The angles and friction coefficients of some rheological granular materials

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Summary

For the visco-plastic materials of type Bingham fluid, like granular materials, the process of flow begins when the force $\bar{F}$, which variation is presented in figure 1, reaches the minimum value of shearing limit.

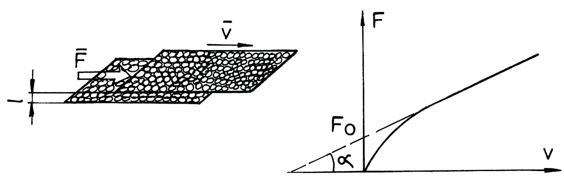

Figure 1: Variation of granular displacement force (relative displacement of granular layers; variation of force function of speed)

The rheological equation of Bingham may be written like:

$$F = F_0 + \eta_p \cdot \frac{s}{l} \cdot v, \tag{1}$$

where:

F_0 - the force to overcome the shearing limit [N];
η_p - coefficient of plastic viscosity [Ns/m^2];
s - the area of displacing sections [m^2];
l - the distance between two successive layers [m];
v - speed of displacement of the layers [m/s].

When the granular material is subjected to shearing oscillations, as can be observed in figure 2, the deformation of the volume of material is produced due to following forces:

external force: depending on q_0 - applied shearing stress;
cohesion force: depending on the coefficient of cohesion c';
viscous force: depending on the product "$\eta_p \cdot \gamma_0 \cdot \omega$", where γ_0 is shearing deformation and ω is the oscillation frequency;
friction force: depending on the product "$p_0 \cdot \mu$", where μ is the friction coefficient between particles in dynamic regime.

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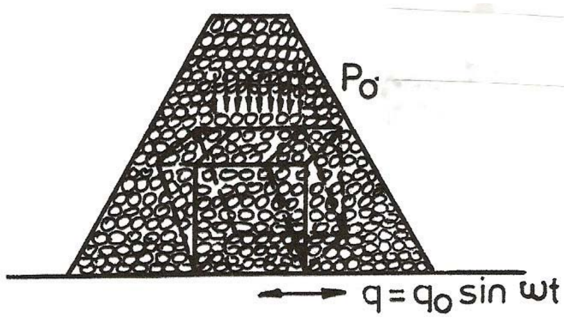

Figure 2: Deformation of a unit volume of material

Due to the fact that the friction forces, either between granules and the work surface, or between granules, have a significant role in particles motion, the friction angles were determined experimentally, respectively the friction coefficients for the analyzed materials, for two regimes: static and dynamic. Dynamic regime consisted of realizing vibration motion, with frequency of 50 [Hz] and amplitudes under one millimeter, of the inclined plane on which the friction angles were measured. The obtained values, recorded in a table, pointed out that in dynamic regime the friction coefficients significantly decrease in comparison with the static regime, the decrease being of few units to few ten units of magnitude.