FRICTIONAL PROPERTIES OF BIOMATERIALS

LECTURE 09

PFE-2.4.5

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Application of frictional properties of biomaterials

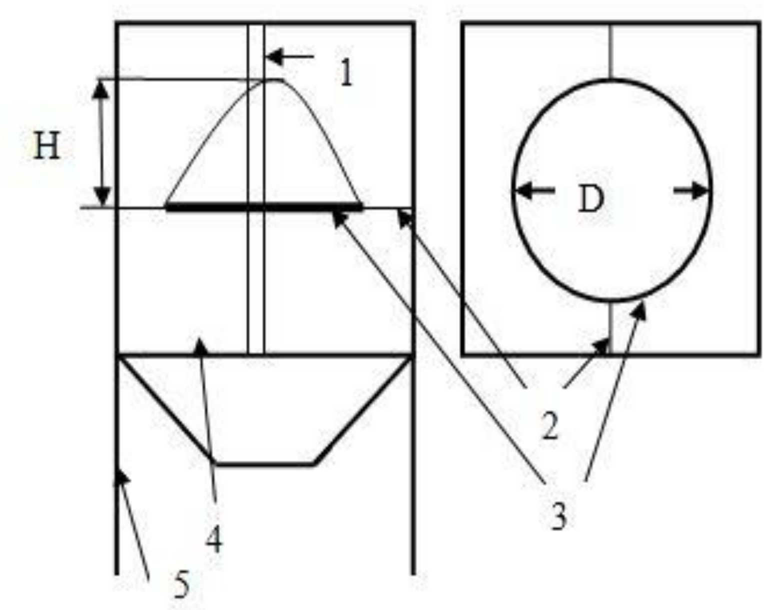
- The angle of repose and coefficient of friction are important in designing equipment for solid flow and storage structures, transports (load and unload) of goods and storage facilities
- The angle of internal friction between seed and wall in the prediction of seed pressure on walls.
- Designing storage bins, hoppers, chutes, screw conveyors, forage harvesters, and threshers.

Angle of Repose

the steepest angle at which a sloping surface formed of loose material is stable.

Angle of Repose

The angle of repose is measured with a square box, which is filled to the top and then removing lid, by allowing the granular material to fall freely, resulting in a conical shape of the sample.



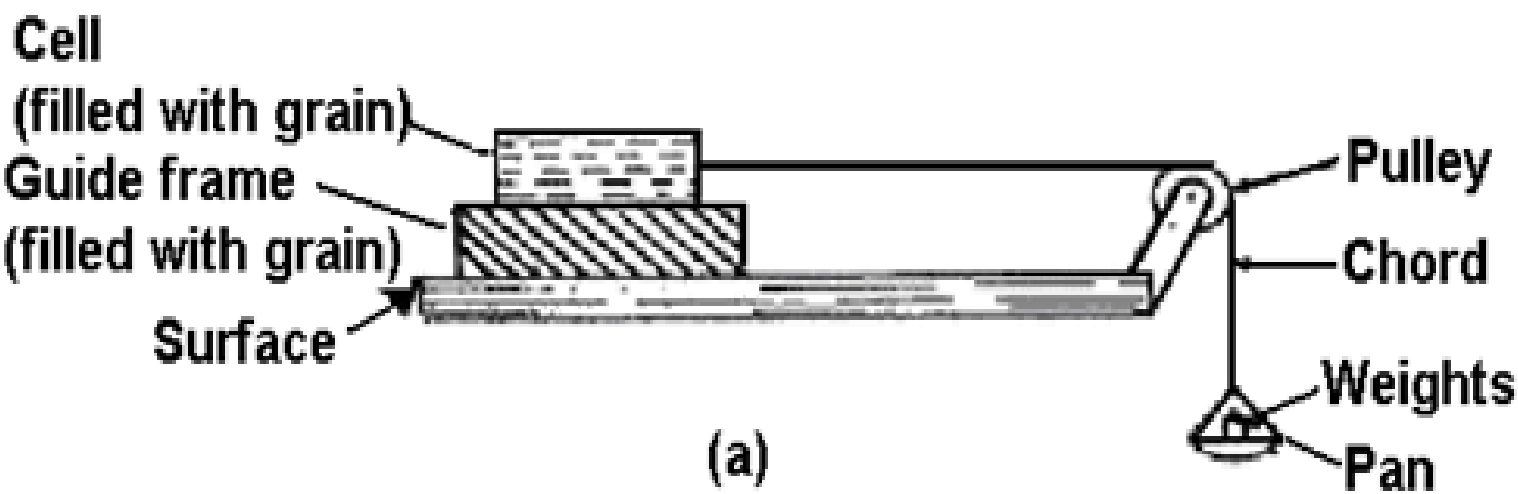
1. Scale
2. Base holder
3. Circular base
4. Transparent face
5. Stand

Types of angle of repose

- **Static angle of friction:** Angle of friction takes up by granular solid to about slide upon itself. Angle repose depends on **Size, shape, Moisture content** and **orientation of the particles**.
- **Dynamic angle of repose:** It arises when bulk of the material is in motion.

Coefficient and Angle of Internal Friction

- The coefficient of internal friction is the friction of seeds against seeds.



(a)

Coefficient and Angle of Internal Friction

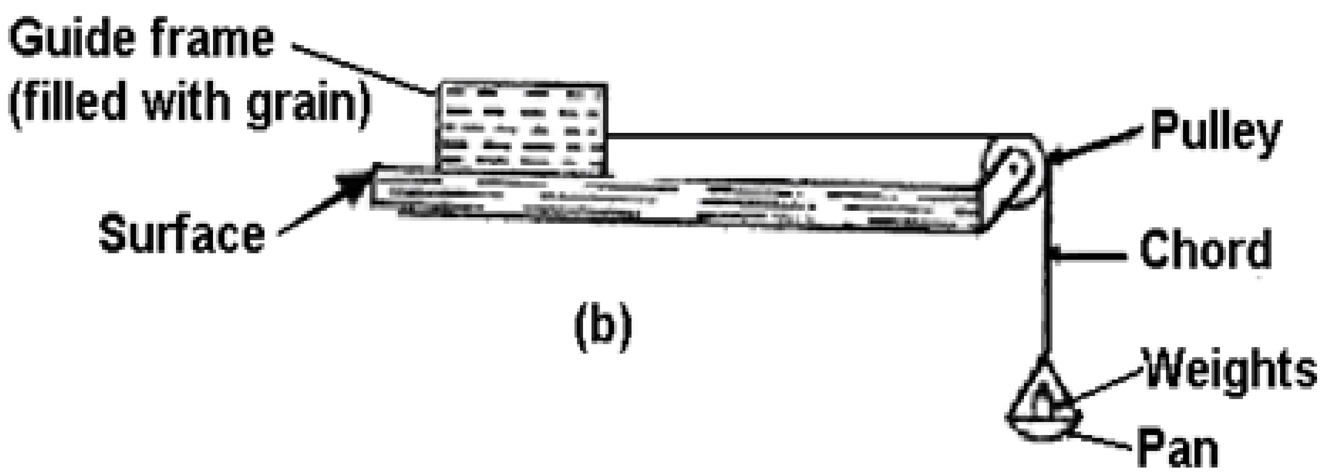
$$\mu = \frac{W_2 - W_1}{W} \qquad \theta_i = \tan^{-1} \mu_i$$

Where

- μ= coefficient of internal friction
- W_1 = weight to cause sliding of the cell when empty (g)
- W_2 = weight to cause sliding of the cell filled with sample material (g)
- W = weight due to the sample material in the cell = volume of cell (cm^3) x bulk density (g/cm^3)

Coefficient of friction on material surfaces

- The coefficient of friction is the friction of seeds against material surfaces.



(b)

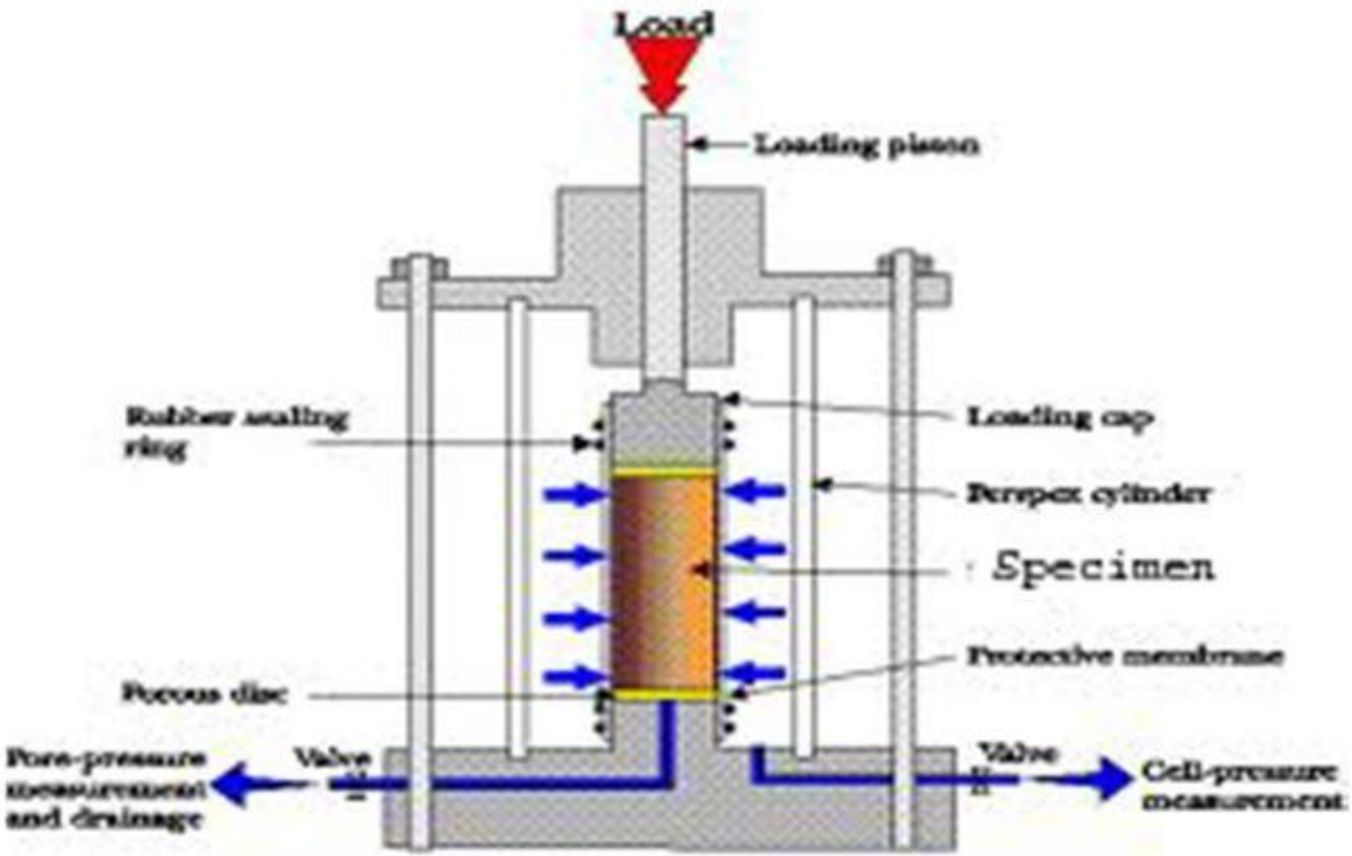
Coefficient of friction on material surfaces

$$\mu_e = \frac{W_2 - W_1}{W}$$

Where

- μ_e = coefficient of external friction
- W_1 = weight to cause sliding of the cell when empty (g)
- W_2 = weight to cause sliding of the cell filled with sample material (g)
- W = weight due to the sample material in the cell = volume of cell (cm^3) bulk density (g/cm^3)

Angle of internal friction for stored grains in bins and silos



Triaxial apparatus

Triaxial test

- In this apparatus, grain cylinder is enclosed in rubber membrane, σ_3 = builds up as vacuum was broken. Then triaxial test compression, gives σ_1 and σ_3 from the motions of the lateral and vertical pressure, angle of internal friction of grain is determined.

$$pressure\ ratio\ (K) = \frac{1-\sin\varphi}{1+\sin\varphi}$$

Triaxial test

$$K = \frac{\sigma_3}{\sigma_1}$$

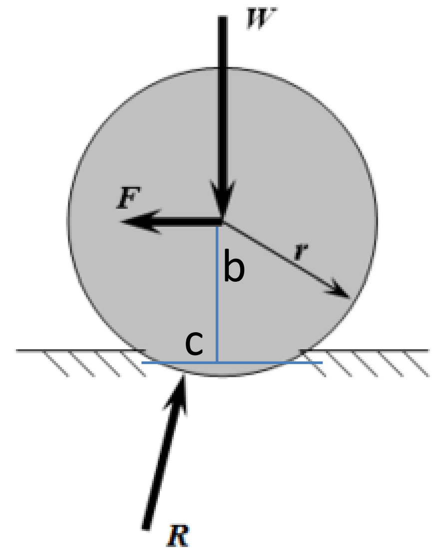
- σ_3 = Lateral pressure
- σ_{1} = vertical pressure
- $\sigma_3 = W\ h\ \tan^2(45 - \phi/2)$
- ϕ = angle of internal friction
- h = depth of grain, below the top of the wall
- W = weight density of grain

Rolling resistance

- Rolling resistance or maximum angle of stability in rolling agricultural material with rounded shape is considered.
- Rolling resistance is directly proportional to the weight of the rolling object, indirectly proportional to the effective radius of the rolling object and directly proportional to coefficient of rolling resistance which depends on the rigidity of the supporting surface.

Rolling resistance

- When a ball or a cylinder rolls over a horizontal surface with a force F, of the surface deforms, there will be a resultant force R.



- Moment at that point
- ∑Mb = F*b – W*c= 0
- For small deformation of the surface for r
- So that c= Fr/W or F = c W/r
- ‘c’ = coefficient of rolling resistance
- F = rolling resistance
- More rigid the surface smaller ‘c’ in rolling resistance.