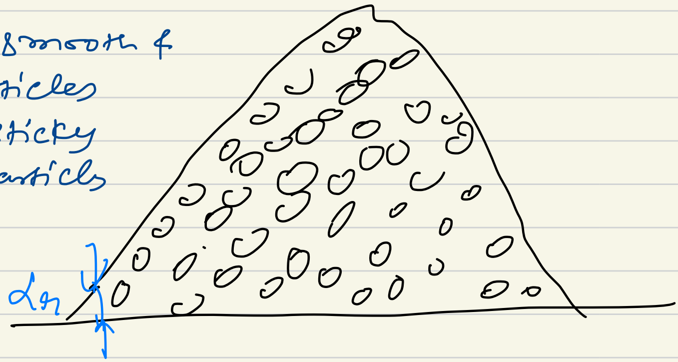
Storage of solids:

* α_r – is low for smooth & rounded particles
  – is high for sticky & angular particles



* in practice, $\alpha_r < \alpha_i$

Angle of Repose & angle of internal friction:

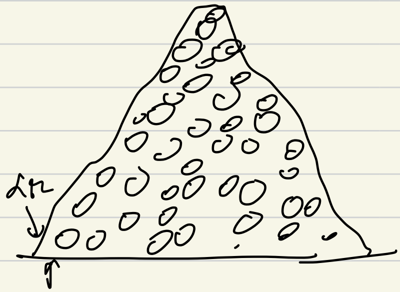
The frictional force with in the particles is measured using angle of internal friction α_i. The tangent of this angle is the coeff. of friction b/w two layers of particles.

Lecture - 7

Storage of solids:

Angle of repose (α_r)

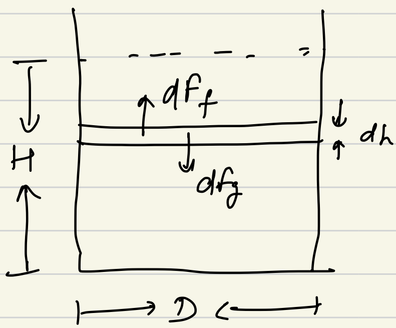
$\alpha_r < \alpha_i'$



Design of storage tank

$$dF_v = dF_g - dF_f$$

$$\left(\frac{\pi D^2}{4}\right) dP_v = \left(\frac{\pi D^2}{4}\right) dh\, \rho_s g - \mu' P_L \pi D\, dh$$



μ' - coeff of friction at the bin wall

P_L - Lateral pressure

P_V - vertical pressure on the bin floor

$$\frac{P_L}{P_V} = k'$$ (a constant, also called coeff of flowability of the material)

k' depends on

- shape & interlocking tendency of particles, degree of packing
- For cohesive materials like wet clay, $k' \simeq 0$
- For free flowing materials, k' — 0.3 to 0.6

$$k' = \frac{1 - \sin\alpha_i'}{1 + \sin\alpha_i'} \qquad \left\{ k' < 1 \Rightarrow P_L < P_V \right\}$$

$$\int_0^H dh = \int_0^{P_V} \frac{D \, dP_V}{D \rho_s g - 4\mu' k' P_V}$$

$$\Rightarrow \boxed{P_V = \frac{\rho_s g}{k_b}\left(1 - e^{-k_b H}\right)} \qquad k_b = \frac{4k'\mu'}{D}$$

Janssen eqn

When $\frac{H}{D}$ is large, $P_v \simeq \frac{\rho_s g}{k_b}$ $\{H > 3D\}$

For $H > 3D$

* Further addition of solids to bin will not change total pressure on the bin floor.

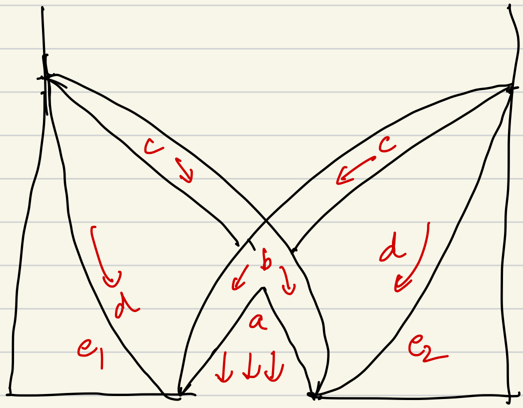
→ In contrast lq, $(P_v)_{lq} = H \rho_L g$

Example: Powder is stored in a silo 12 m height & 3 m dia, $\rho_s = 850\ kg/m^3$, friction coeff. with regard to silo wall is 0.45 (μ'). Calculate static vertical & horizontal pressure exerted at the base of silo. $\alpha_i' = 42^\circ$

Solution: $k' = 0.2$

$$\left.\begin{aligned} P_V &= 53\ kPa \\ P_L &= 10.6\ kPa \end{aligned}\right\}$$

Solid discharge from the central bottom of a storage bin :



- First portion (a) having shape of a cone/wedge flows out
- After that solids in the elliptic portion (b) above (a) falls out
- Finally (c) & (d) come into motion at the end
- e_1 & e_2 remain behind forming a conical 'dead zone'.