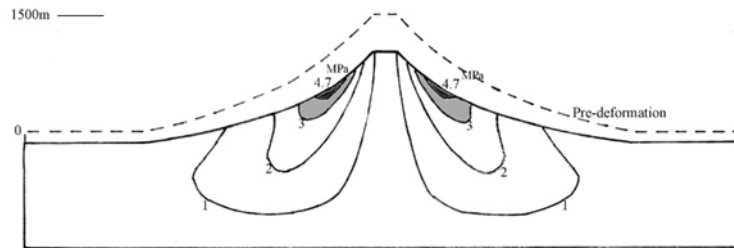


Fig.6.15 Shear stress due to dead weight