SNS COLLEGE OF TECHNOLOGY
AN AUTONOMOUS INSTITUTION

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DEPARTMENT OF FOOD TECHNOLOGY

COURSE CODE & NAME: 23AGT207 & ENGINEERING PROPERTIES OF AGRICULTURE PRODUCE

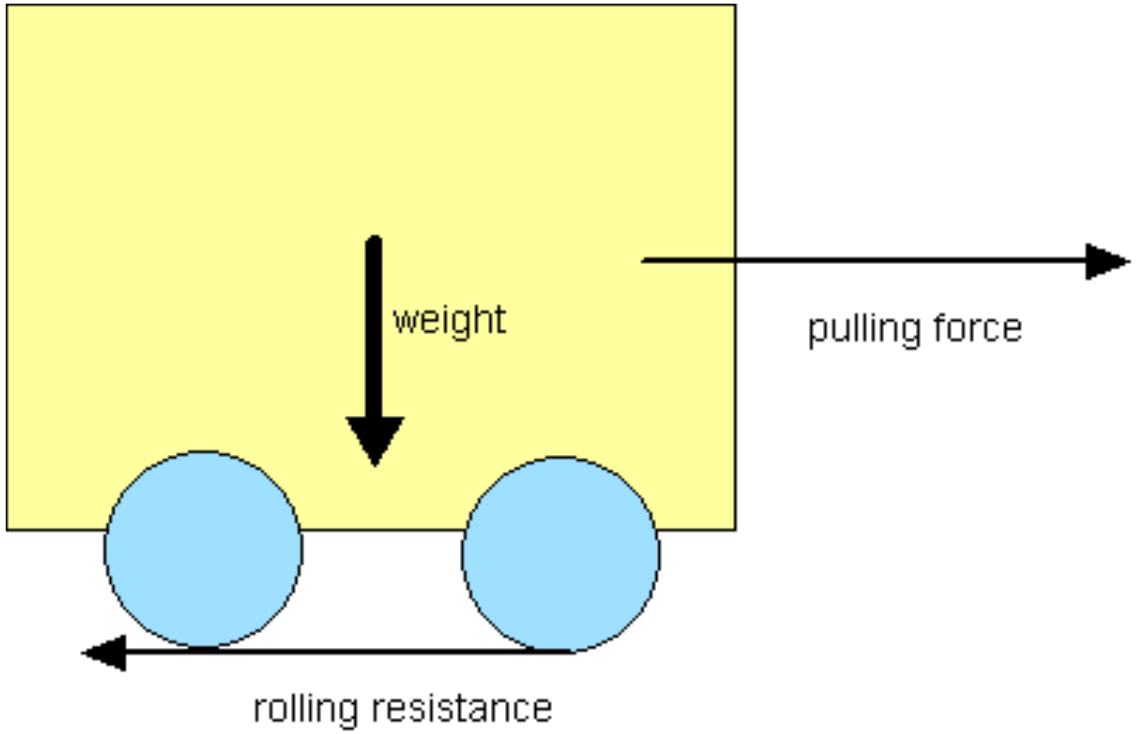
II YEAR / IV SEMESTER

UNIT : III THERMAL PROPERTIES

TOPIC 3 : Thermal Properties- Rolling Resistance and Angle of internal friction

Rolling Resistance

Rolling resistance is the force that resists the rolling of a wheel or other circular (rounded) object along a surface caused by deformations in the object and/or surface. Generally the force of rolling resistance is less than that associated with kinetic friction.



Rolling resistance/Maximum angle stability

In some material handling application, rolling resistance or maximum angle of stability in rolling agricultural material with rounded shape is considered. eg. Gravity conveying of fruits and vegetables. 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

$\Sigma Mb = F*b - W*c = 0$

For small deformation of the surface for r

So that $c = Fr/W$ or $F = c\ W/r$

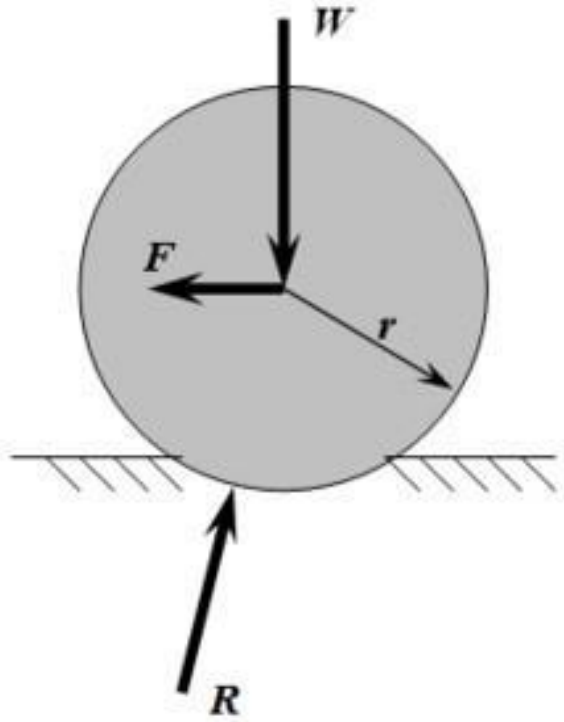
'c' = coefficient of rolling resistance

F = rolling resistance

R = radius of the rolling object

More rigid the surface smaller 'c' in rolling resistance.

W = m g = normal force or weight of body(N,) .



Rolling resistance is directly proportional to

- the weight of the rolling object,
- coefficient of rolling resistance which depends on the rigidity of the supporting surface

Rolling Resistance is indirectly proportional to the effective radius of the rolling object

Angle of internal friction (friction angle).

A measure of the ability of a unit of solid material to withstand a shear stress.

It is the angle (φ), measured between the normal force (N) and resultant force (R), that is attained when failure just occurs in response to a shearing stress (S).

Its tangent (S/N) is the coefficient of sliding friction. Its value is determined experimentally.

Angle of Internal Friction, can be determined in the laboratory by the Direct Shear Test or the Triaxial Stress Test.

Angle of internal Friction

The angle of internal friction is the angle at which a material's particles can no longer resist deformation or failure under shear stress. It's a measure of a material's strength

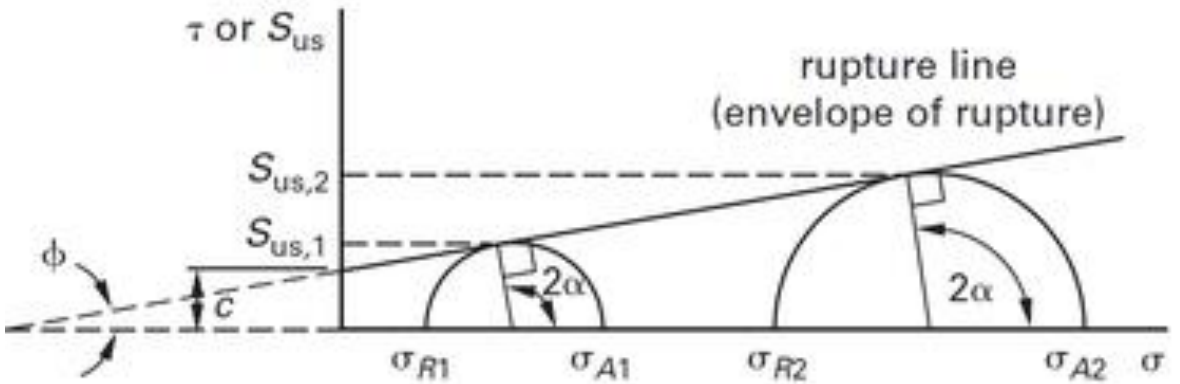
The angle between the normal force and the resultant force when a material fails under shear stress

It indicates

The maximum degree of deviation from horizontal that a solid can maintain before deforming or failing

The formula for the angle of internal friction (often denoted as ϕ), related to the coefficient of friction

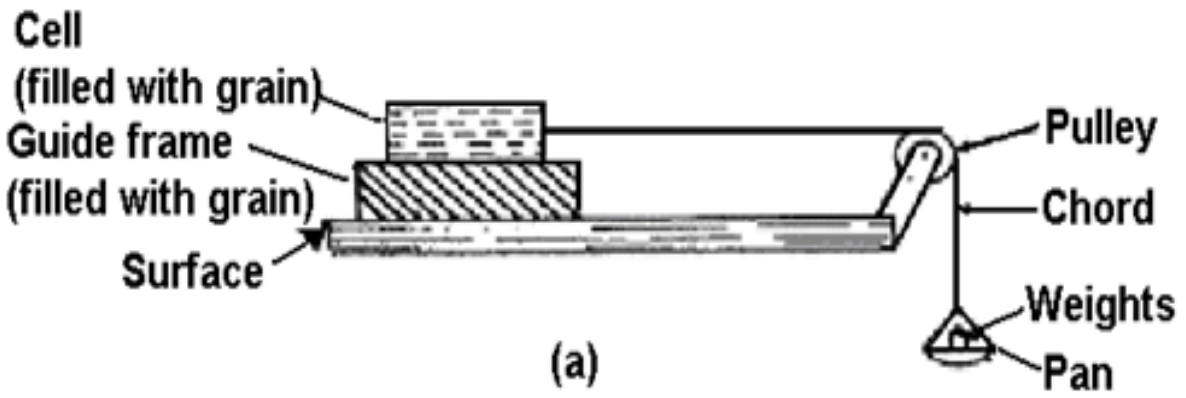
(μ), is $\phi = \tan^{-1}(\mu)$.

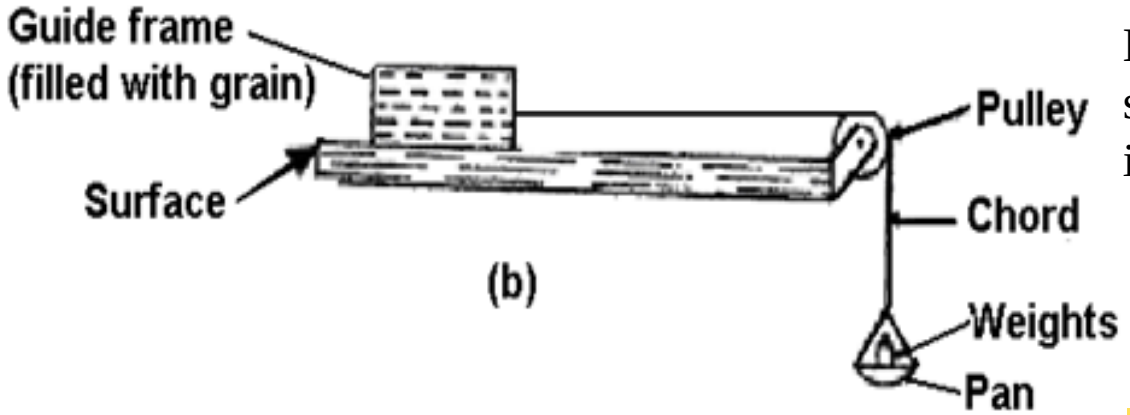


Example:

If the coefficient of friction (μ) is 0.5, then the angle of internal friction (ϕ) would be $\tan^{-1}(0.5) \approx 26.57$ degrees.

Measurement of (a) coefficient and angle of internal friction (b) coefficient of friction on material surfaces





A guide frame of size 20x15x5cm is placed under a cell of size 8.5x8.5x5 cm.
The guide frame and the cell are filled with the sample material.
The cell is tied with the cord passing over a pulley attached to the pan.

Then, weights (W2) are placed in the pan to cause the cell to just slide.

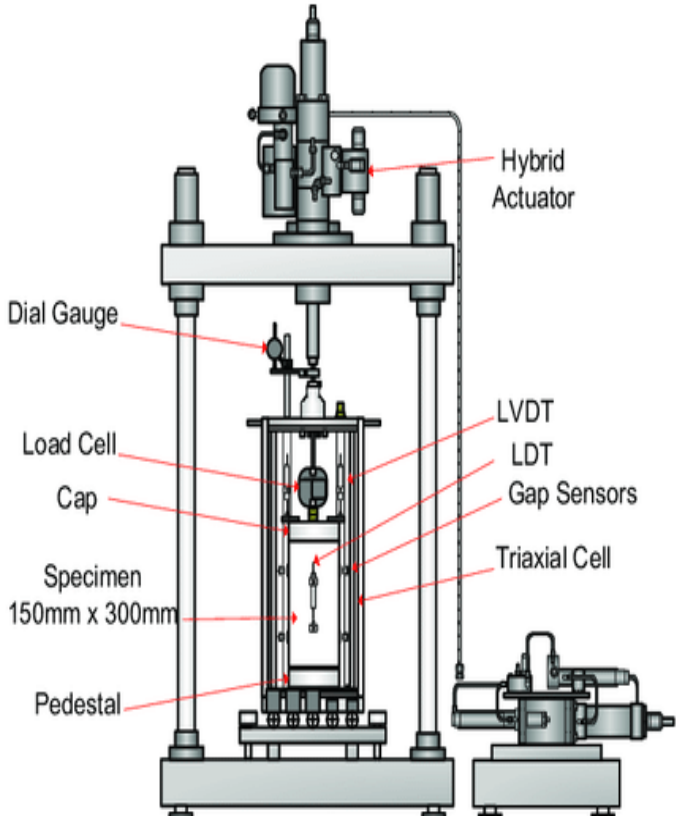
Next, the cell is emptied and weights (W1) to initiate sliding over the guide frame are noted. The coefficient of internal friction is calculated as follows:

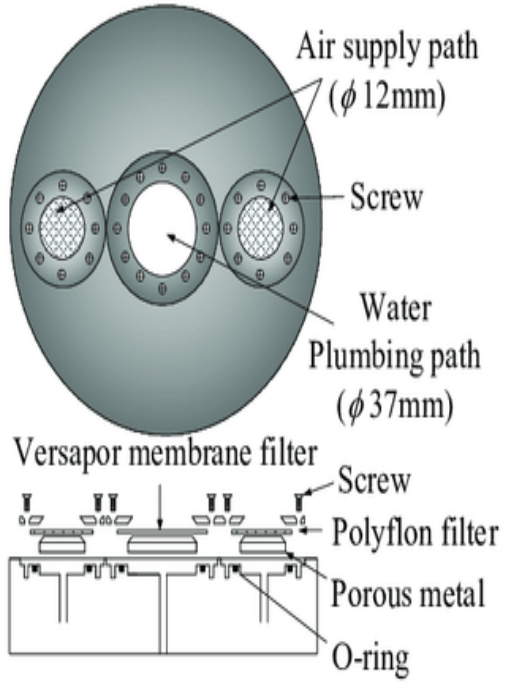
Angle of internal friction determination

Triaxial test: In this apparatus, grain cylinder is enclosed in rubber membrane,
σ3 =builds up as vaccum was broken.
Then triaxial test compression, gives σ1 and σ3 from the motions of the lateral and vertical pressure, angle of internal friction of grain is determined.

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

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





σ3 = Lateral Pr.
σ1 = vertical Pr.
σ3 = Wy tan2(45 – j/2); j= angle of internal friction; y = depth of grain, below the top of the wall; W = weight density of grain

Quick Recap

Activity:

Imagine rice or wheat grains that are procured from farmers need to be stored until next season. How do you apply the thermal properties on friction and rolling resistance to design a storage structure (Refer any case study either from India or International)

THANK YOU...