Tensile/Trapezoid Test Notes

Variables and units

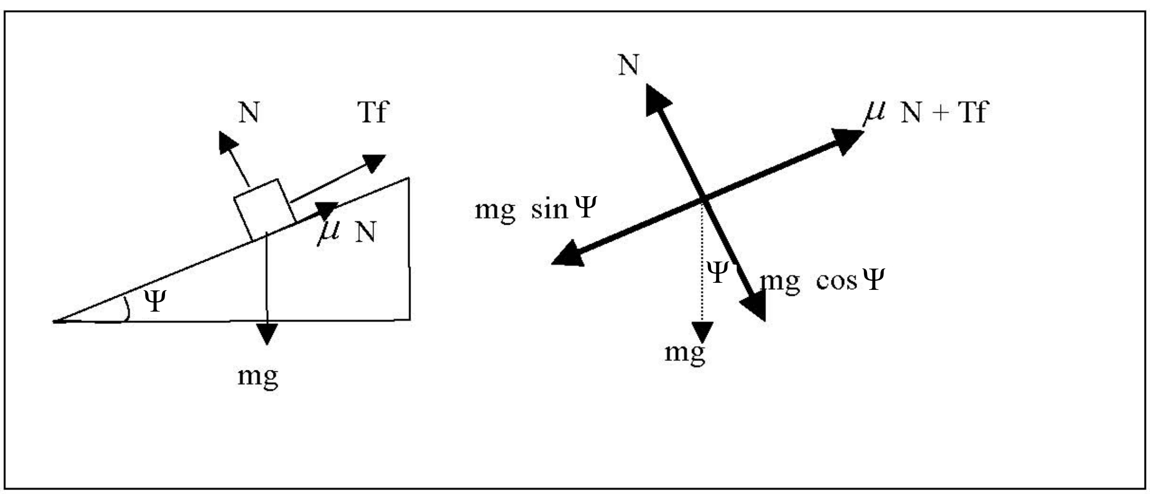
T_f = Tensile Force [N]
S_t = Tensile Stress [Pa]
T_S = Tensile Strength [Pa]

m = mass of the snow element (kg)
N = normal force (N)
g = acceleration due to gravity ($9.8 m/s^2$)
μ = coefficient of friction (0.1 for trapezoid tests, no units)
Ψ or θ = slope angle (degrees or radians)

ρ = *average* density of the snow element (kg/m^3)
V = volume of the snow element (m^3)
H = thickness of the trapezoid (m)
W_b = width of the trapezoid base/bottom (m)
W_f = width of the trapezoid fracture face/fracture plane (m)
L_t = length of the trapezoid from base to fracture plane (m)

b = width of slab (m)
h = height of slab (m)
L_S = length of slab on slope (m)
A = area of fracture plane (b*h, m^2)

Free Body Diagram



1. Balance forces in the free body diagram:

a) $N = mg\cos\psi$
b) $mg\sin\psi = \mu N + T_f$

2. Determine the tensile force (T_f) for the trapezoid test:

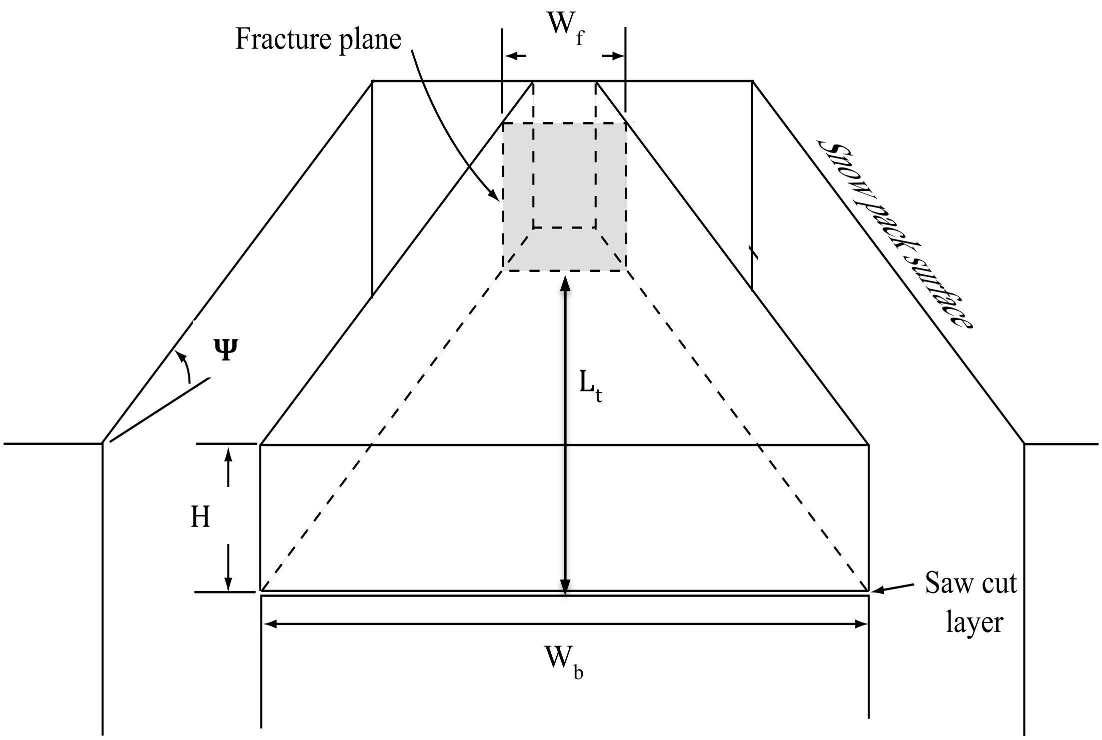
$$T_f = mg\sin\psi - \mu mg\cos\psi$$

a) $T_f = mg(\sin\psi - \mu\cos\psi)$

Since $m = \rho V$ (mass = volume*density)....

b) $$\boxed{T_f = \rho V g(\sin\psi - \mu\cos\psi)}$$

3. The tensile strength (T_S) is determined as follows, using the trapezoid test:



Start with equation 2b:

a) $T_f = \rho V g(\sin\psi - \mu\cos\psi)$

Substitute the volume of a trapezoid for V

$\left(V = \frac{1}{2} H L_t (W_f + W_b)\right)$

b) $T_f = \rho \frac{1}{2} H L_t (W_f + W_b) g(\sin\psi - \mu\cos\psi)$

Because $Pressure = \frac{Force}{Area}$, we divide T_f by the area of the fracture plane ($A = W_f H$) to get the tensile strength:

$$T_S = \frac{T_f}{A}$$

c) $T_S = \frac{\rho \frac{1}{2} H L_t (W_f + W_b) g (\sin\psi - \mu\cos\psi)}{W_f H}$

Simplify

$$\boxed{T_S = \frac{\rho g L_t (W_f + W_b)(sin\,\psi - \mu\,cos\,\psi)}{2W_f}}$$

4. The tensile stress (S_t) on a slope of length L_S is determined as follows:
While the trapezoid test allows us to determine the tensile strength of a layer, we can also apply the concept of tensile stress to a larger slab on a slope.
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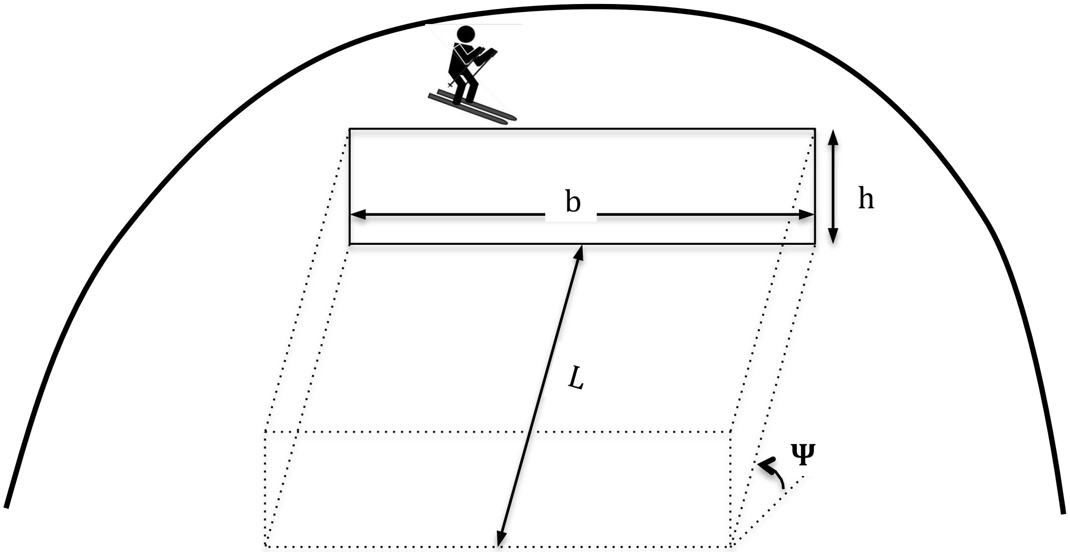

Like before, we start with $Pressure = \frac{Force}{Area}$, dividing T_f by the area of the fracture plane to get the tensile strength:

$$S_t = \frac{T_f}{A}$$

This time, however, the fracture plane is different than in the trapezoid test:

$$A = bh$$

And we no longer factor in friction to our equation for tensile force (T_f):

$T_f = \rho V g(\sin\psi - \mu\cos\psi)$ becomes $T_f = \rho V g \sin\psi$

So:

a) $S_t = \frac{T_f}{A} = \frac{\rho V g \sin\psi}{bh}$

Volume, in this scenario, is the volume of the slab :

$$V = bhL_S$$

b) $S_t = \frac{\rho bhL_S g \sin\psi}{bh}$

Simplify:

$$\boxed{S_t = \rho L_S g \sin\psi}$$