GEOMORPHOLOGY

LANDSLIDES IN UNCONSOLIDATED MATERIAL

LANDSLIDES OCCUR WHEN THE STRESS ON A HILLSLOPE EXCEEDS THE STRENGTH OF THAT SLOPE. LANDSLIDES OCCUR ON A FAILURE SURFACE AND **ALL STRENGTH ANALYSES ARE MADE IN REFERENCE TO THE FAILURE SURFACE.** GEOLOGICALLY, THE FAILURE SURFACE MAY CORRESPOND TO A CONTRAST IN GRAIN SIZE OR WEATHERING INTENSITY.

ONE OF THE MOST COMMON MODELS USED TO ANALYZE THE STABILITY OF HILLSLOPES IS THE INFINITE SLAB APPROXIMATION. IT IS A FORCE BALANCE MODEL APPROPRIATE FOR **TRANSLATIONAL SLIDES SLIPPING ON A PLANAR FAILURE SURFACE**.

JUST AS WE DISCUSSED FOR DEBRIS FLOWS, THE SHEARING STRESS OR DRIVING FORCE ON A HILLSLOPE CAN BE CALCULATED. IT IS EXPRESSED IN PASCALS **($kg\ m^{-1}\ s^{-2}$).**

$\tau = \rho_{slab} g h \sin\alpha$ THE SHEARING STRESS, **THE DRIVING FORCE**!

h IS THE THICKNESS OF THE SLAB MEASURED PERPENDICULAR TO THE SURFACE, **meters**

ρ_{slab} IS THE DENSITY OF THE SLAB MATERIAL, **$kg\ m^{-3}$**

α IS THE SLOPE ANGLE OF THE FAILURE SURFACE

g IS THE ACCELERATION OF GRAVITY, **$9.8\ m\ s^{-2}$**

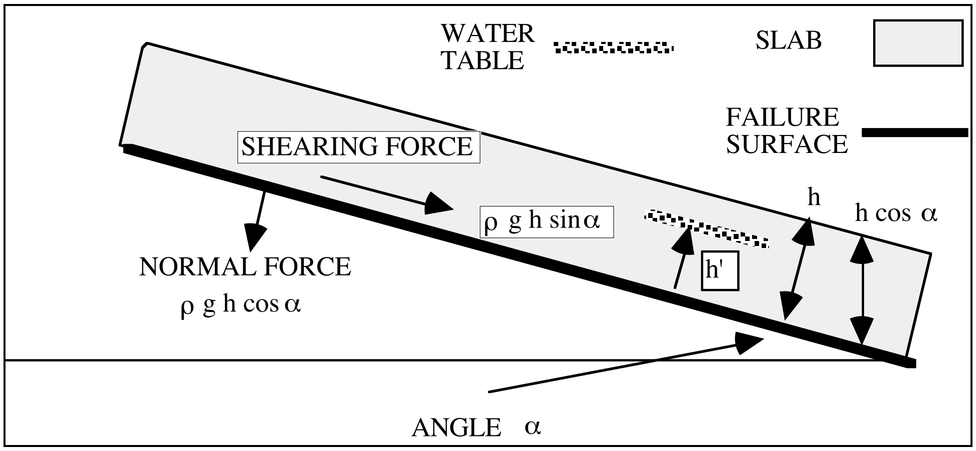
THE STRENGTH (*s*) OF SOIL CAN BE MODELED USING THE COULOMB EQUATION. THE EQUATION HAS SEVERAL TERMS.

$s = c + \sigma \tan\phi$ THIS IS THE RESISTING FORCE, **THE SHEAR STRENGTH!**

"***c***" COHESION IS THE TENDENCY OF A MATERIAL TO "STICK" TO ITSELF. CLAYS ARE COHESIVE AS ARE ROCKS OR SOILS WHICH HAVE UNDERGONE SOME CEMENTATION. COHESION IS EXPRESSED IN PASCALS (**$kg\ m^{-1}\ s^{-2}$**). CLAYS HAVE COHESIONS RANGING FROM 10000 TO 150000 PASCALS. TILLS HAVE COHESIONS ABOVE 150000 PASCALS.

ϕ OR THE ANGLE OF INTERNAL FRICTION IS A PROPERTY OF THE MATERIAL AND RANGES FROM OVER 50° FOR COARSE GRAVEL TO LESS THAN 30° FOR FINE SAND.

σ IS THE NORMAL STRESS EXCERTED ON THE FAILURE SURFACE BY THE MATERIAL ABOVE IT. THE STEEPER THE SLOPE, THE LESS THE NORMAL FORCE WILL BE. IN DRY MATERIALS, THE NORMAL FORCE CAN BE CALCULATED USING THE COSINE OF THE SLOPE AND THE WEIGHT OF MATERIAL. THE NORMAL STRESS CAN BE EXPRESSED IN PASCALS (**$kg\ m^{-1}\ s^{-2}$**)..



IF THE MATERIAL IN THE SLIDE IS SATURATED WITH WATER, THE NORMAL FORCE WILL BE REDUCED. THINK ABOUT THIS IN TERMS OF BUOYANCY AS THE GRAINS "FLOAT" IN GROUNDWATER. THE COULOMB EQUATION THEN BECOMES

$$s = c + (\sigma - u)\tan\phi$$

u IS THE PRESSURE OF THE WATER AT THE FAILURE PLAIN WHICH CAN BE EXPRESSED IN PASCALS (**kg m^{-1} s^{-2}**) USING THE EQUATION BELOW. **h'** IS THE ELEVATION OF THE WATER TABLE ABOVE THE FAILURE SURFACE (**meters**).

$$u = \rho_{water} g h'$$

IF THE RESISTING FORCE IS GREATER THAN THE DRIVING FORCE THE HILLSLOPE WILL BE STABLE....BUT IF THE DRIVING FORCE IS GREATER, THE HILLSLOPE WILL FAIL. ENGINEERS AND GEOLOGIST EXPRESS THIS RELATIONSHIP USING A TERM CALLED THE FACTOR OF SAFETY (**F**). HILLSLOPES ARE STABLE IF F>1; THEY FAIL IF F<1.

$$\mathrm{F} = \frac{\mathrm{RESISTING}}{\mathrm{DRIVING}} = \frac{c + (\sigma - u)\tan\phi}{\rho_{slab} g h \sin\alpha}$$

substituting from the diagram above …….

$$F = \frac{c + (\rho_{slab} g h \cos\alpha - u)\tan\phi}{\rho_{slab} g h \sin\alpha}$$

substituting for *u*

$$F = \frac{c + (\rho_{slab} g h \cos\alpha - \rho_{water} g h')\tan\phi}{\rho_{slab} g h \sin\alpha}$$

WHEN DOING THESE TYPES OF CALCULATIONS IT IS VERY IMPORTANT TO KEEP TRACK OF YOUR UNITS! WORKING IN METERS IS AN EASY WAY TO GO, JUST MAKE SURE THAT COHESIONS ARE IN PASCALS. FOR A RIGOROUS TREATMENT OF THE PROBLEM YOU MUST CONSIDER NOT ONLY THE DRY BUT ALSO THE SATURATED DENSITY OF THE SLAB.