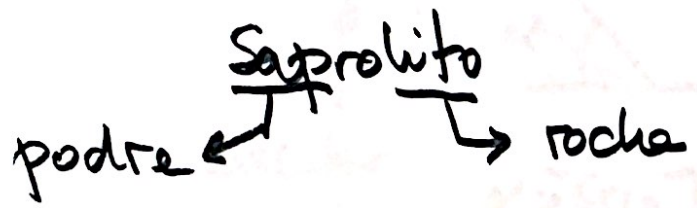
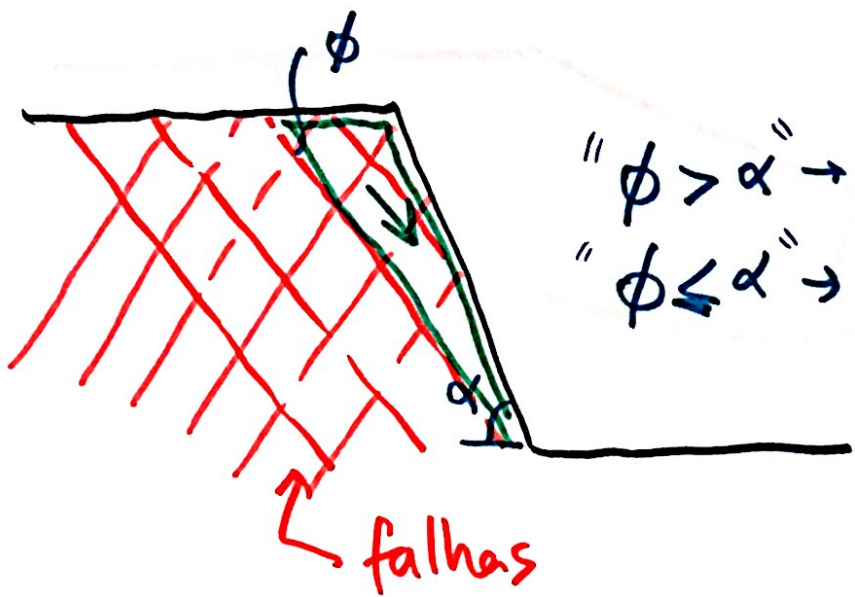


ESTABILIDADE DE TALUDES

SOLOS - Residuais, → também podem ter planos de descontinuidade



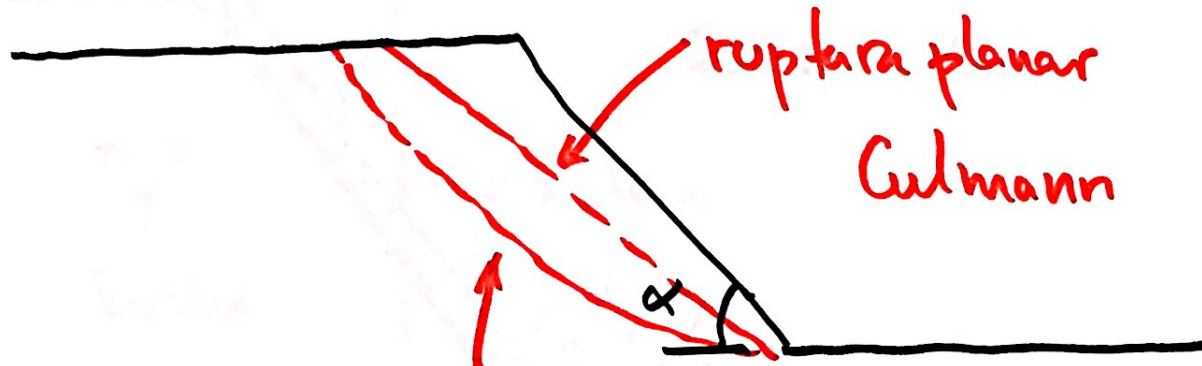
ROCHAS → planos de descontinuidade → falhas
 fraturas
 xistossidade



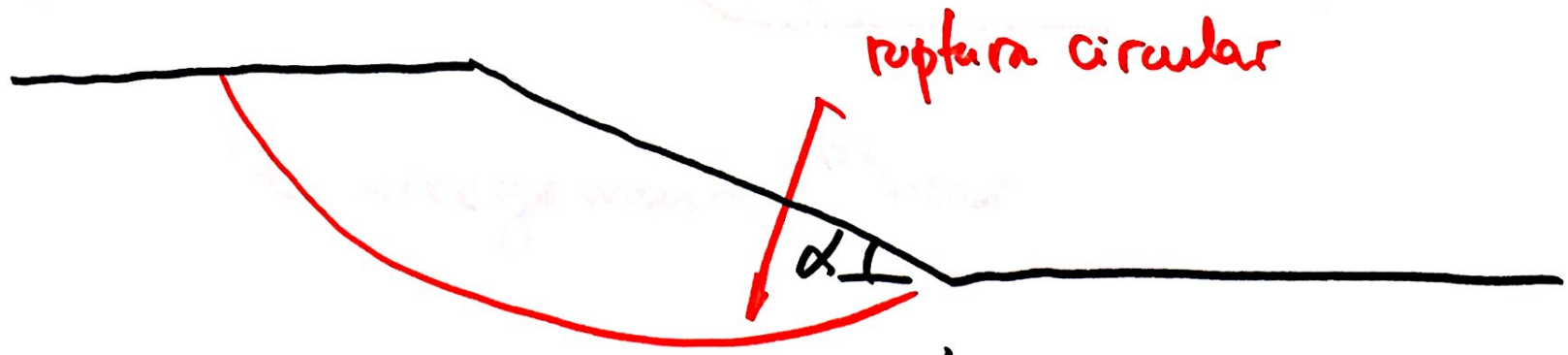
" $\phi > \alpha$ " → estável
 " $\phi \leq \alpha$ " → instável

ruptura em cunha

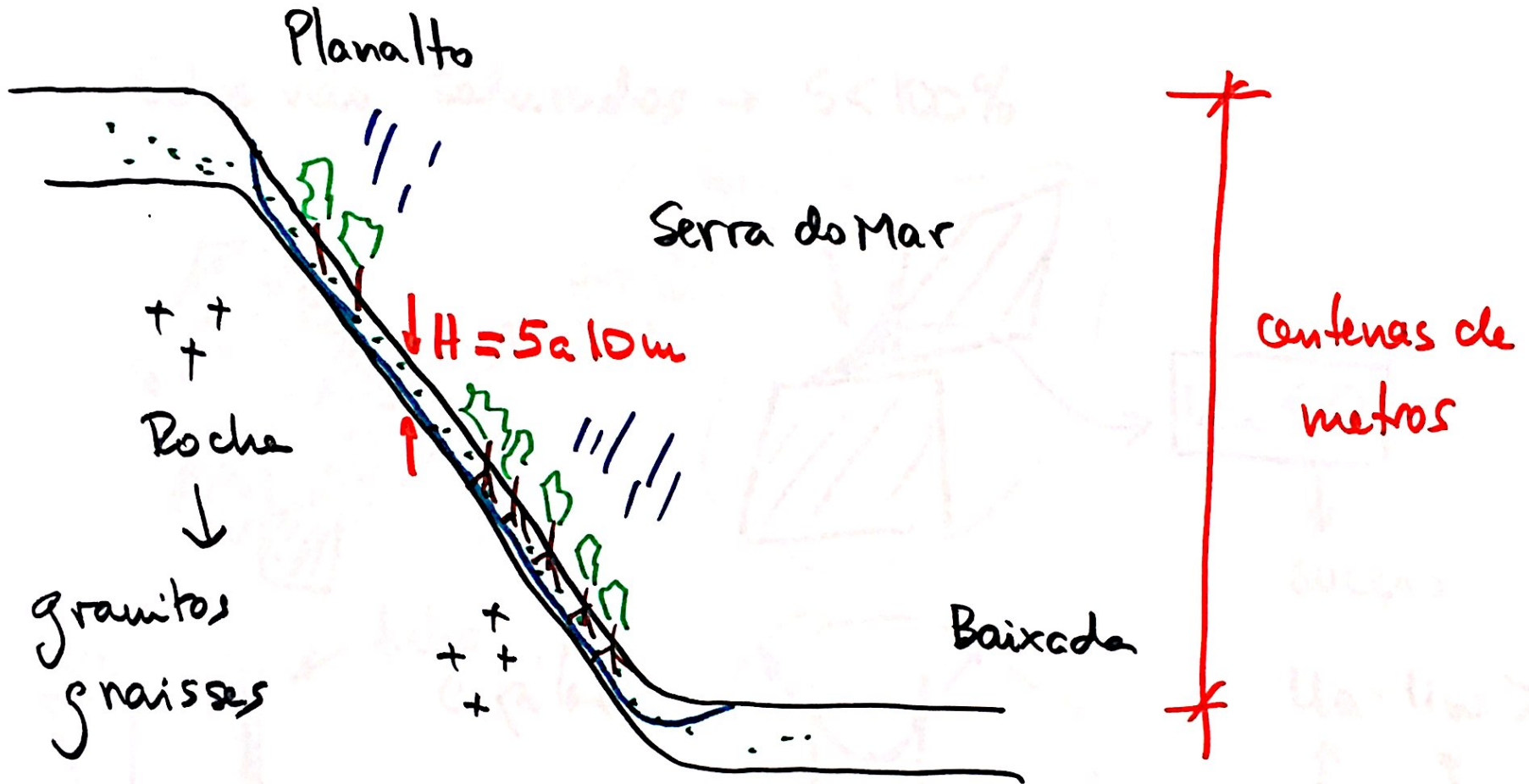
SOLOS - Homogêneos



$\alpha \gtrsim 60 \text{ a } 70^\circ$ - taludes íngremes

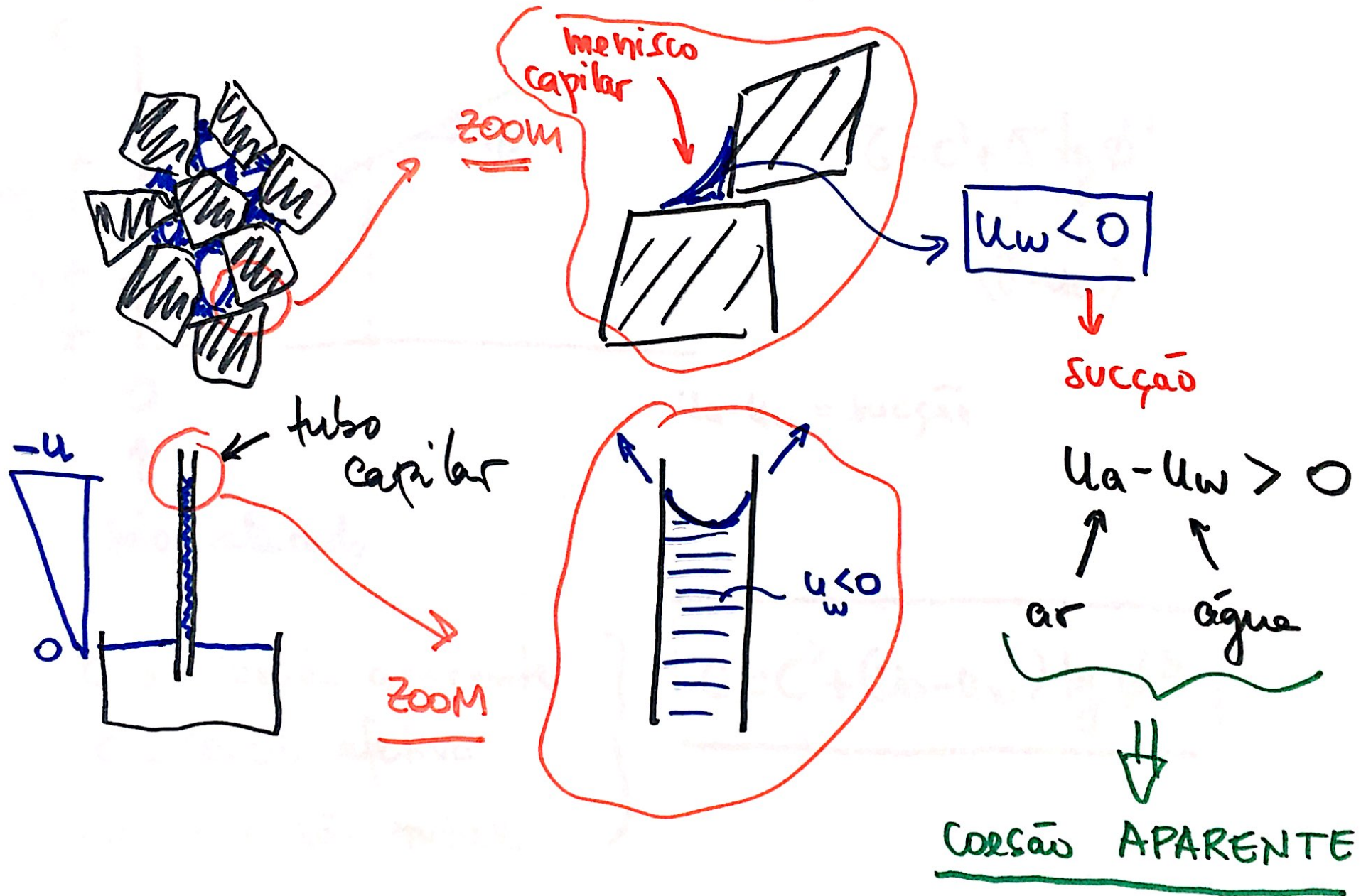


$\alpha \lesssim 60 \text{ a } 70^\circ$



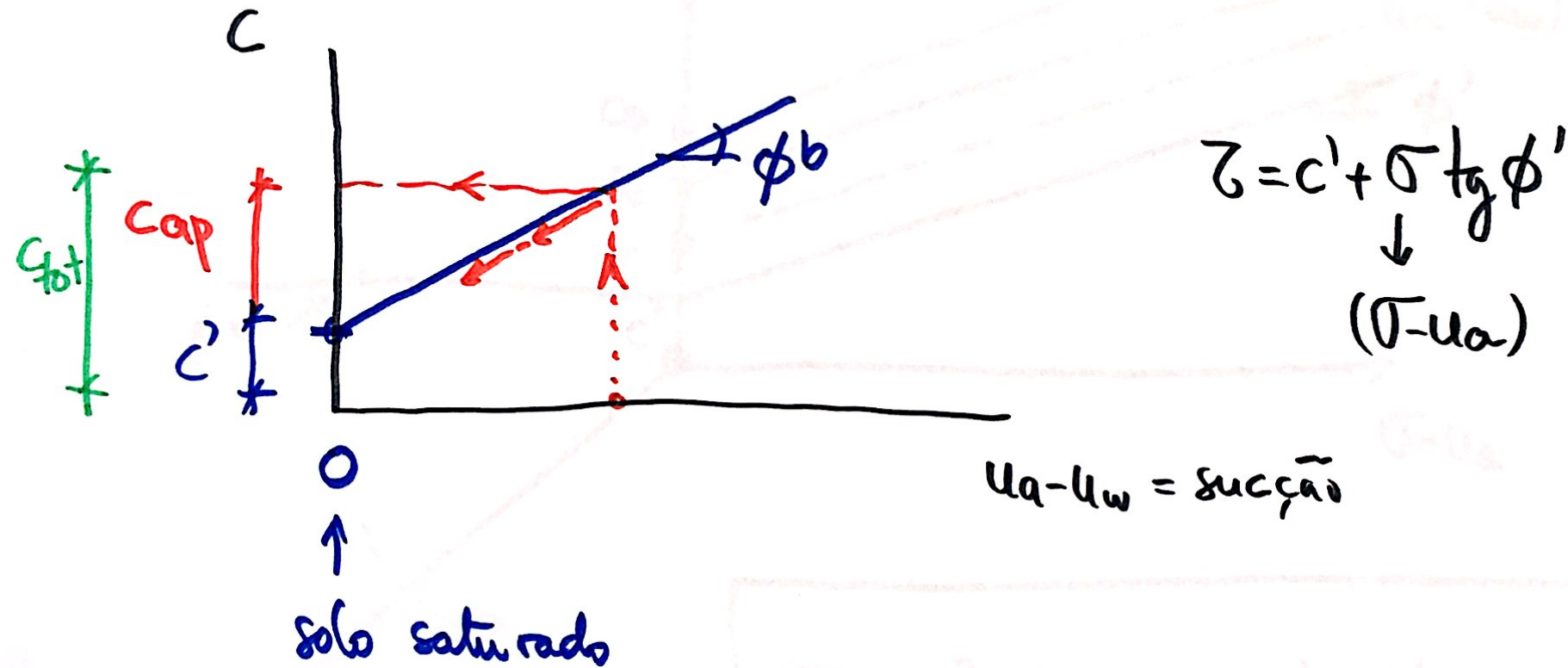
Escorregamento Planar

Solos não saturados $\rightarrow S < 100\%$



Ensaio Triaxiais com Sucção Controlada

5



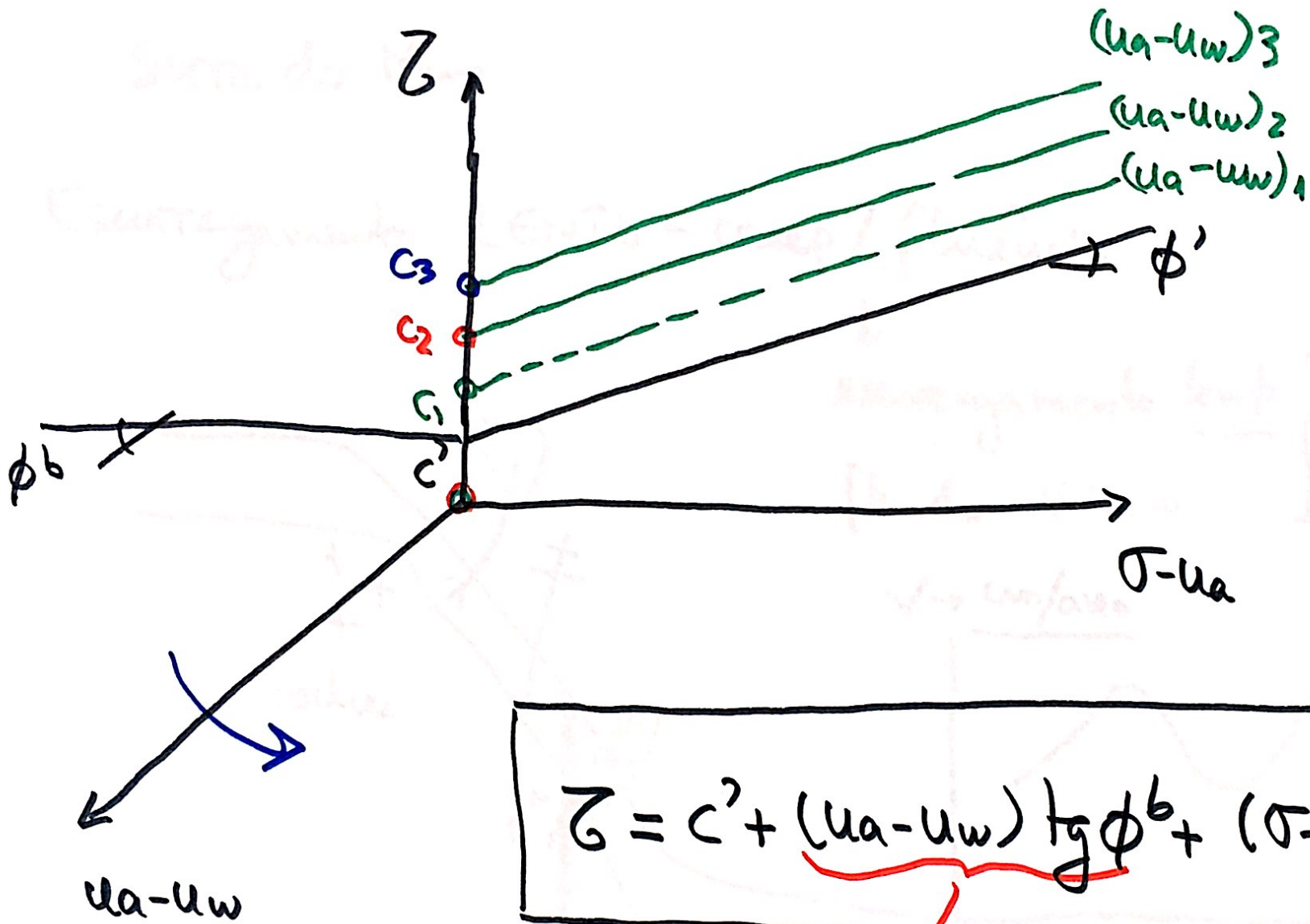
C_{ap} = coesão aparente

c' = coesão efetiva

C_{tot} = coesão total

$$C = c' + (u_a - u_w) \operatorname{tg} \phi_b$$

6



$$\tau = c' + \underbrace{(u_a - u_w)}_{c_{ap}} \tan \phi^b + (\sigma - u_a) \tan \phi'$$

$$\tau = c' + c_{ap} + (\sigma - u_a) \tan \phi'$$

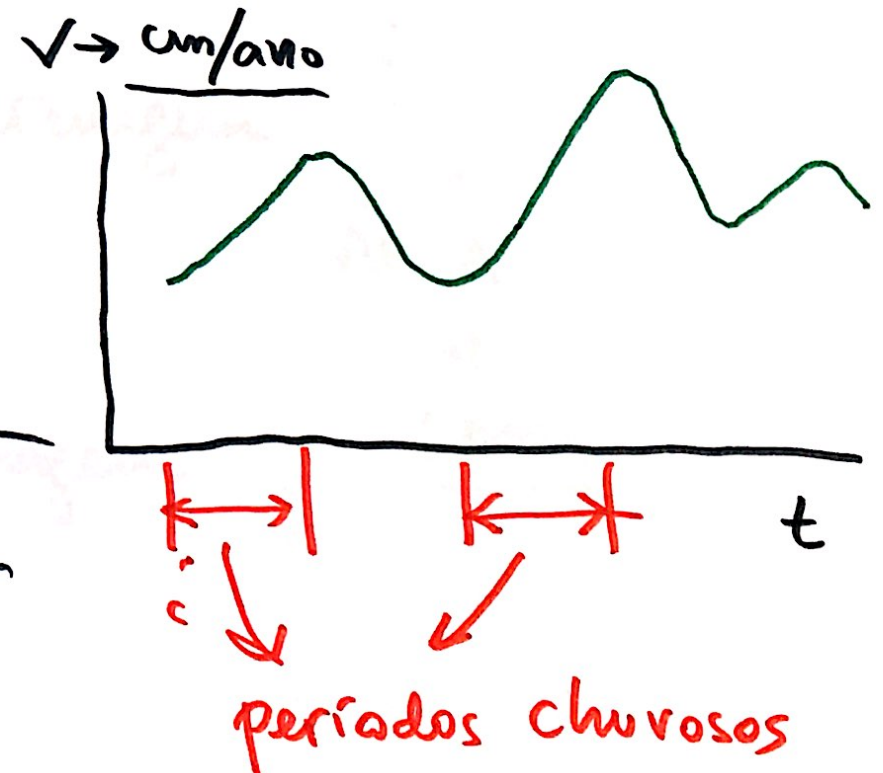
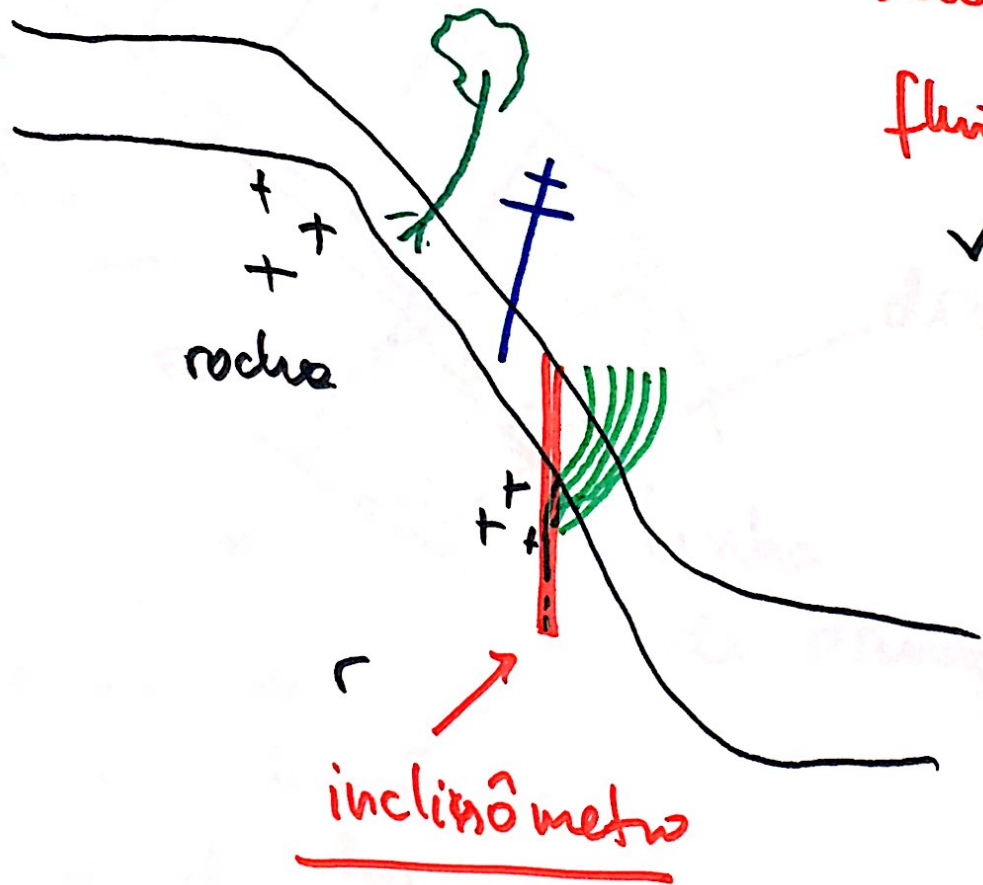
$$\tau = c + (\sigma - u_a) \tan \phi'$$

Serra do Mar

7

Escorregamento LENTO - creep / fluência

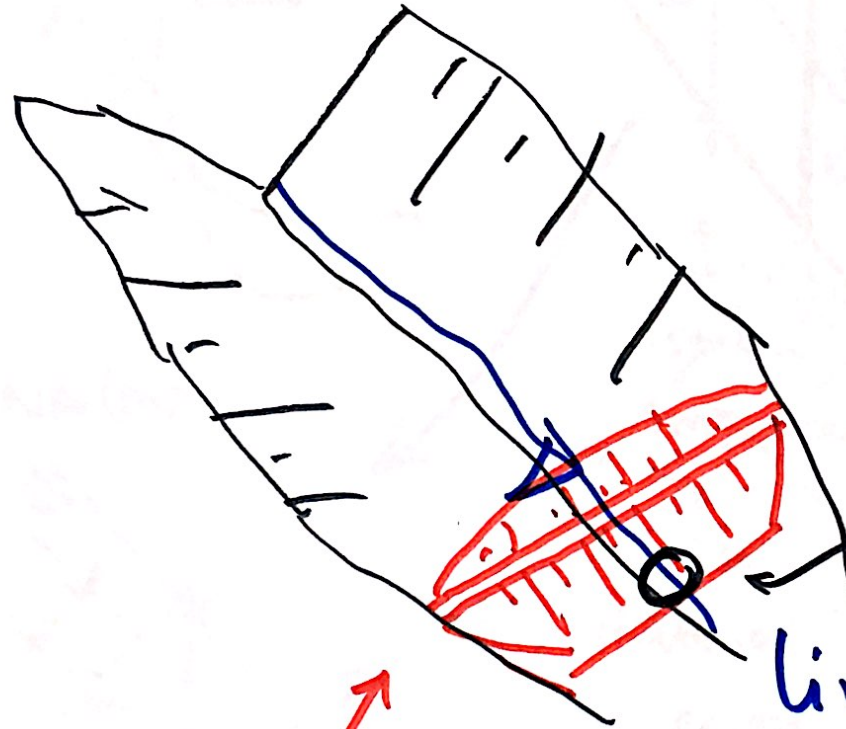
↓
escorregamento lento } f(chuvas)
fluido viscoso



Serra do Mar - "Debris" Flow

Detritos

$v = \text{km/h} \rightarrow$



arraste de - solo
 blocos de rocha
 troncos de árvore

⋮

+
ÁGUA

||
LAMA

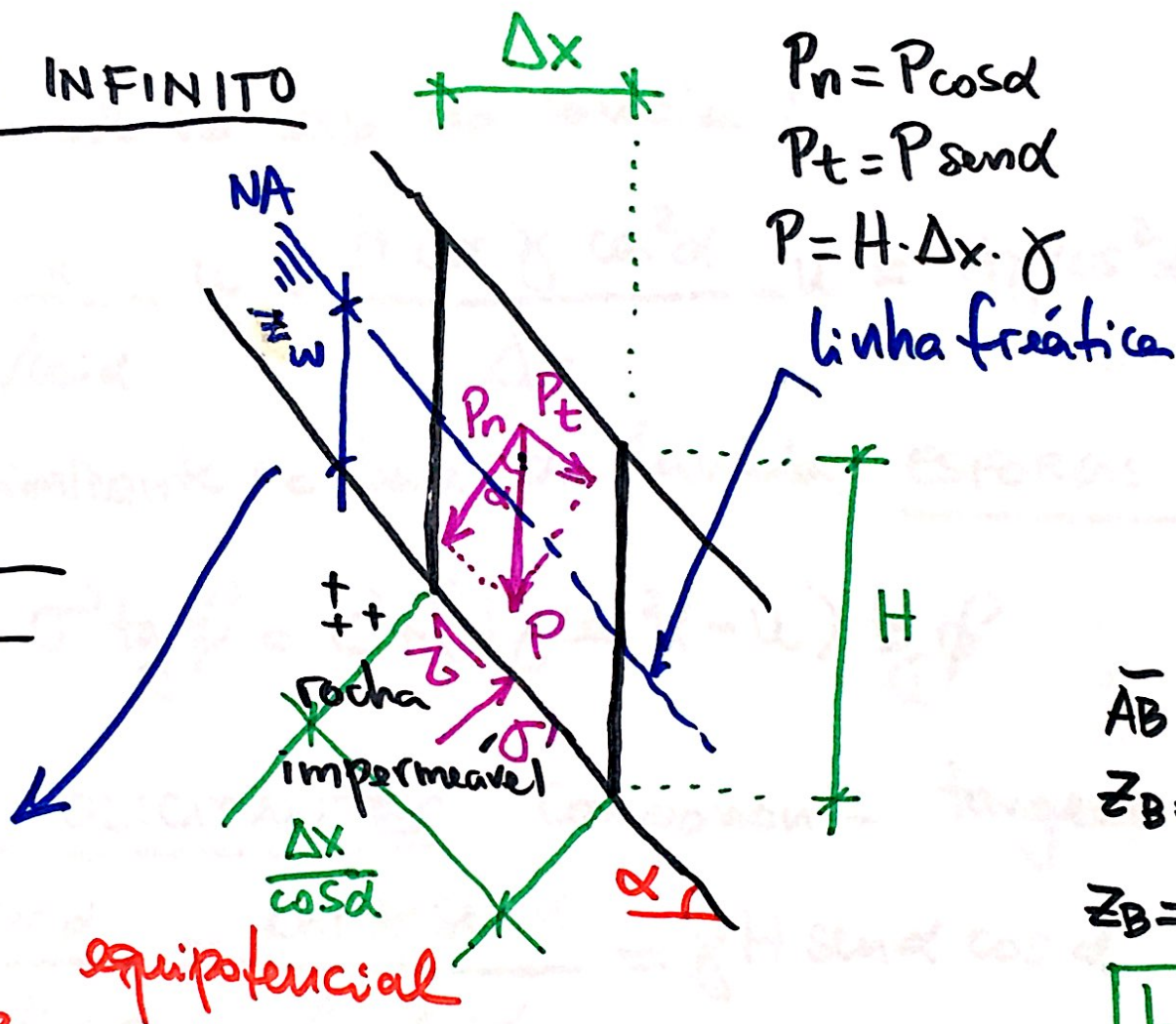
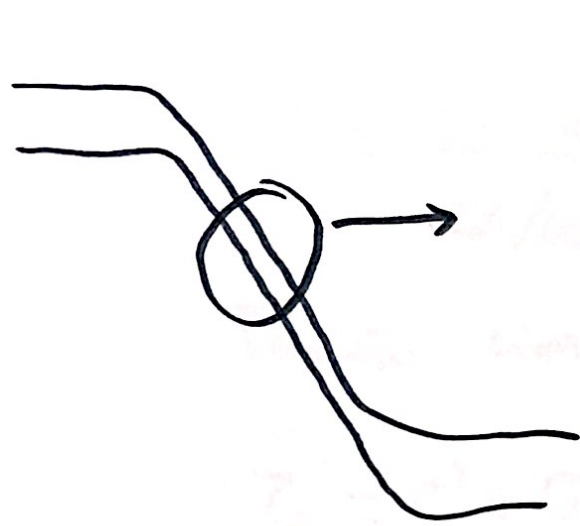
drenagem

linha
de drenagem

↗
 barramentos
 para contenção
 de detritos

TALUDE INFINITO

9



$$P_n = P \cos \alpha$$

$$P_t = P \sin \alpha$$

$$P = H \cdot \Delta x \cdot \gamma$$

linha freática

$$\bar{AB} = z_w \cos \alpha$$

$$z_B = \bar{AB} \cos \alpha$$

$$z_B = z_w \cos^2 \alpha$$

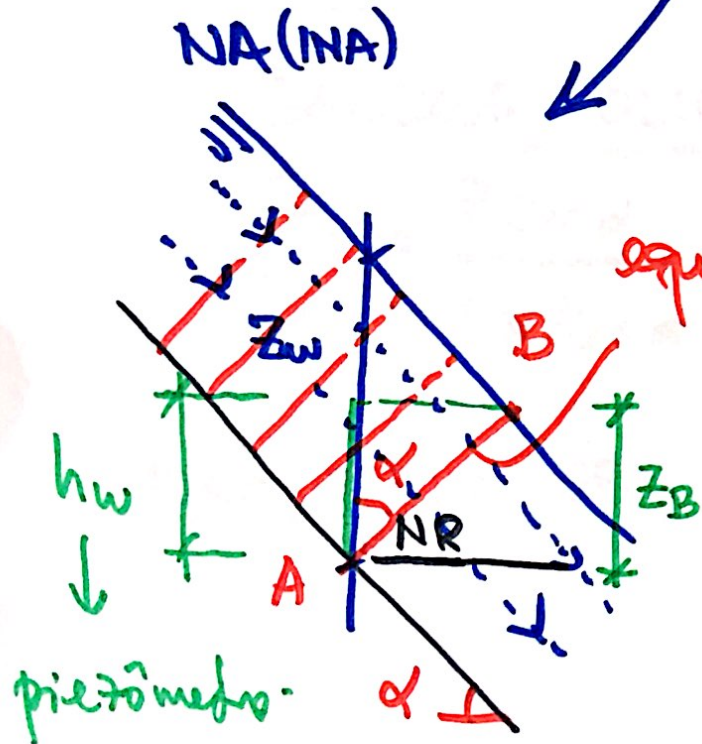
$$h_w = z_w \cos^2 \alpha$$

$$u = \gamma_w \cdot z_w \cos^2 \alpha$$

equipotencial

carga piezométrica em A

$$\left. \begin{aligned} H_A &= z_A + \frac{u_A}{\gamma_w} \Rightarrow z_A = 0 & H_A &= \frac{u_A}{\gamma_w} \\ H_B &= z_B + \frac{u_B}{\gamma_w} \Rightarrow z_B = H_B & u_B &= 0 \end{aligned} \right\} \frac{u_A}{\gamma_w} = z_B$$



piezômetro

Tensão normal na base da lamela:

(10)

$$\sigma' = \frac{P \cos \alpha - u}{\Delta x / \cos \alpha} = \frac{H \cdot \Delta x \cdot \gamma \cdot \cos^2 \alpha - u}{\Delta x} = H \gamma \cos^2 \alpha - u$$

Tensão cisalhante na base da lamela: ESFORÇOS RESISTENTES

$$\tau_R = c' + \sigma' \operatorname{tg} \phi' = c' + (H \gamma \cos^2 \alpha - u) \operatorname{tg} \phi'$$

ESFORÇOS SOLICITANTES: Componente tangencial do Peso

$$\tau_i = \frac{P \sin \alpha}{\Delta x / \cos \alpha} = \frac{\Delta x H \gamma \sin \alpha}{\Delta x / \cos \alpha} = \gamma H \sin \alpha \cos \alpha \quad + \sigma_T$$

$$\text{FATOR DE SEGURANÇA: } FS = \frac{\tau_R}{\tau_i} = \frac{c' + (\gamma H \cos^2 \alpha - u) \operatorname{tg} \phi'}{\gamma H \sin \alpha \cos \alpha}$$

$$FS = \frac{c' + (\gamma H \cos^2 \alpha - \gamma_w \cdot z_w \cdot \cos^2 \alpha) \operatorname{tg} \phi'}{\gamma H \operatorname{sen} \alpha \cos \alpha}$$

$$FS = \frac{c'}{\gamma H \operatorname{sen} \alpha \cos \alpha} + \frac{\gamma H \cos^2 \alpha (\gamma H - \gamma_w z_w) \operatorname{tg} \phi'}{\gamma H \operatorname{sen} \alpha \cos \alpha}$$

$$FS = \frac{c'}{\gamma H} \operatorname{sec} \alpha \operatorname{cosec} \alpha + \left(1 - \frac{\gamma_w z_w}{\gamma H} \right) \frac{\operatorname{tg} \phi'}{\operatorname{tg} \alpha}$$

FS min qdo $z = H \Rightarrow$ ruptura ocorre na base da camada de solo

Casos particulares

a) talude seco e sem coesão $FS = \frac{tg\phi'}{tg\alpha}$

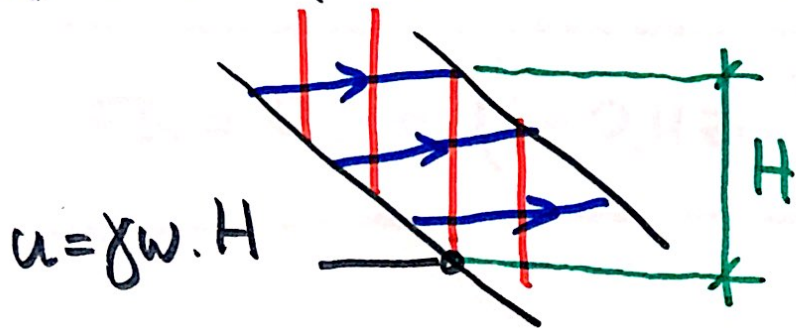
b) $c=0$ fluxo // ao talude
 Solo saturado $\Rightarrow z_w = H$ } $FS = \left(1 - \frac{\gamma_w}{\gamma}\right) \frac{tg\phi'}{tg\alpha}$

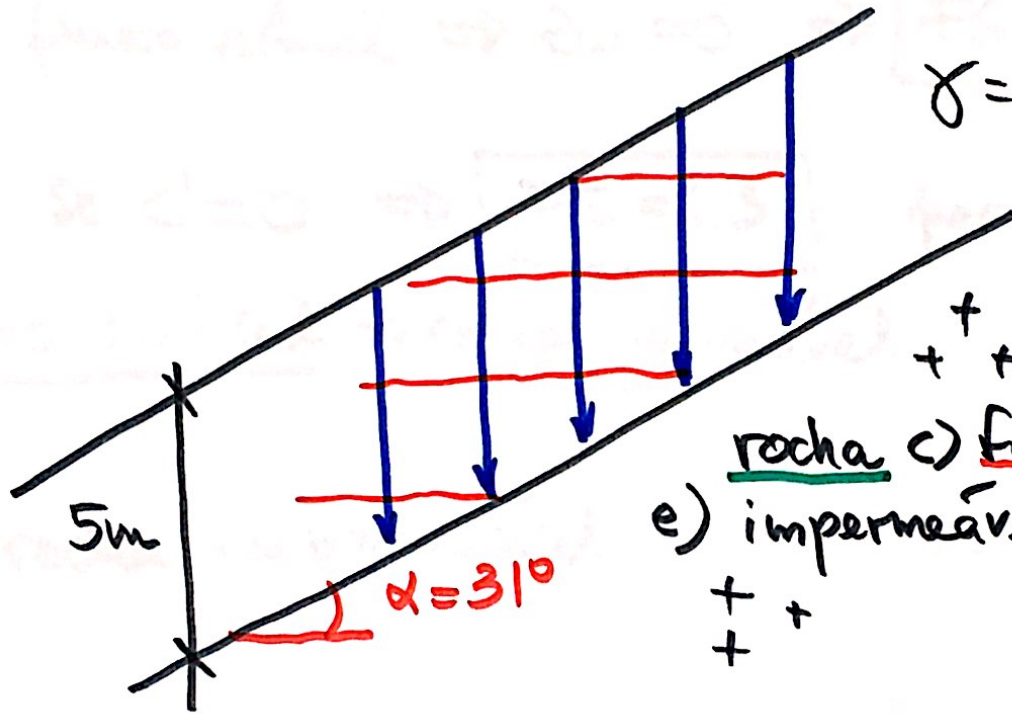
$\gamma_w = 10 \text{ kN/m}^3$
 $\gamma \approx 20 \text{ kN/m}^3$

$FS = 0,5 \frac{tg\phi'}{tg\alpha}$

c) $c=0$ fluxo vertical $\Rightarrow u=0$ $FS = \frac{tg\phi'}{tg\alpha}$

d) $c=0$ fluxo horizontal $FS = \frac{tg\phi'}{tg 2\alpha}$





$\gamma = 18 \text{ kN/m}^3$

$c = 20 + \sigma' \text{tg } 38^\circ$

solo suprolítico

rocha c) fratura - permeável

e) impermeável

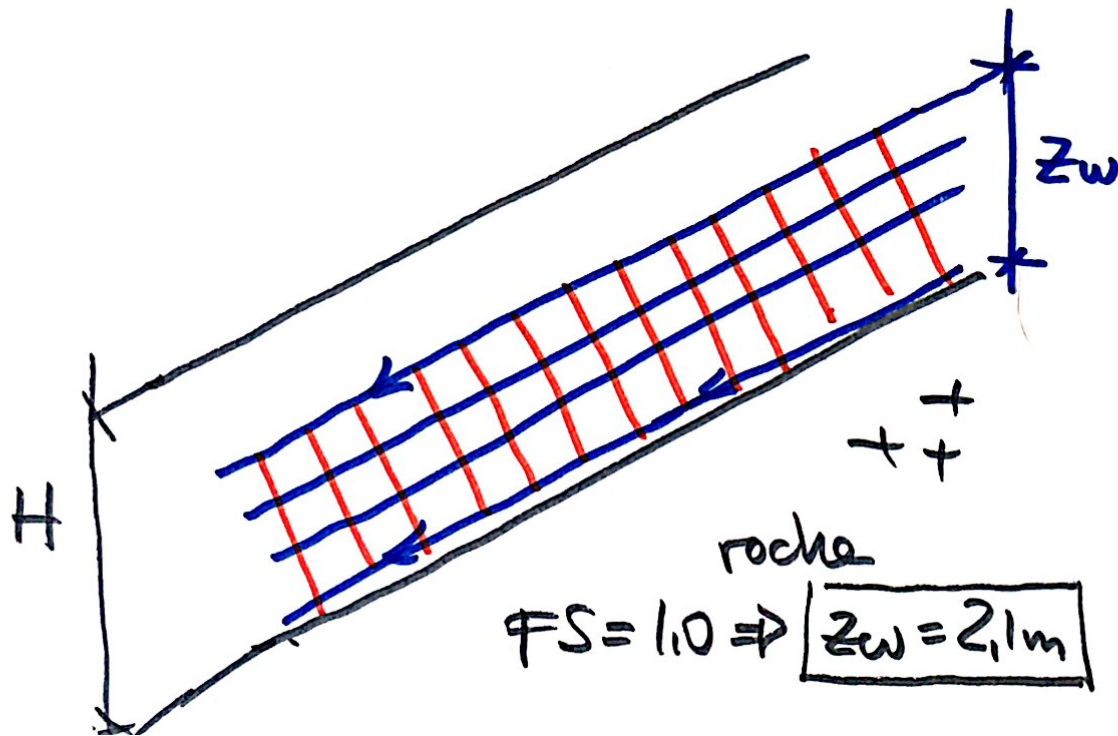
$$FS = \frac{20}{18 \times 5} \sec 31^\circ \cos 31^\circ + \left(1 - \frac{\gamma_w z_w}{\gamma H} \right) \frac{\text{tg } 38^\circ}{\text{tg } 31^\circ}$$

$$FS = 0,5 + (1 - 0,11 z_w) 1,3$$

c) fluxo vertical $\Rightarrow z_w = 0 \Rightarrow \boxed{FS = 1,8}$

d) se $c' = 0 \Rightarrow \boxed{FS = 1,3}$ perda da coesão aparente
fluxo vertical \Rightarrow rocha permeável

e) rocha impermeável



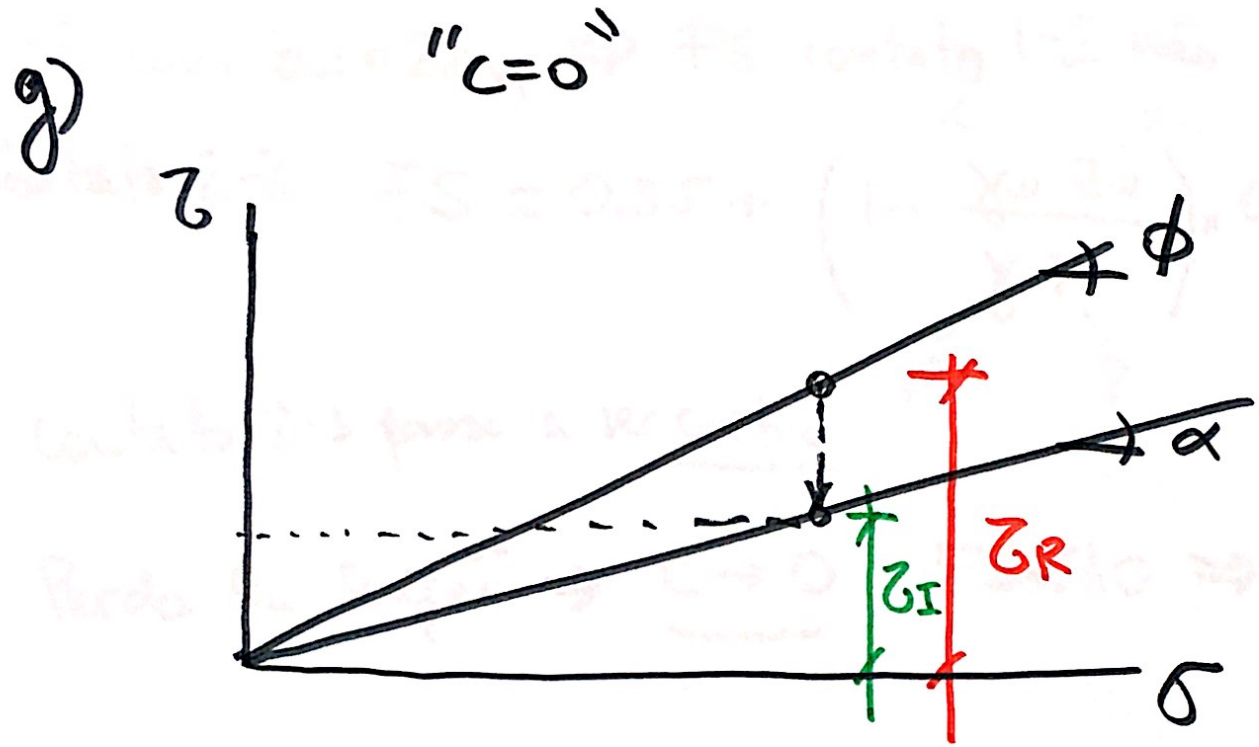
$$FS = 1,5 = 0,5 + (1 - 0,11z_w) / 1,3$$

$$z_w = 2,1m$$

$$h_w = z_w \cdot \cos^2 \alpha = 1,5m$$

$$f) FS = 1,5 = (1 - 0,11z_w) \times 1,3$$

$\leftarrow z_w \Rightarrow$ ruptura



$$FS = \frac{\tan \phi}{\tan \alpha} = \frac{z_R}{z_I}$$

u=0

FS em ripa de terra

unidade 1-2 $\Rightarrow FS = \frac{25 \cdot \sec 36^\circ \cdot \csc 36^\circ}{19 \cdot 4} = 1,29$

unidade 2-3 $\Rightarrow FS = \frac{35 \cdot \sec 36^\circ \cdot \csc 36^\circ}{19 \cdot 7} = 1,28$

unidade no estado 1-2

0,55

0,72

c) FS com $z_w = 2,0m \Rightarrow$ FS contato 1-2 não é alterado

Contato 2-3: $FS = 0,55 + \left(1 - \frac{\gamma_w \cdot z_w}{\gamma H} \right) \times 0,72 = 1,16 \leftarrow$ crítico

(Handwritten annotations: 10 above γ_w , 2m above z_w , 19 below γ , 7 below H)

Contato 2-3 para a ser crítico.

Perda de sucção \Rightarrow $C \rightarrow 0$ $FS < 1,0 \Rightarrow$ RUPTURA

b) FS em época de seca

Contato 1-2 $\Rightarrow FS = \frac{25}{19 \times 4} \sec 36^\circ \operatorname{cosec} 36^\circ + \frac{\operatorname{tg} 22^\circ}{\operatorname{tg} 36^\circ} = 1,24$

contato 2-3 $\Rightarrow FS = \underbrace{\frac{35}{19 \times 7} \sec 36^\circ \operatorname{cosec} 36^\circ}_{0,55} + \underbrace{\frac{\operatorname{tg} 28^\circ}{\operatorname{tg} 36^\circ}}_{0,72} = 1,28$

ruptura no contato 1-2.

Tirante : elemento de contenção de taludes

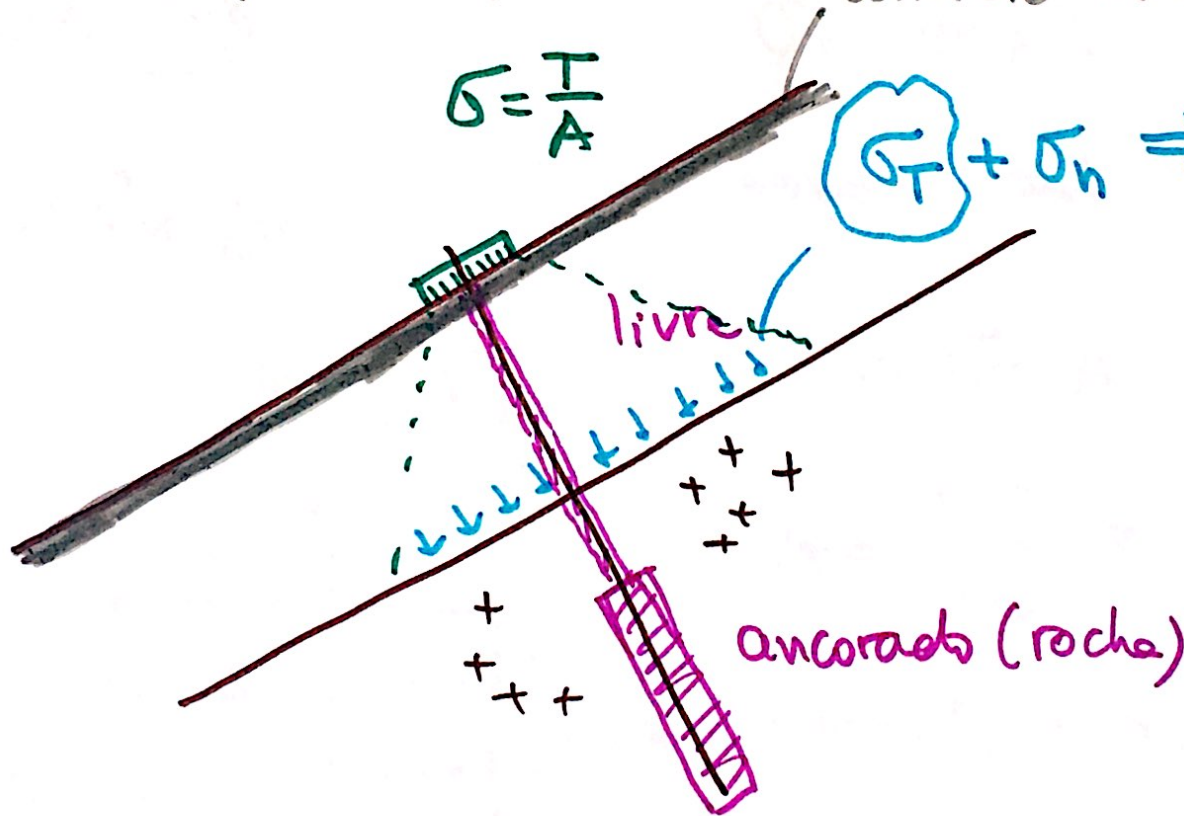
barra de aço }
cordoalha }
fio de aço }

tirante → PROTENDIDO

concreto armado

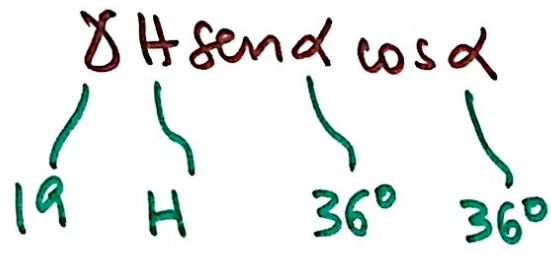
$$\sigma = \frac{T}{A}$$

$$\sigma_T + \sigma_n \Rightarrow \underline{FS = 1,50}$$



$$FS = \frac{c' + (\gamma H \cos^2 \alpha - u + \sigma_T) \tan \phi'}{\dots}$$

1,5



incognita

contacto 2-3

$$u = z_w \cdot \cos^2 \alpha \cdot \gamma_w$$

2m 10 kN/m³

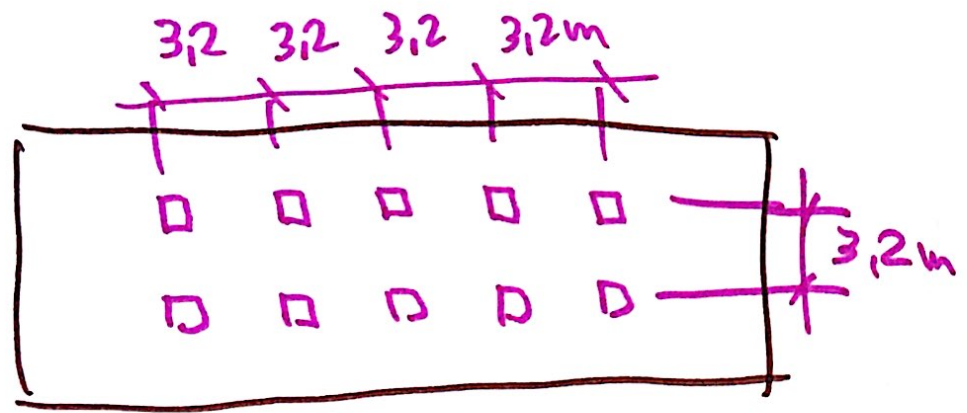
$$\sigma_T = 40 \text{ kPa}$$

Dado: tirante 400 kN = T_T

$$T_T = \sigma_T \cdot A$$

$$A = \frac{400}{40} = 10 \text{ m}^2 = e^2$$

1 tirante a cada 3,2m



vista frontal