Mecânica dos Solos

Introdução

Prof. Fernando A. M. Marinho
2019







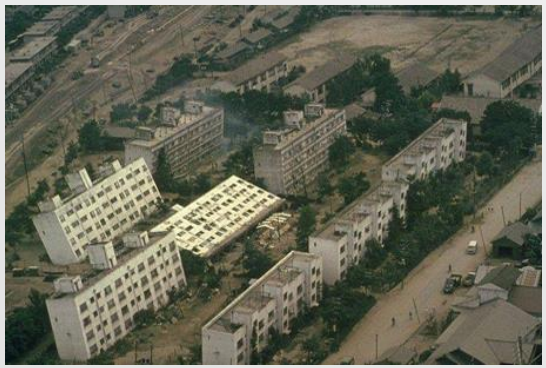


Todas as obras que vimos ao nosso redor é suportado por solo ou rocha.

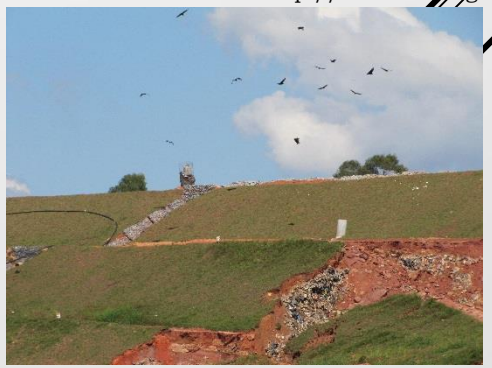
A engenharia geotécnica é responsável por isto.

Qualquer coisa que não seja suportada por solo, ou flutua ou voa ou cai

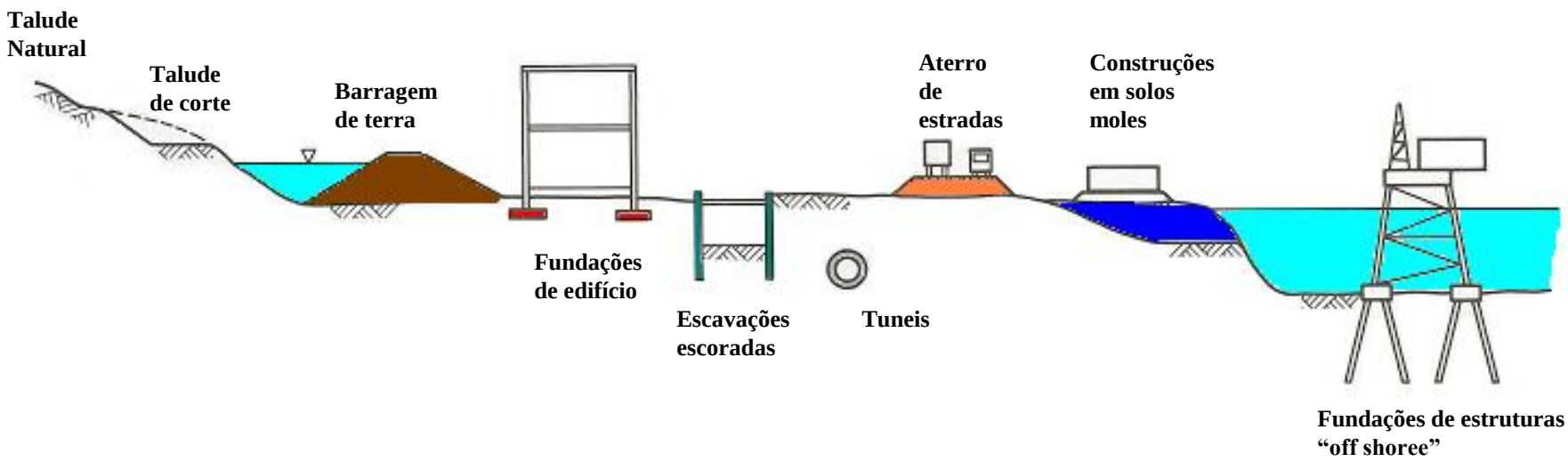
http://www.whatisgeotech.org/







Exemplos de obras de Engenharia Geotécnica



Modificado de Atkinson (1993)

Existem obras que são:

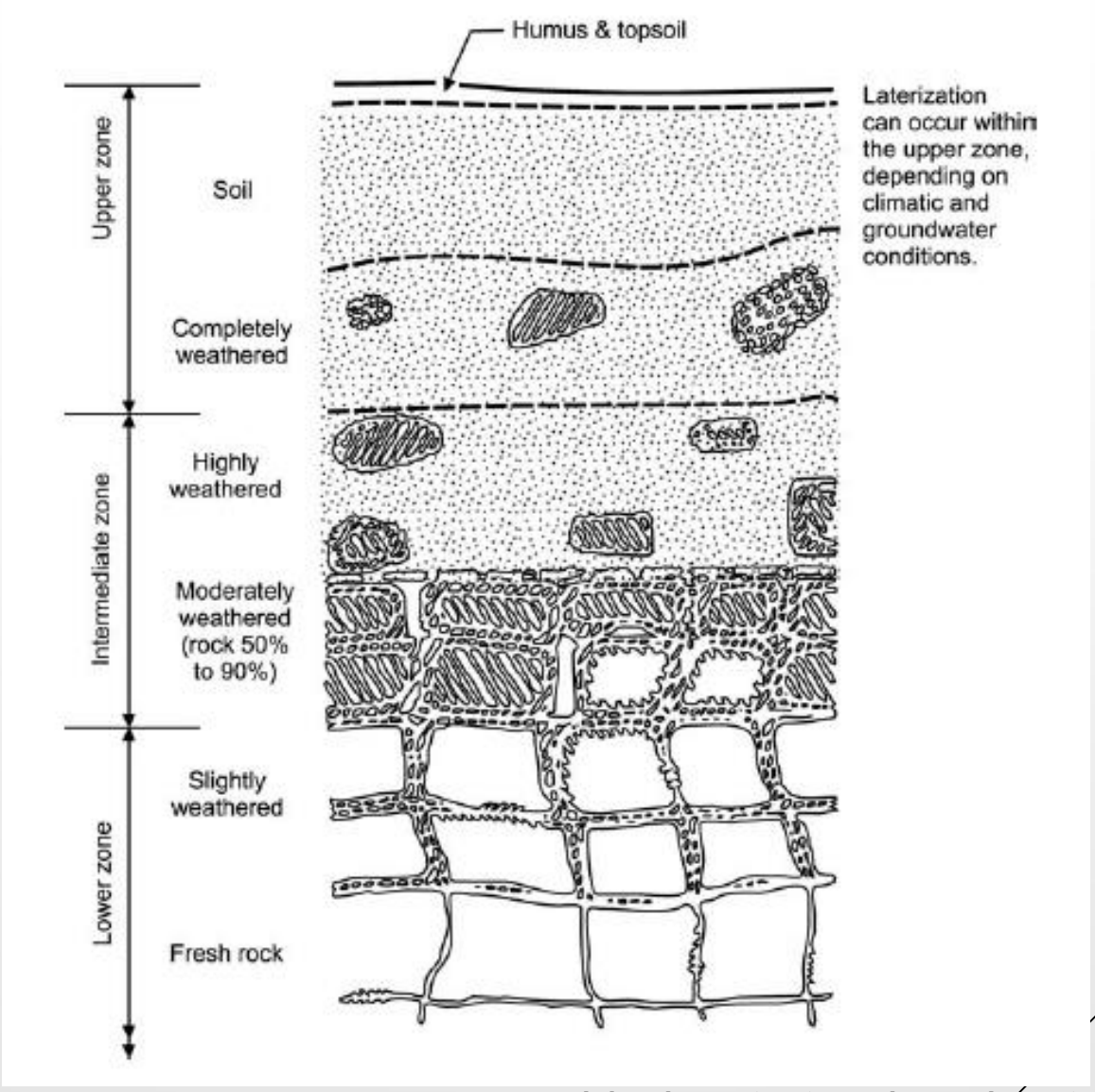
No solo : Fundações de edifícios, pontes

Dentro do solo: Tuneis, subterâneos,

Com solo : Estradas, Aterros, Barragens.

Suportadas : Muros de arrimo.

Perfil Típico de Solo Residual



Blight and Leong (2012) Baseado em Little (1969)

PERFIL INDIVIDUAL DE SONDAGEM A PERCUSSÃO

SP – 01

COTA E N.A. | PROF. (m) | PERFIL | DESCRIÇÃO DO MATERIAL | Nº DE GOLPES – PENETRAÇÕES | Nº DE GOLPES – SPT | AMOS. | PENETRAÇÃO SPT (30cm) — 10 20 30 40

12/11/96 — 6,30

COLÚVIO

AREIA MÉDIA A GROSSA, ARGILOSA, COM PEDREGULHOS E RAÍZES, MARROM-ESCURA — 0.90 — SS

argilosa, fofa, marrom-avermelhada — 2.00

argilo-siltosa, medianamente compacta, marrom-amarelada — 3.00

siltosa, medianamente compacta, marrom-amarelada — 4.00

SOLO DE ALTERAÇÃO DE ROCHA (GRANITO) — SA

siltosa, medianamente compacta, marrom e rósea — AREIA MÉDIA A GROSSA

siltosa, muito compacta, marrom e róseo — 7.00

8.15

siltosa, muito compacta, rósea e cinza — RAM

PENETRAÇÕES	SPT	AMOS.
01/15 — 01/15 — 02/15	3	1
03/15 — 06/15 — 08/15	14	2
04/15 — 06/15 — 07/15	13	3
04/15 — 05/15 — 06/15	11	4
03/15 — 06/15 — 05/15	11	5
05/15 — 06/15 — 07/15	13	6
12/15 — 19/15 — 23/15	42	7
16/15 — 45/15 — –/–	45/15	8
20/10 — 05/01 — –/–	5/1	9
20/03 — –/– — –/–	* 20/3	** 10
25/01 — –/– — –/–	* 25/1	** 11
05/01 — –/– — –/–	* 5/1	** 12

N.A. DIA 09/11/96 = 6,20m

k=4,5x10⁻⁵cm/s

k=1,5x10⁻⁵cm/s

k=3,7x10⁻⁵cm/s

k=7,2x10⁻⁵cm/s

12.66

FURO TERMINADO COM 12,66m EM MATERIAL IMPENETRÁVEL À PEÇA DE LAVAGEM

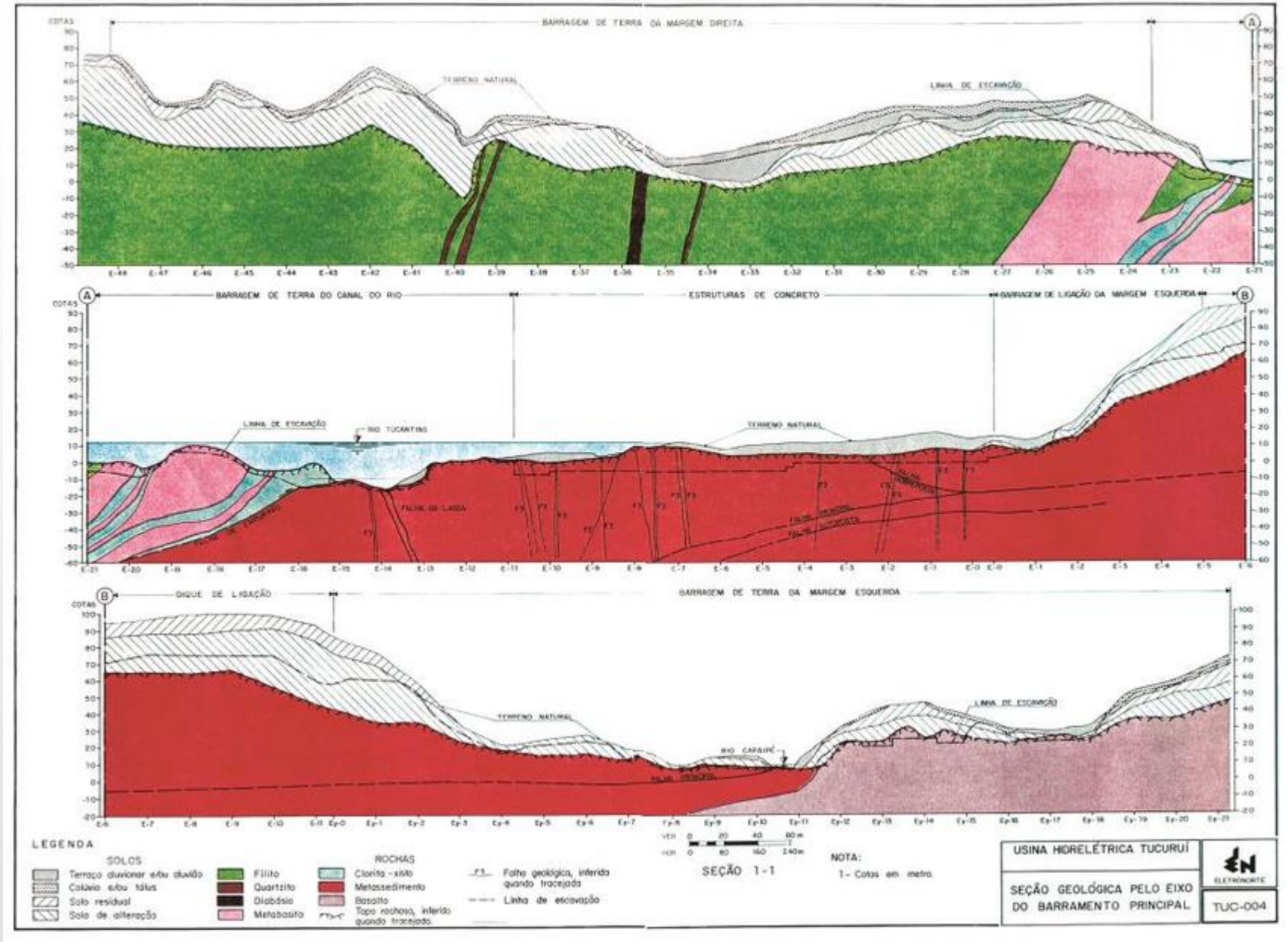
*– PARA OS PRIMEIROS 15cm

**– AMOSTRA NÃO RECUPERADA

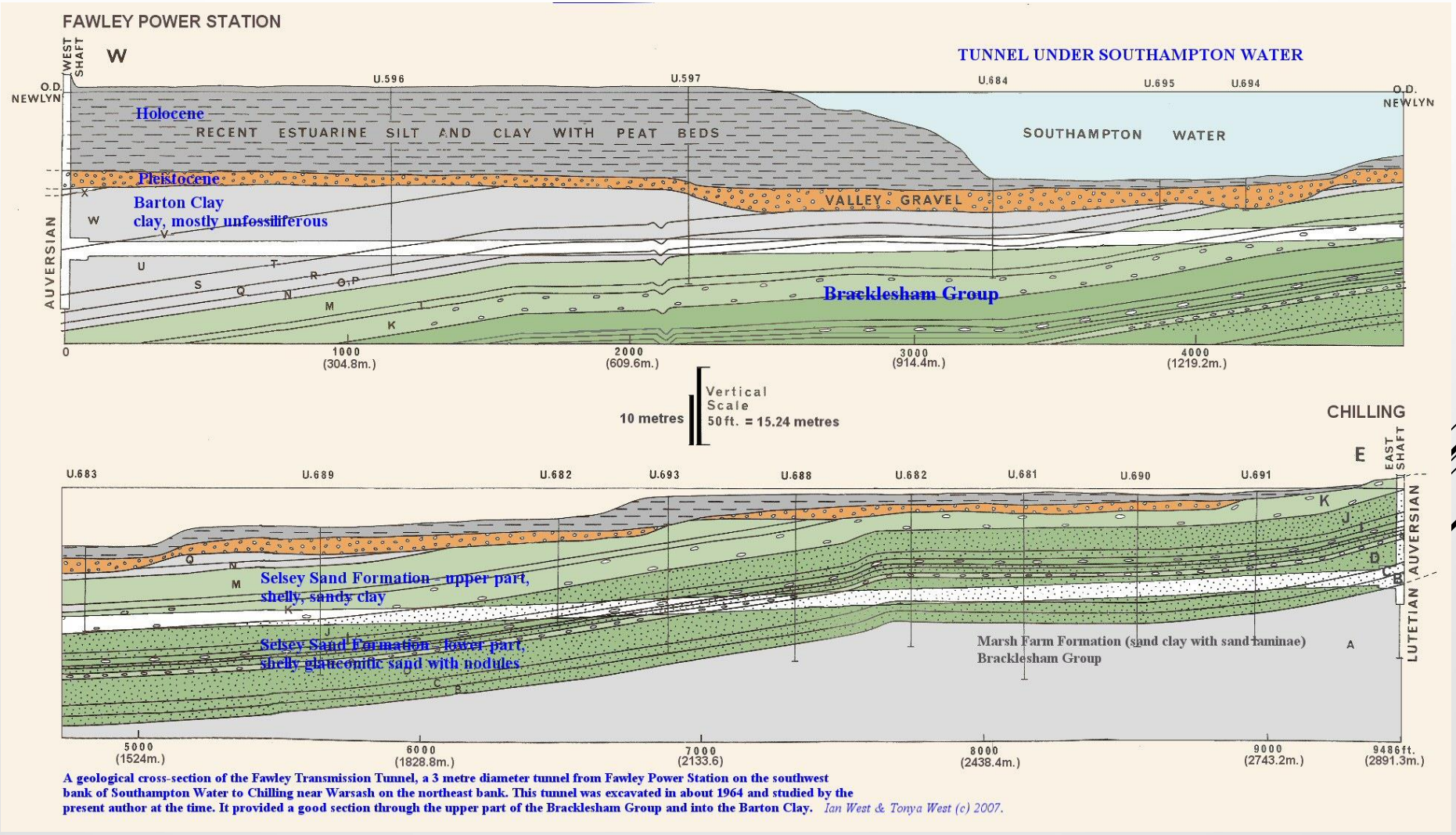
▩ ENSAIO DE INFILTRAÇÃO

LAVAGEM POR TEMPO	
Trecho: 12,60 a 12,66m	
Tempo (min)	*Avanço (m)*
10	0,03
10	0,02
10	0,01

Perfil Geológico ao longo do eixo – Barragem de Tucuruí



Perfis geológico-geotécnicos



A geological cross-section of the Fawley Transmission Tunnel, a 3 metre diameter tunnel from Fawley Power Station on the southwest bank of Southampton Water to Chilling near Warsash on the northeast bank. This tunnel was excavated in about 1964 and studied by the present author at the time. It provided a good section through the upper part of the Bracklesham Group and into the Barton Clay. *Ian West & Tonya West (c) 2007.*

Taludes

Mina de Grasberg Mine, província de Papau na Indonésia



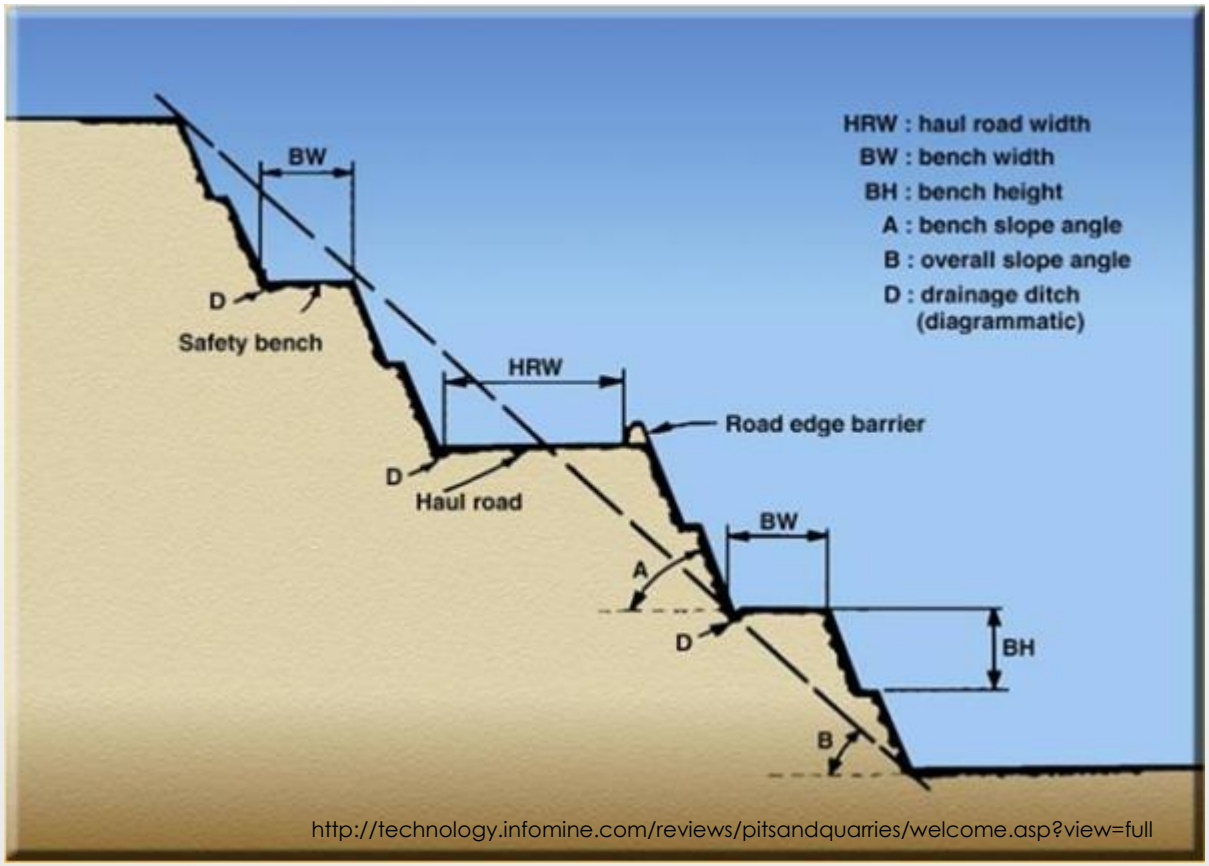
Maior mina de ouro do mundo e a segunda de cobre

Taludes





Taludes


HRW : haul road width
BW : bench width
BH : bench height
A : bench slope angle
B : overall slope angle
D : drainage ditch
(diagrammatic)
BW
D
Safety bench
HRW
Road edge barrier
D
Haul road
BW
A
D
BH
B
http://technology.infomine.com/reviews/pitsandquarries/welcome.asp?view=full

Um caso de obra



Um caso de obra



Tecnologia





Acidentes



Kennecott mine



Acidentes

Mina de Yallourn, Australia



Acidentes

A Mina de Mount Polley



Ruptura – 4 de Agosto de 2014
Volume de rejeitos – Aproximadamente 25 milhões de m3 de água e rejeitos.

Acidentes



Fundão

Ruptura – 5 de Novembro de 2015

17 mortos e 2 desaparecidos.
Volume de rejeitos – Aproximadamente 62 milhões de m3 de água e rejeitos.

Acidentes

Barragem de rejeito do Fundão





Ruptura – 5 de Novembro de 2015

17 mortos e 2 desaparecidos.
Volume de rejeitos – Aproximadamente 62 milhões de m3 de água e rejeitos.

Acidentes

Barragem de Brumadinho





Ruptura – 25 de Janeiro de 2019

mais de 200 mortos e cerca de 93 desaparecidos
Volume de rejeitos – Aproximadamente 12,7 milhões de m^3 de água e rejeitos.

Acidentes

Estação Pinheiros do Metrô



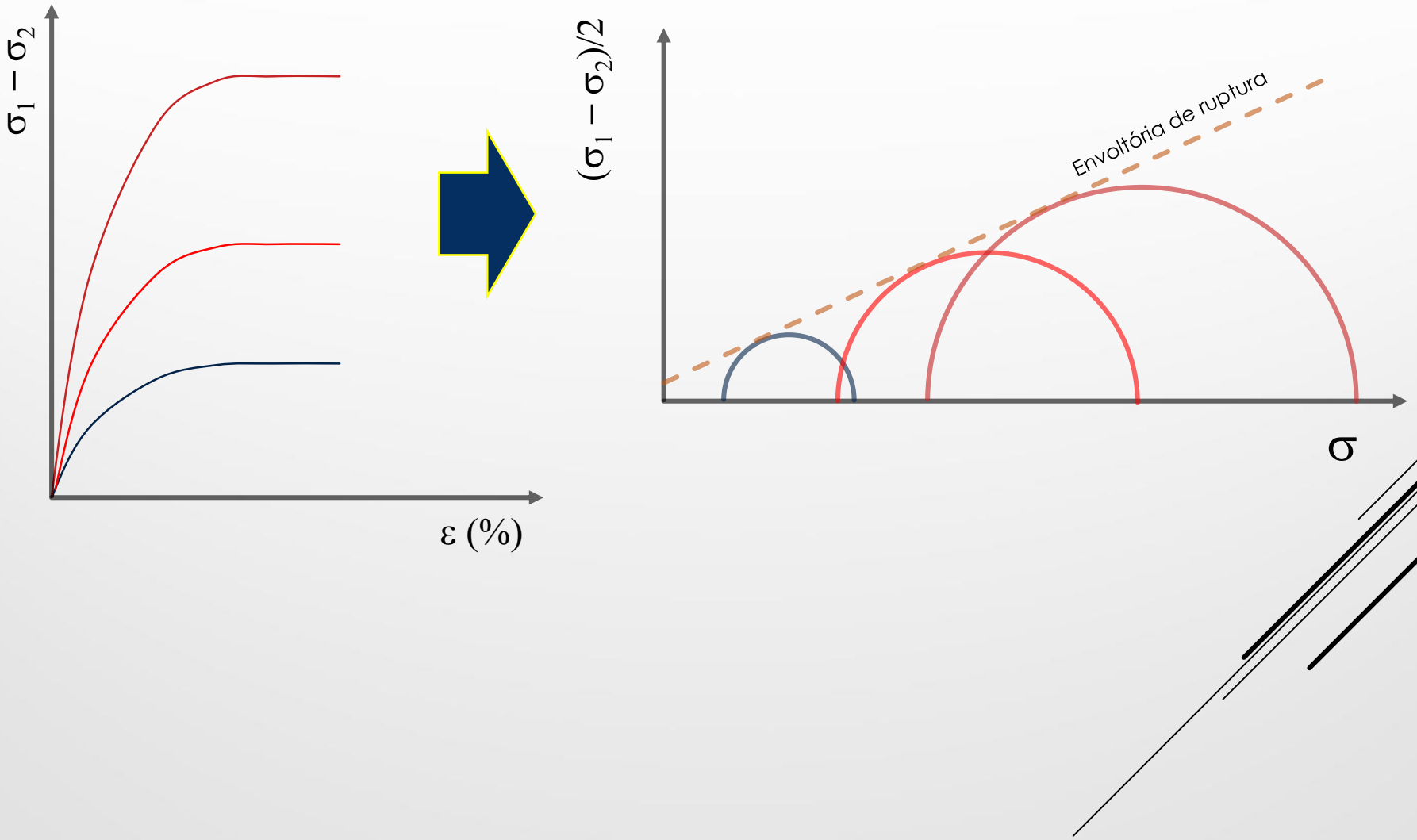
Ruptura – 12 de janeiro de 2007
7 mortos

A geotecnia procura analisar o comportamento dos materiais particulados pensando em:

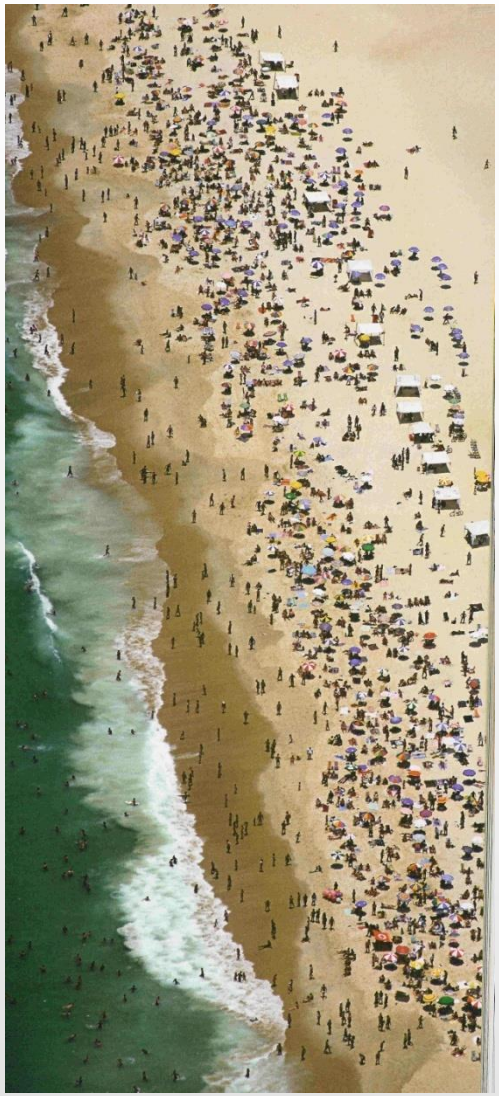
Resistência
Permeabilidade
Compressibilidade

O Objetivo é prever o comportamento das obras

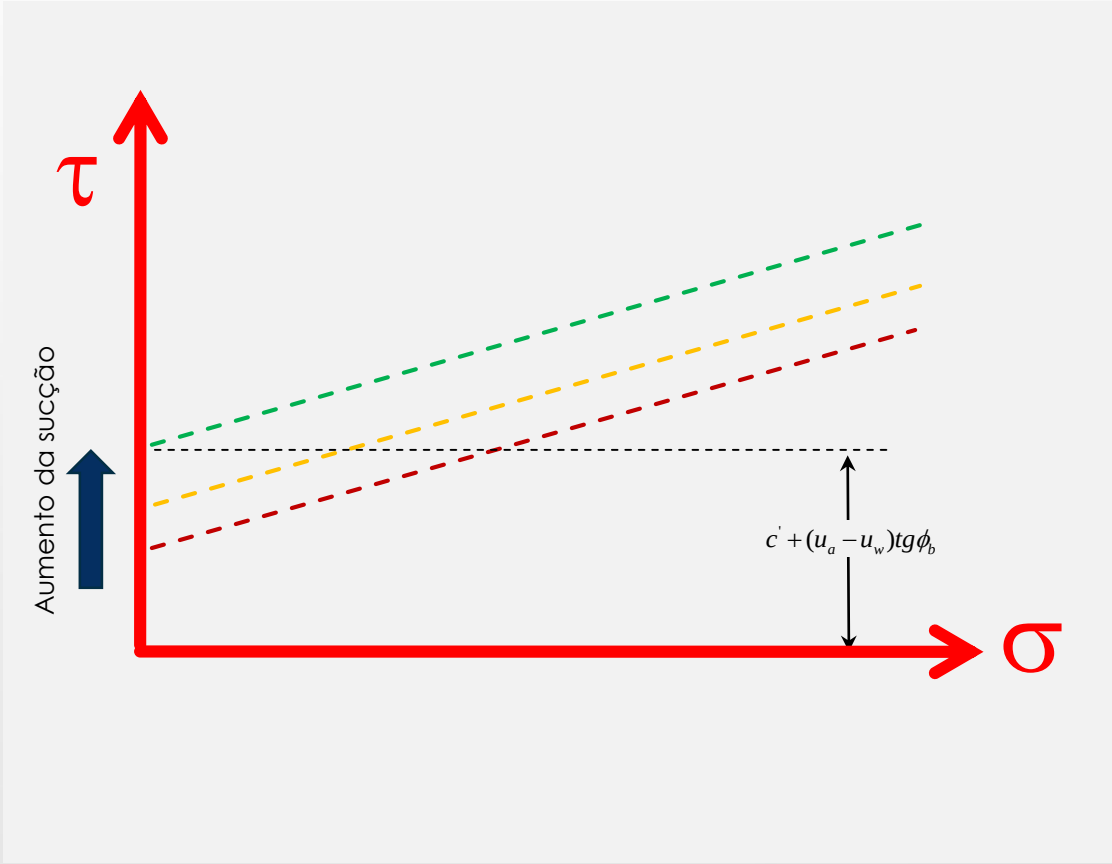
Curvas tensão-deformação e envoltória de ruptura



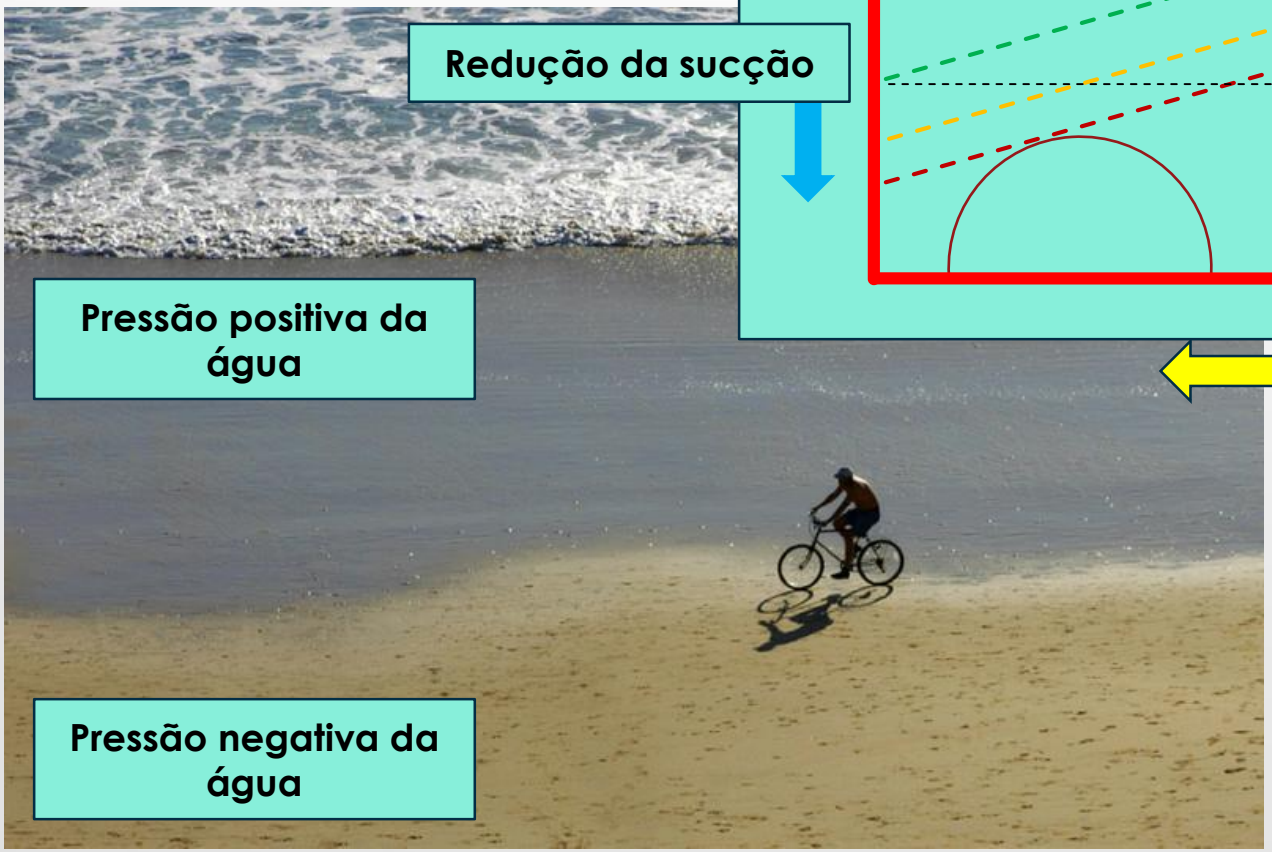
Capilaridade – Retenção - Resistência

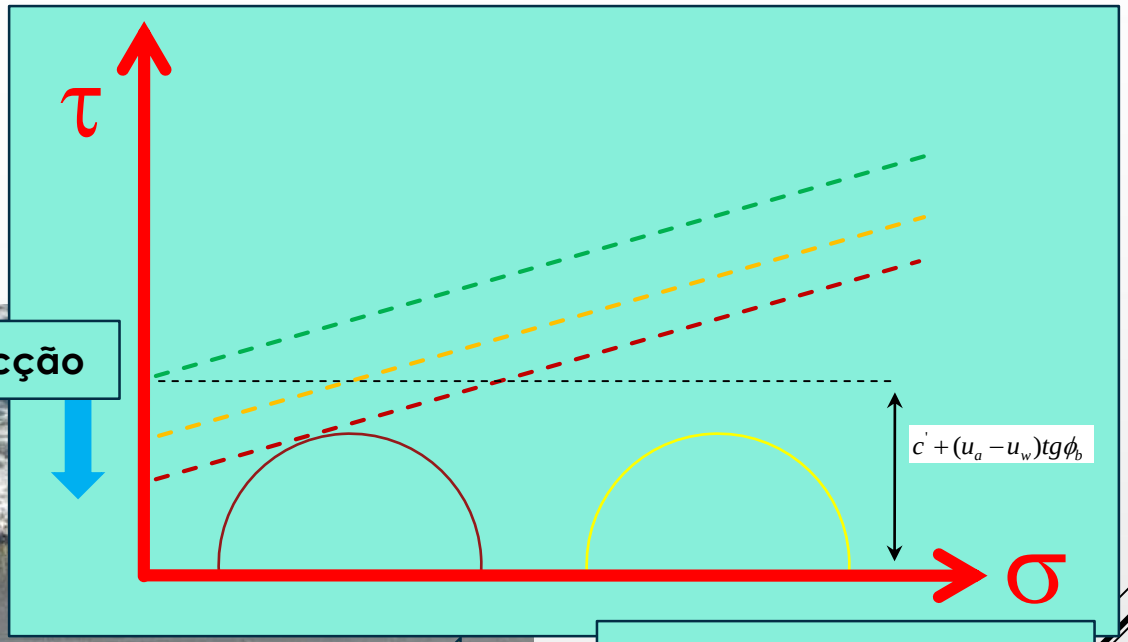






Efeitos da Não Saturação na Prática





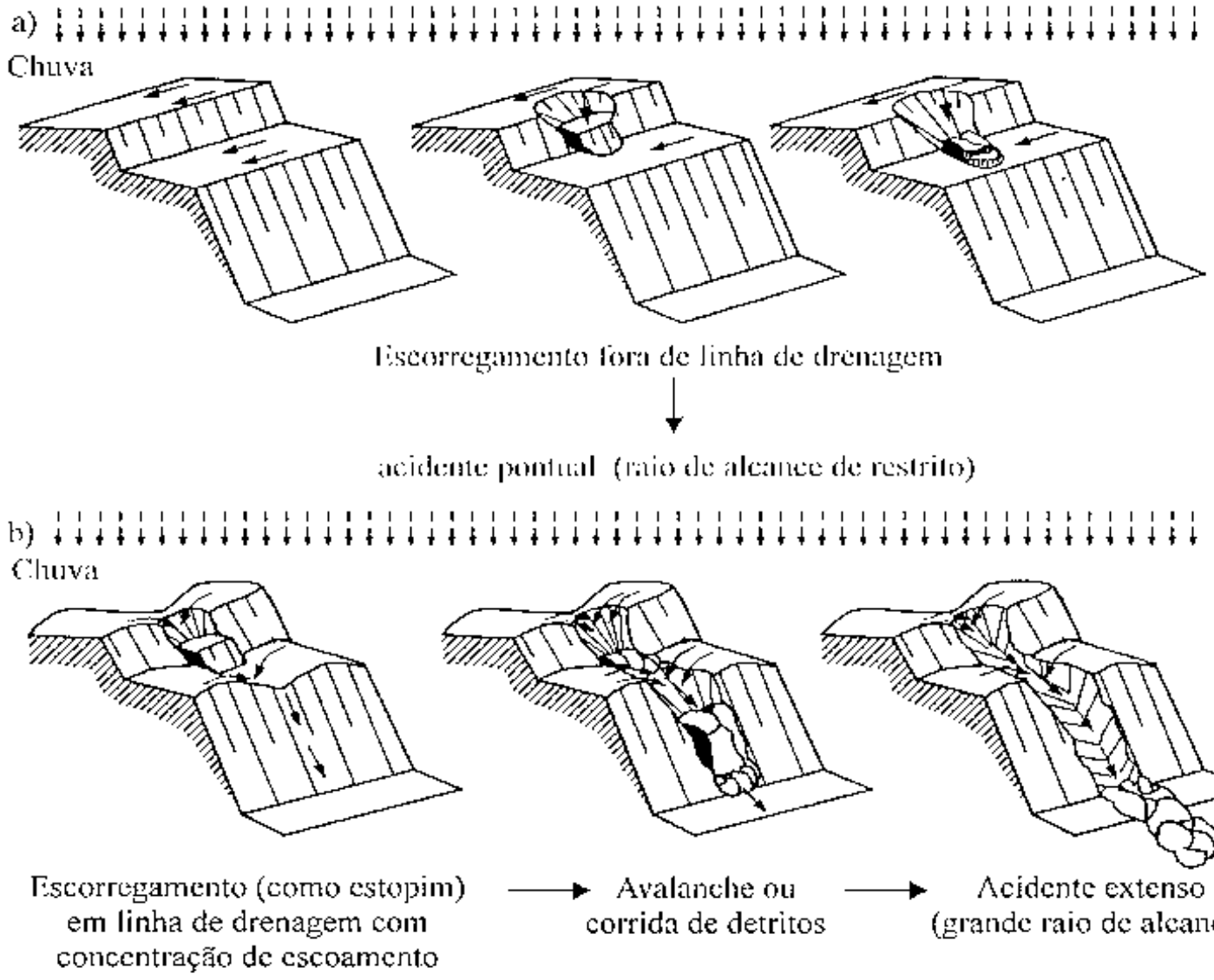
Redução da sucção

Pressão positiva da água

Pressão negativa da água

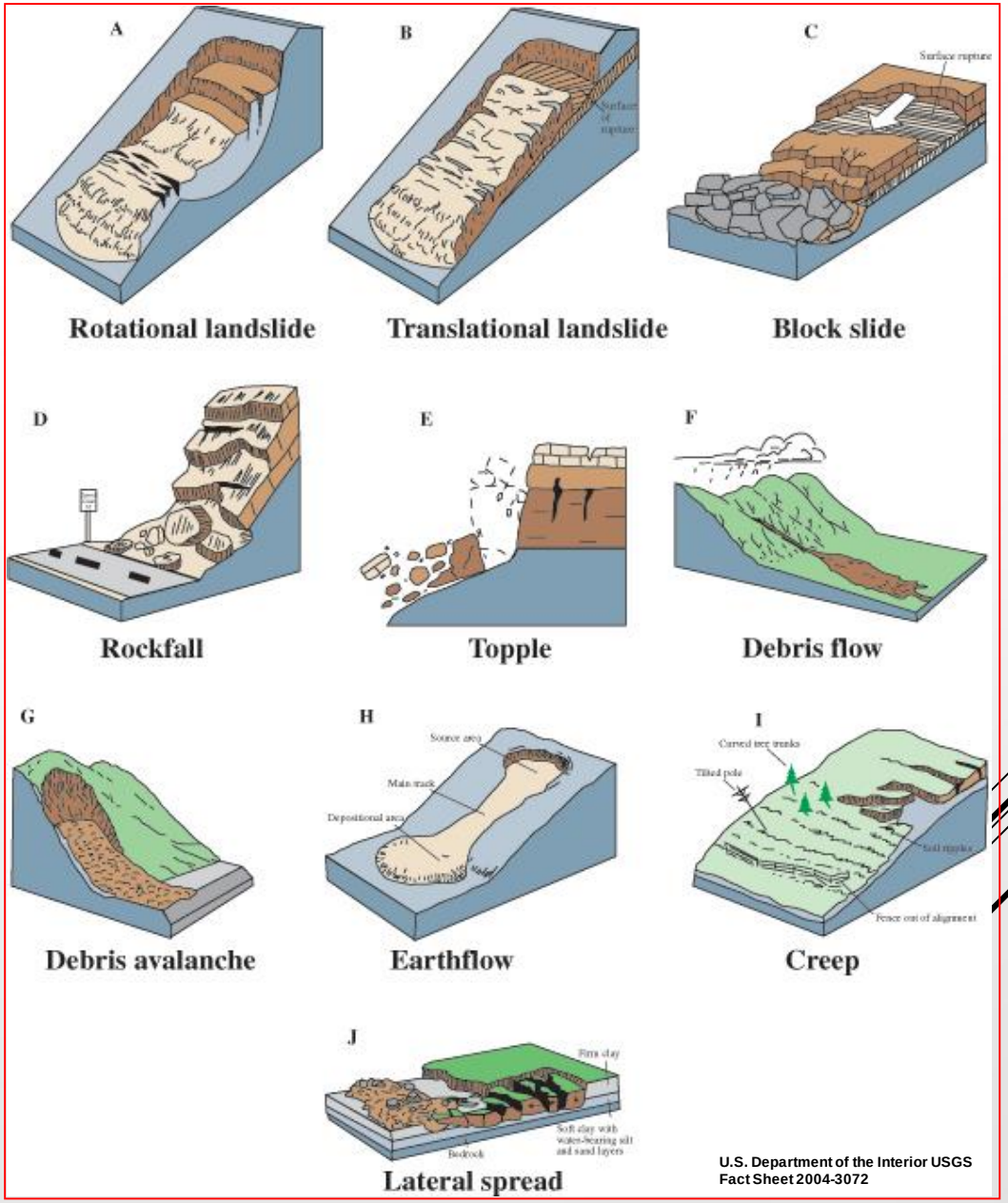
Aumento da pressão positiva da água

Mecanismos Rupturas de taludes

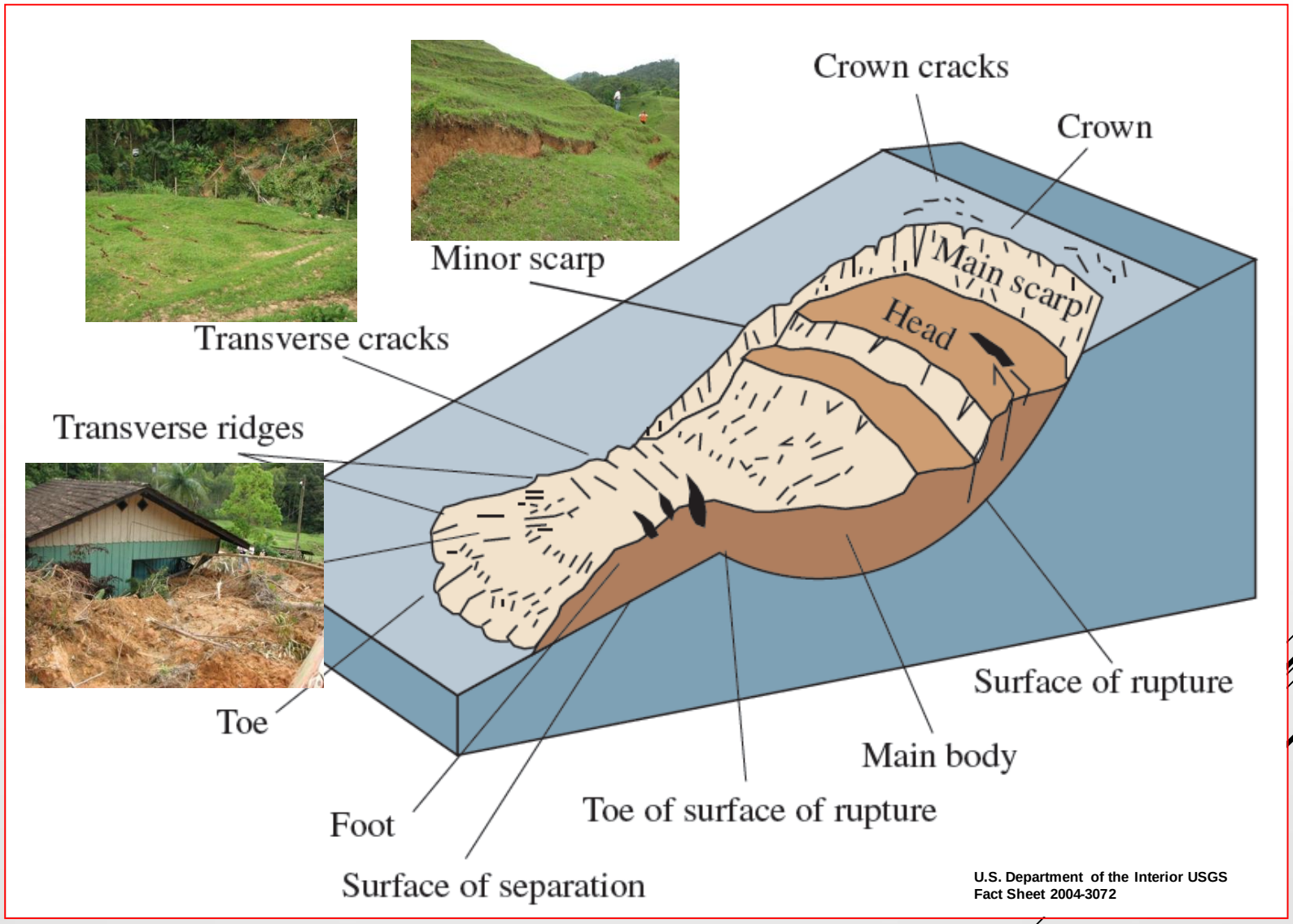


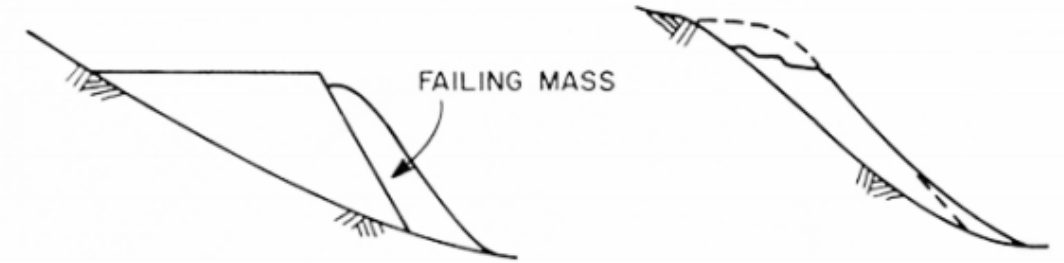
Oliveira e Augusto Filho (2005)

Tipos de escorregamentos

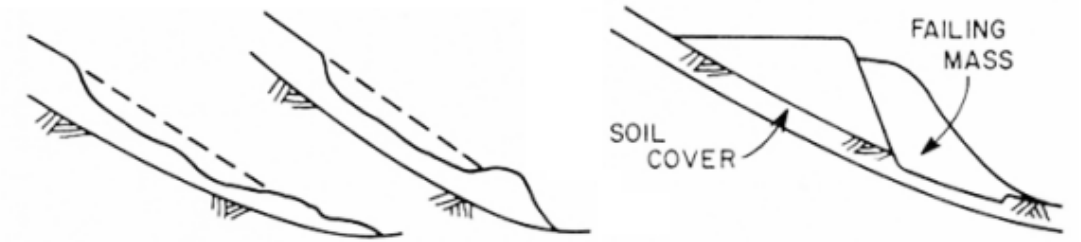


Tipos de escorregamentos

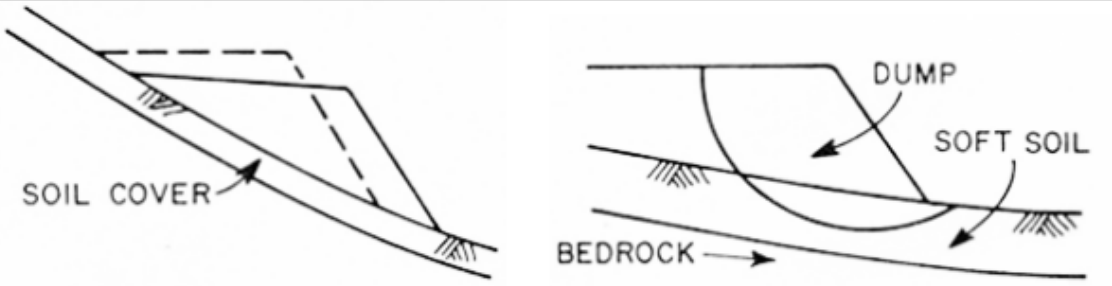




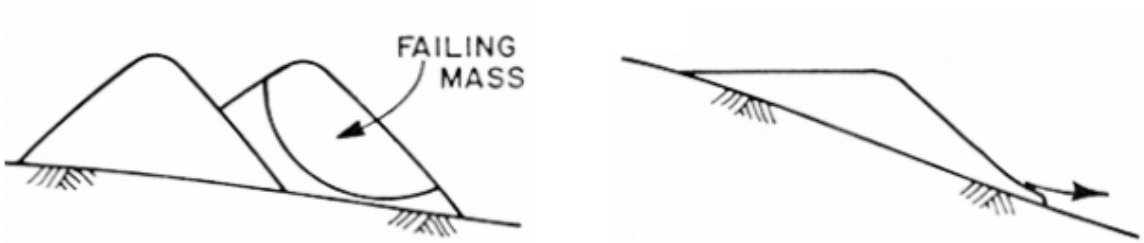
Surface slide **Edge slide**



Shallow flow slides **Base failure (spreading)**



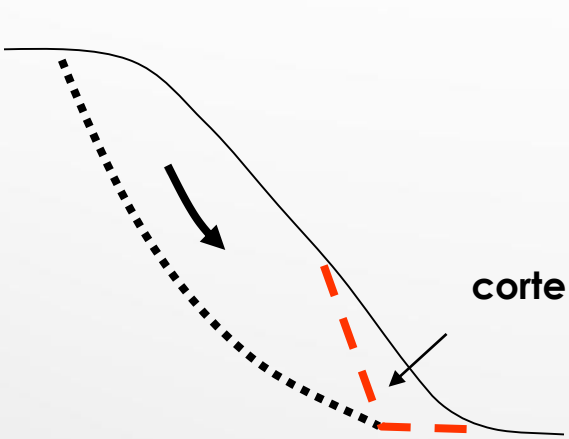
Block Translation **foundation circular failure**



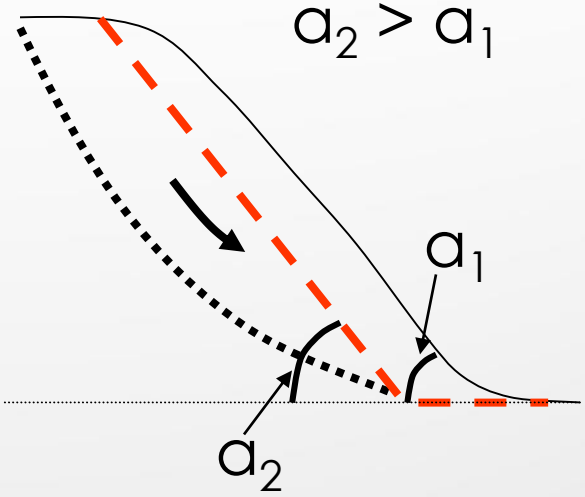
Circular Arc failure **Toe spreading**

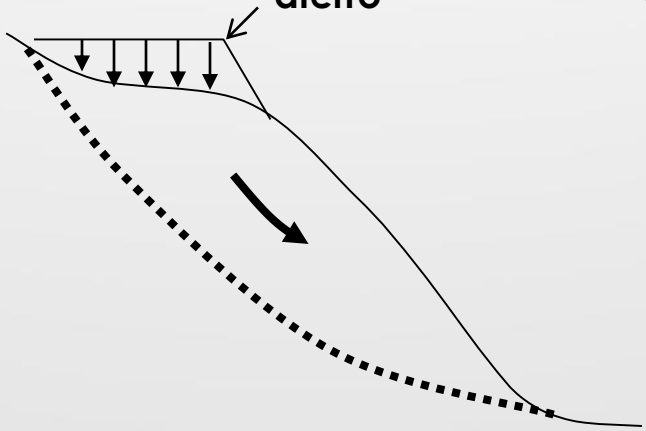
Escorregamentos

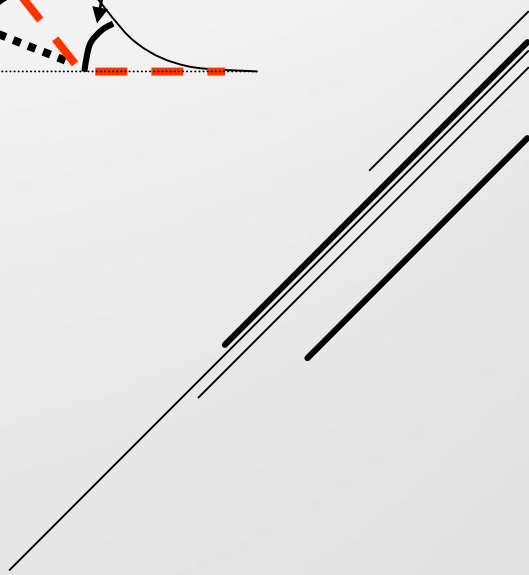
- *Alteração da geometria*
- *colocação de sobrecarga*
- *infiltração de água*
- *desmatamento e poluição ambiental*



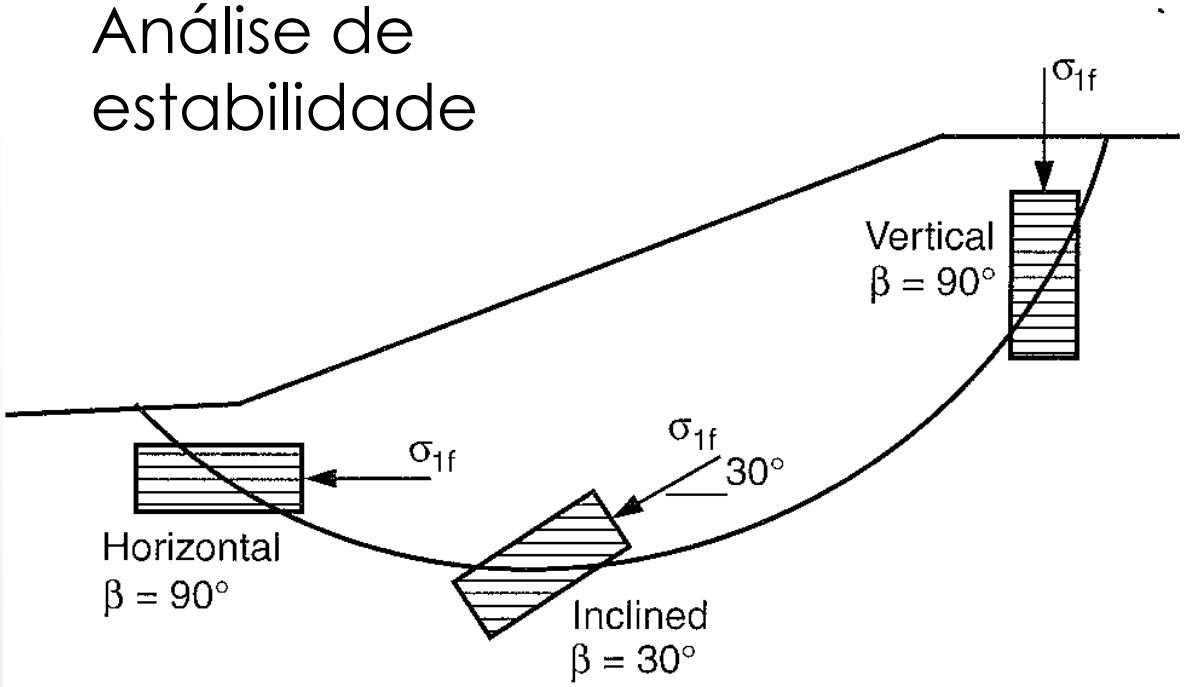
corte no pé do talude



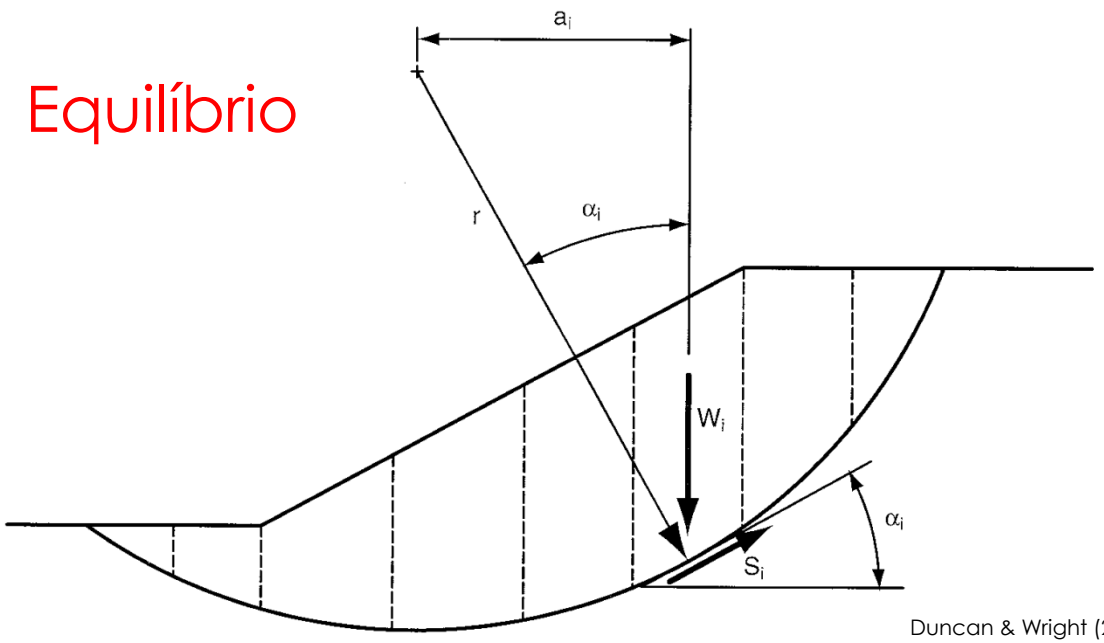




Análise de estabilidade



Equilíbrio



Duncan & Wright (2005)

Superfícies de ruptura antigas

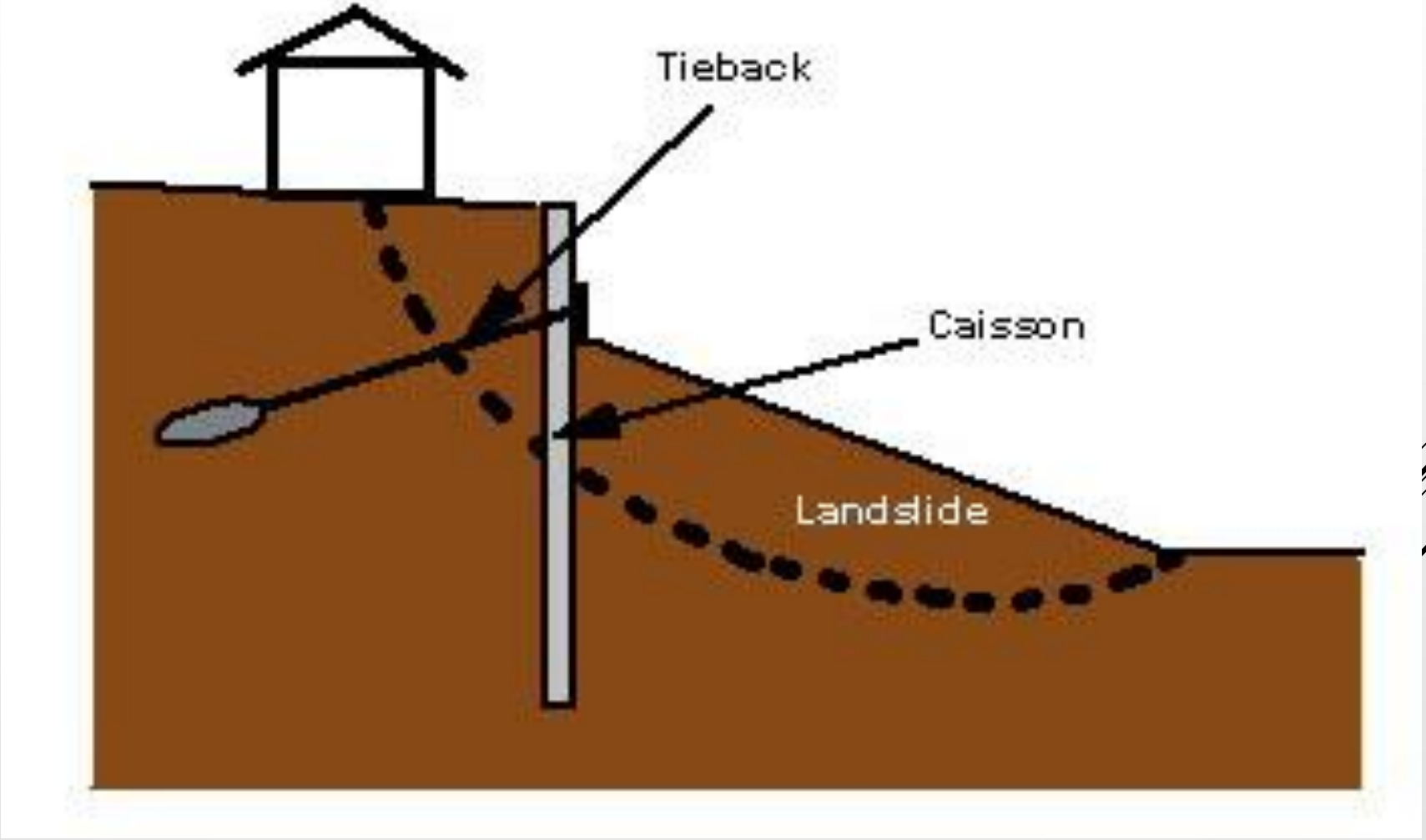


Figure 4. March 2008 Landslide (outlined in black), hosted in Ancient Landslide (outlined in red).

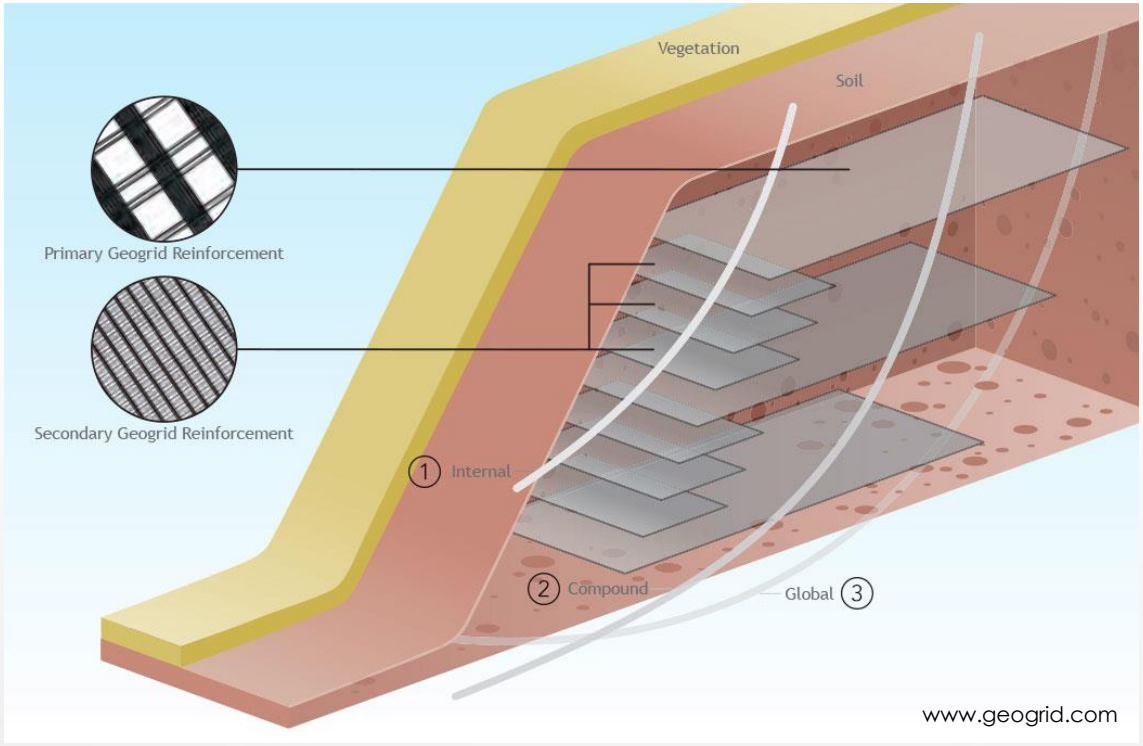
http://www.azgs.az.gov/hazard_info_hwy87_2008.shtml

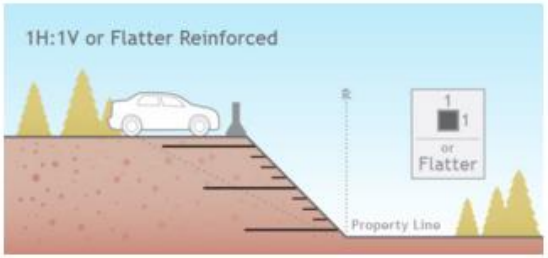
Técnicas para solução de problemas

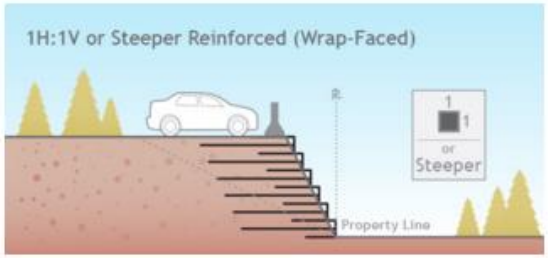
Estabilização de taludes com tirantes e estaca prancha

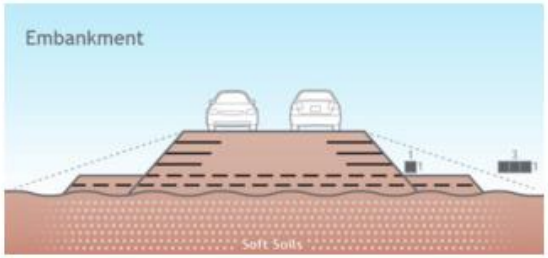


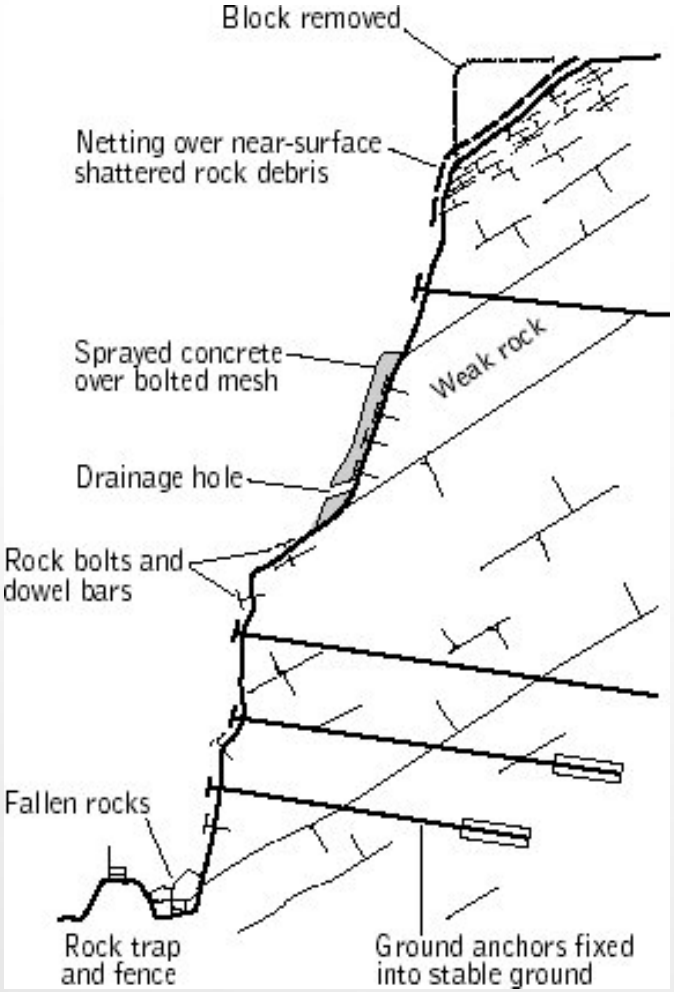
Técnicas de Estabilização em Aterros













http://www.tecnosolo.com.br/servicos/cortinas.html



Salvador – Foto: Prof. Luiz Edmundo Campos



Morro do Macaco – Diadema – Foto FAMMarinho



Aterro de resíduos sólidos – Itaquecetuba – Foto : FAMMarinho





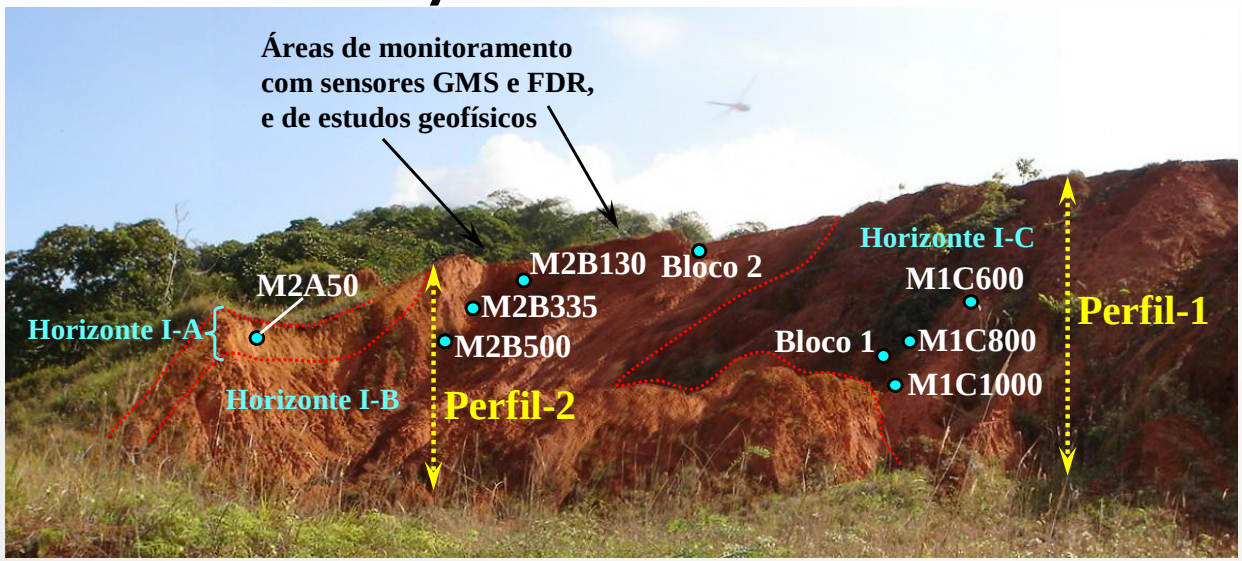
Área de mineração de saibro - Marandúba – Foto : FAMMarinho

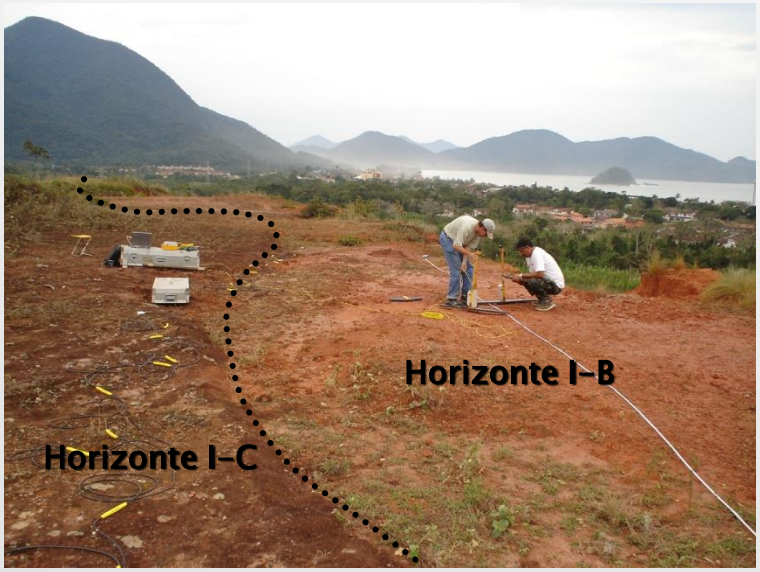


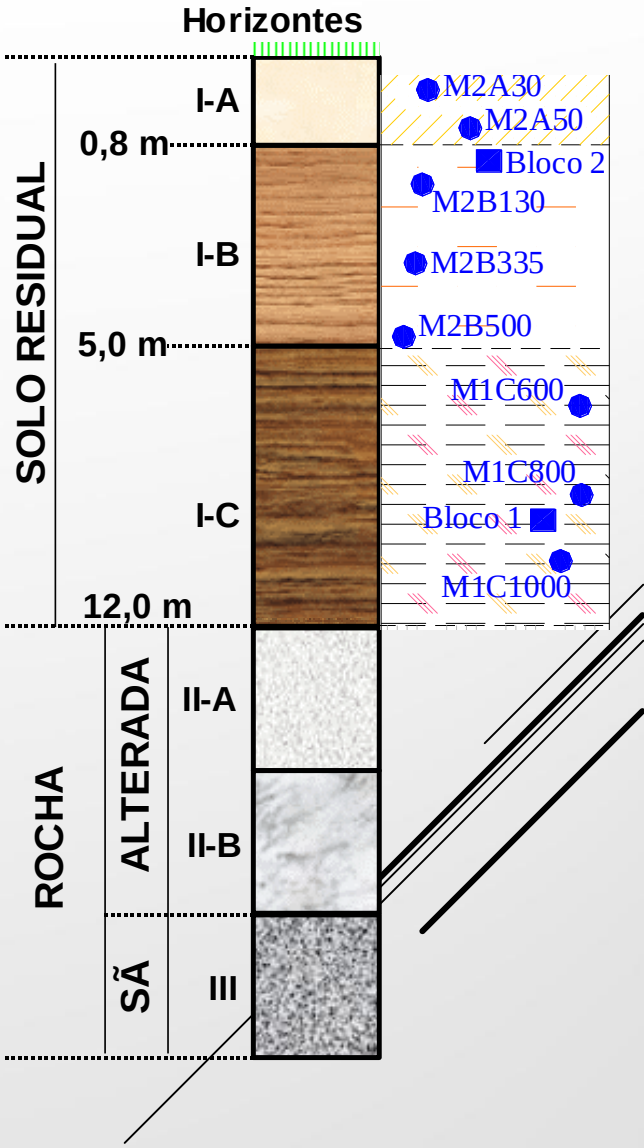
Área de mineração de saibro - Marandyba – Foto : FAMMarinho

Residual Soil Profiles

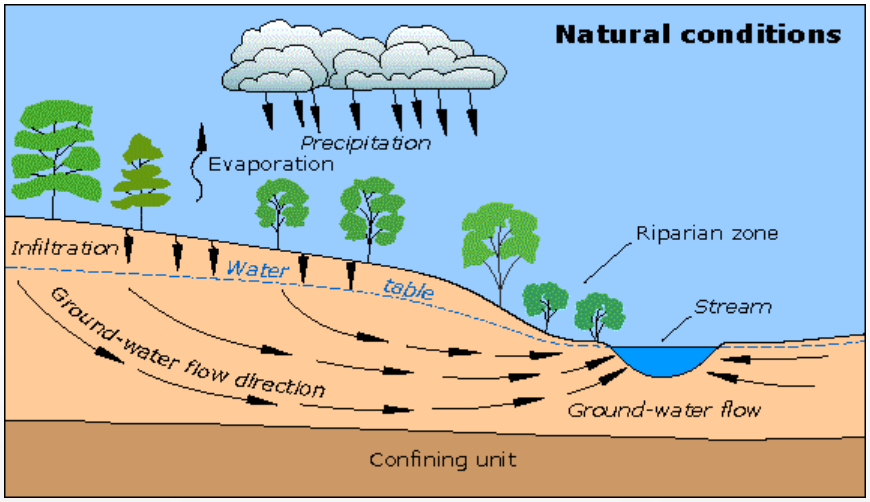
Area of study 1 – Maranduba

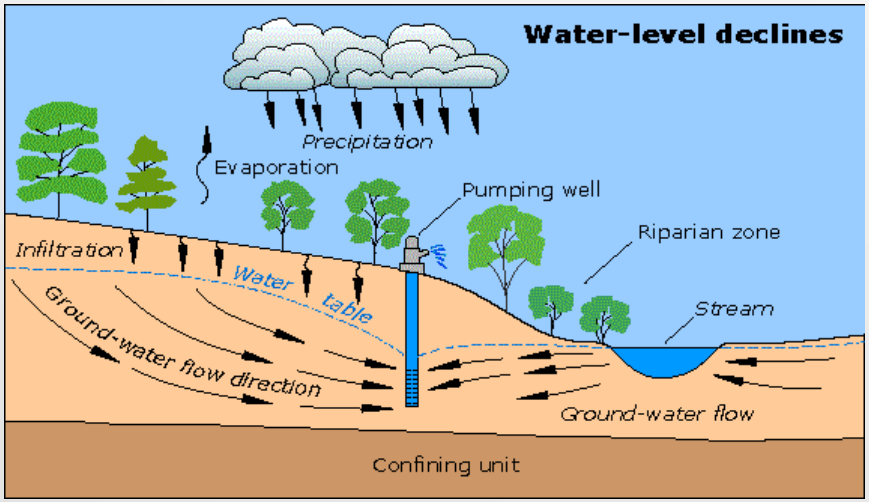


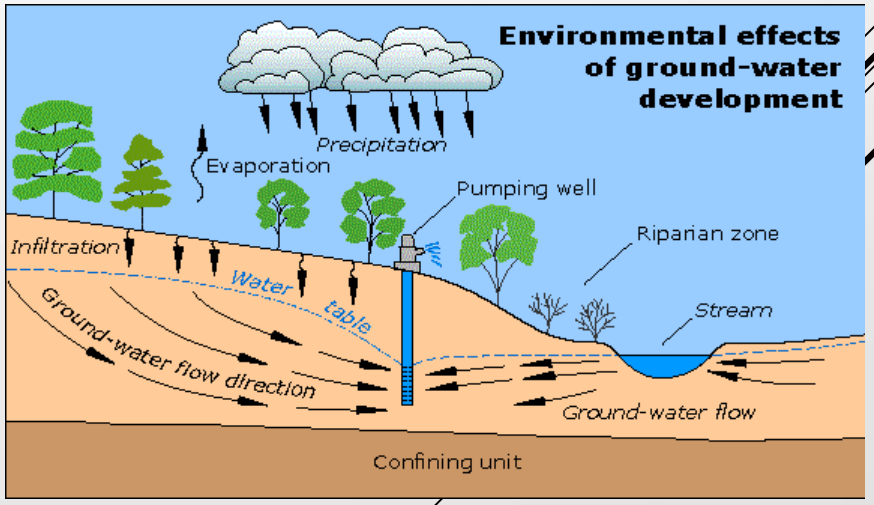




Fluxo de água no solo



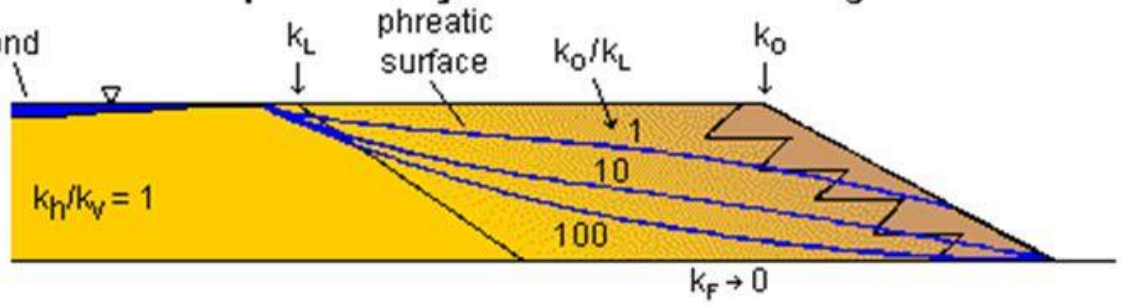




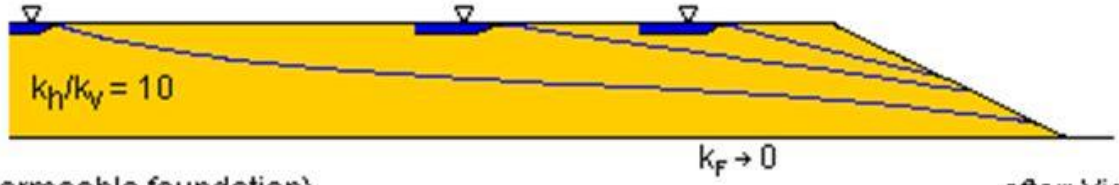
Fluxo de Água

Phreatic Surface in Upstream Dams

Influence of beach permeability variation for nonhomogeneous embankments



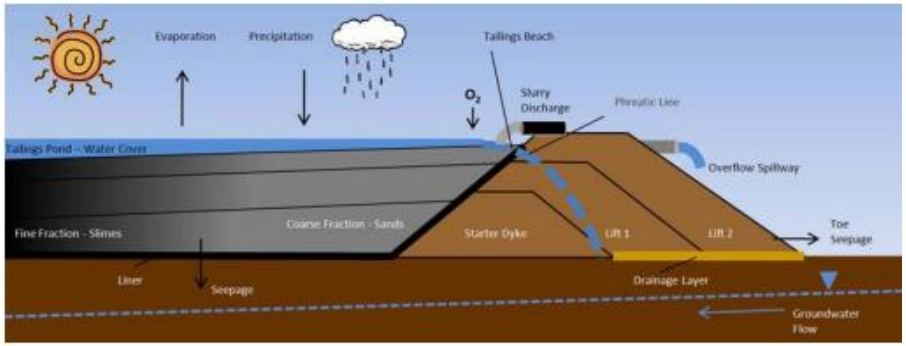
Influence of beach width for homogeneous, anisotropic embankments



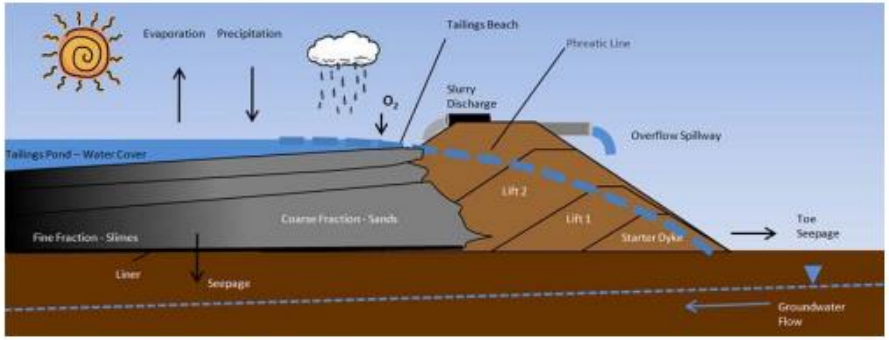
(impermeable foundation)

after: Vick 1983

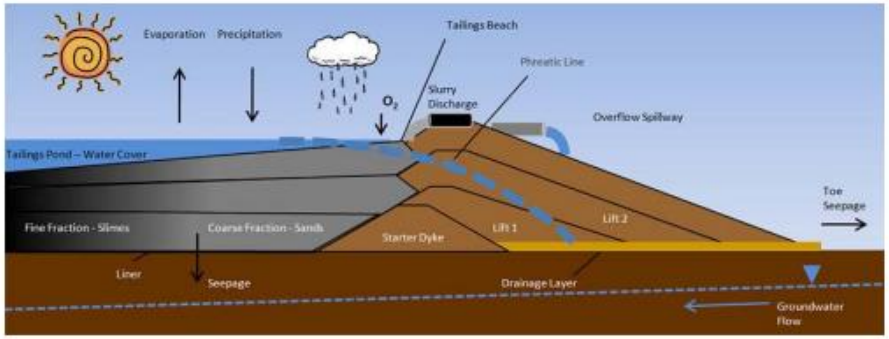
k_L = permeability at the edge of the pond water at the slimes zone
k_0 = permeability at the spigot point (dam crest)
k_F = permeability of foundation
k_h / k_v = anisotropy ratio (horizontal vs. vertical)



Downstream Construction Method

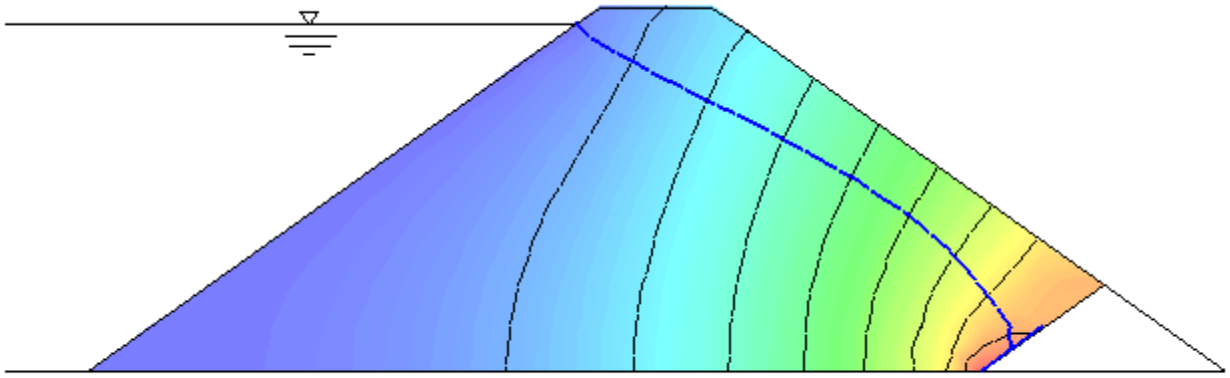


Upstream Construction Method

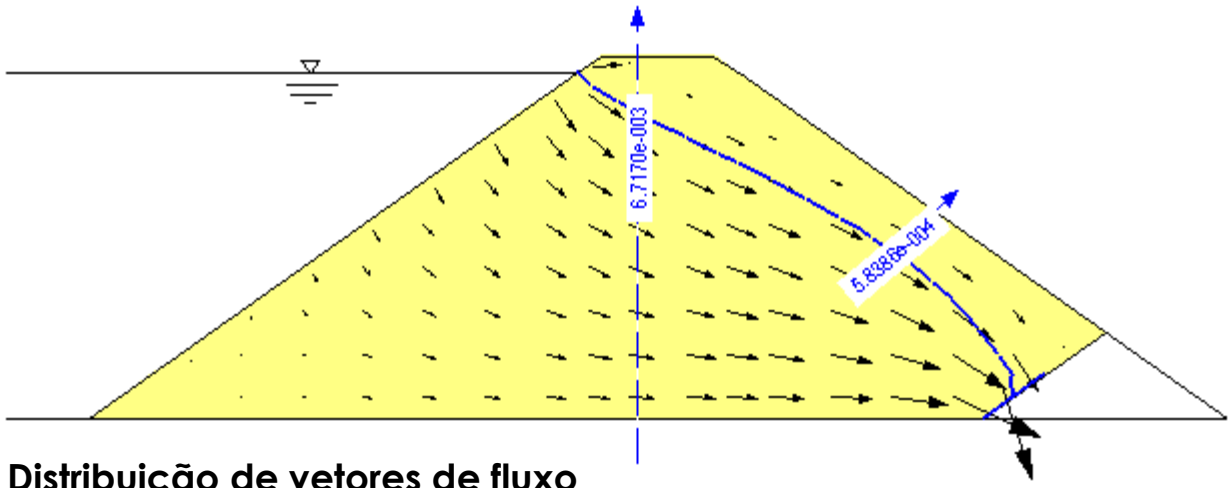


Centerline Raise Construction Method

Fluxo de Água em Barragens

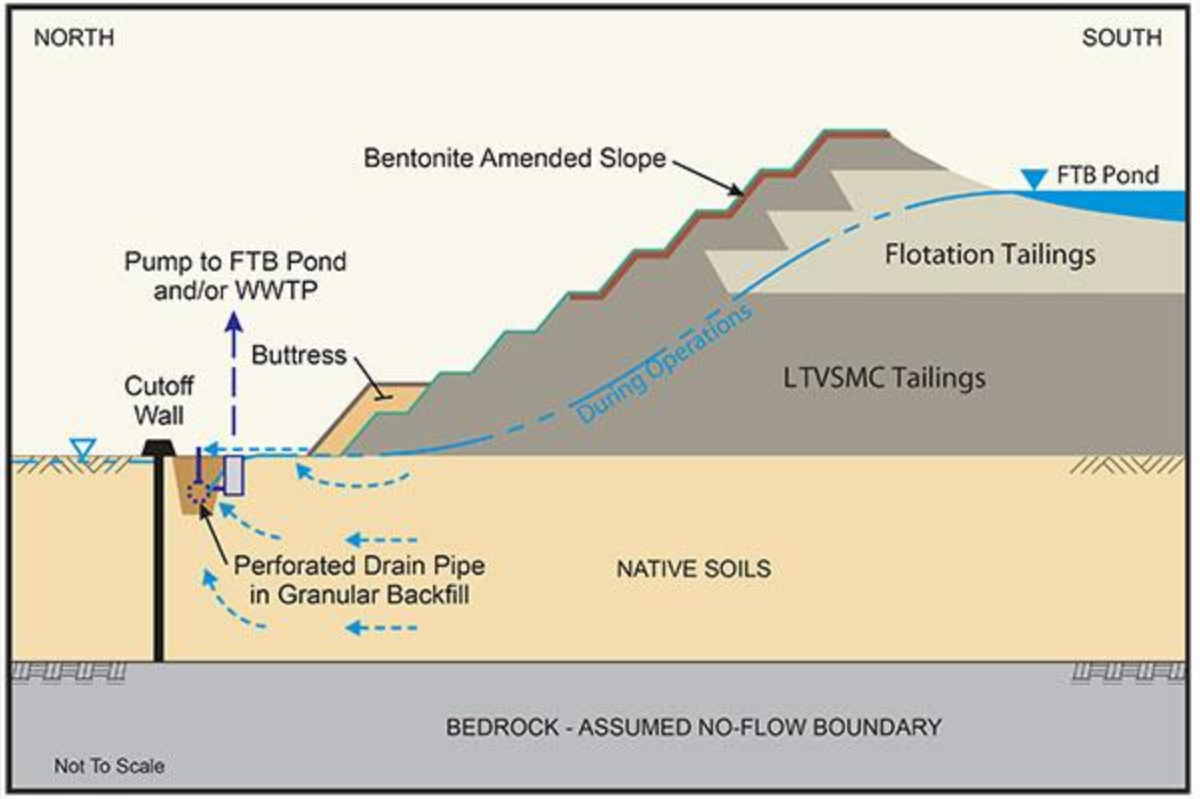


Distribuição de cargas hidráulicas

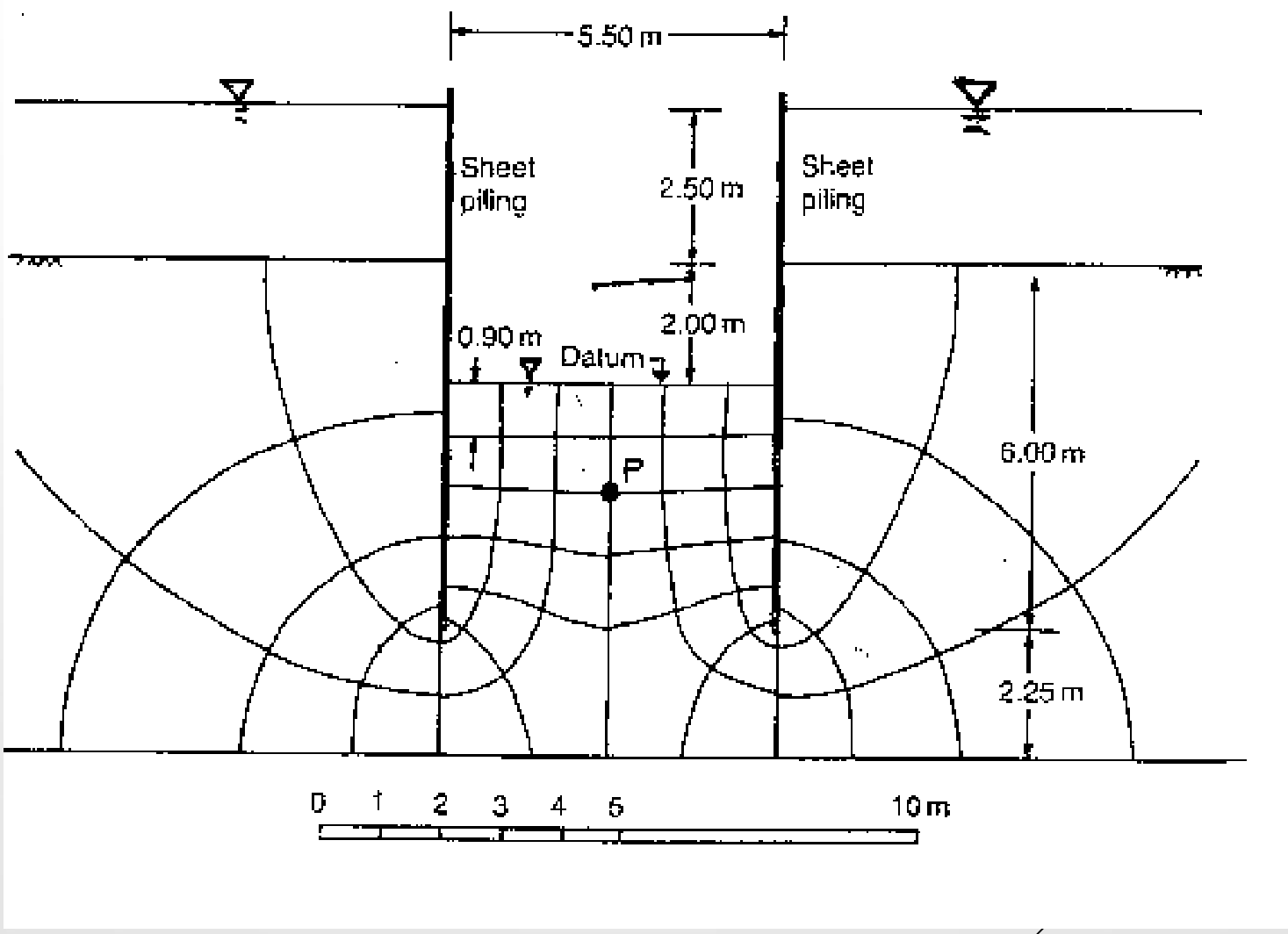


Distribuição de vetores de fluxo

Fluxo de Água em Barragens de Rejeitos



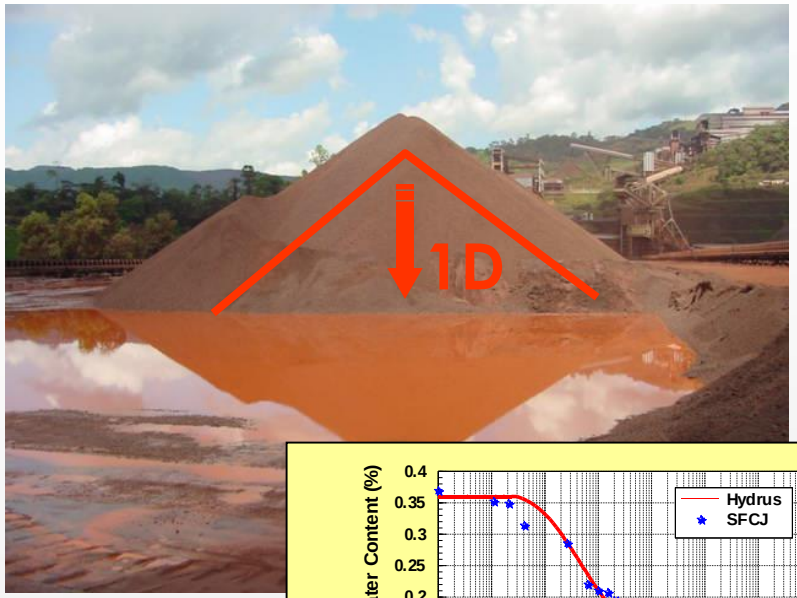
Fluxo de Água em Valas



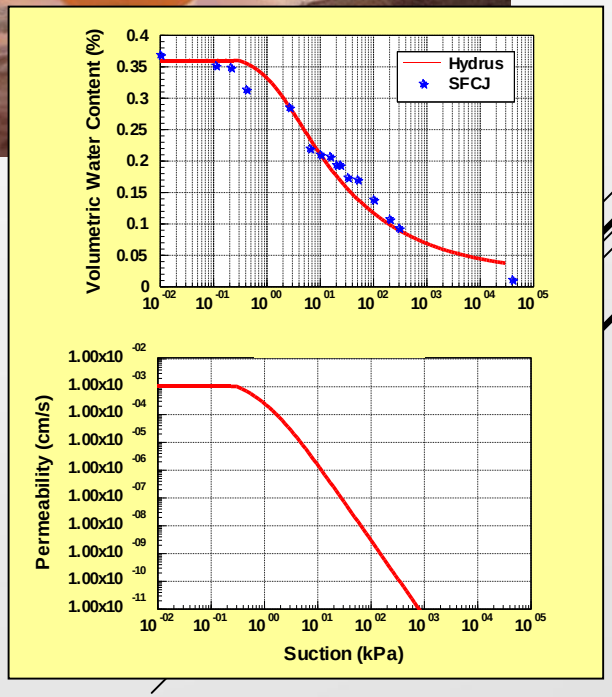
Estudos do Movimento da Água em Meio Não Saturado na Solução de Problemas

No pátio de estocagem

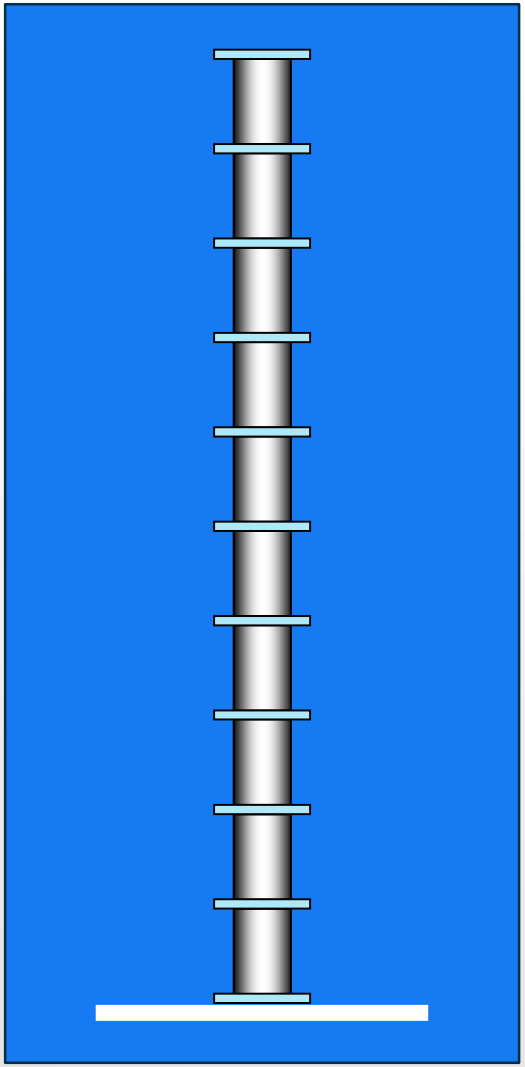
No navio







Modelo Físico do Problema





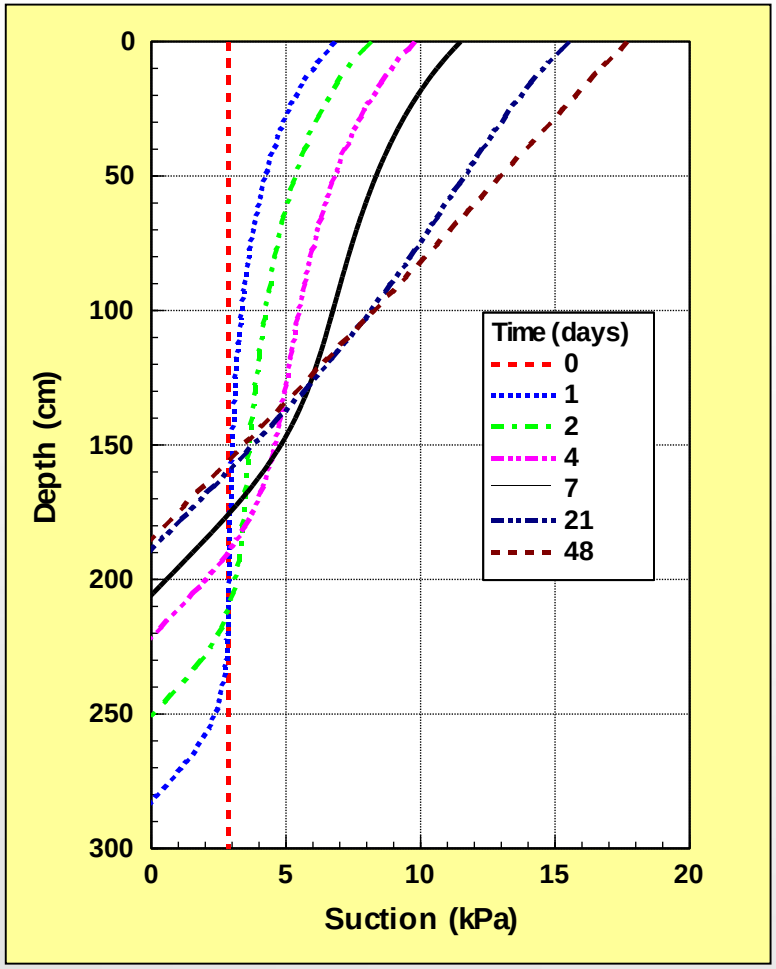


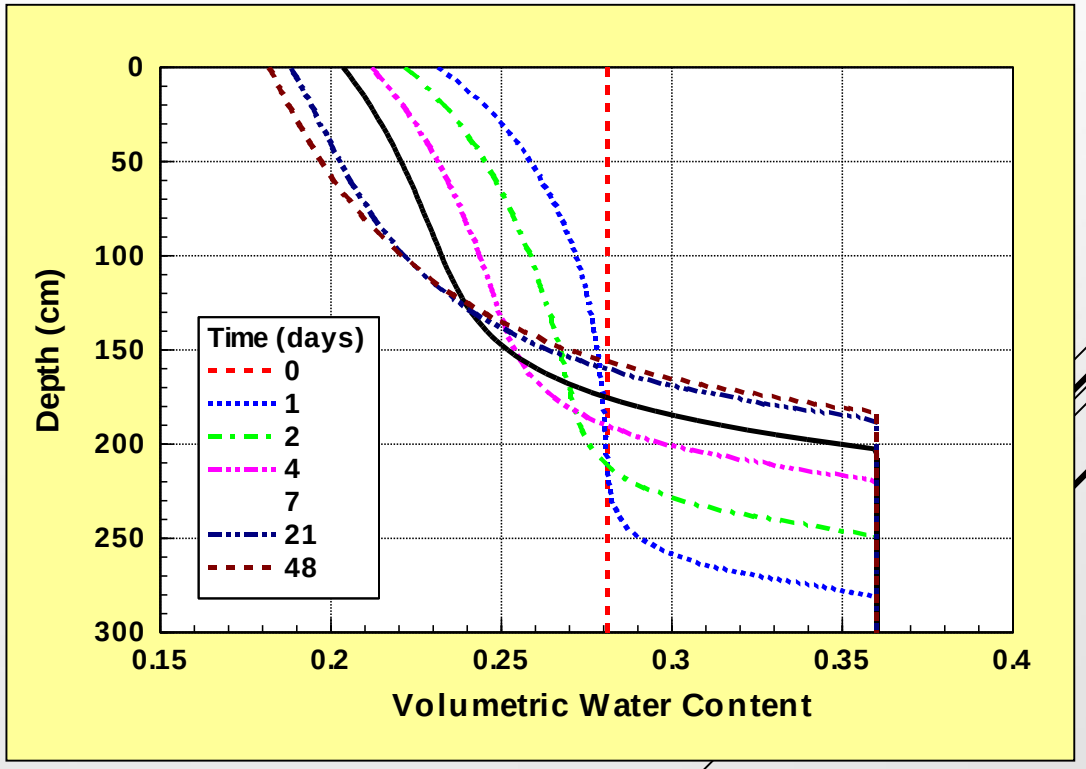






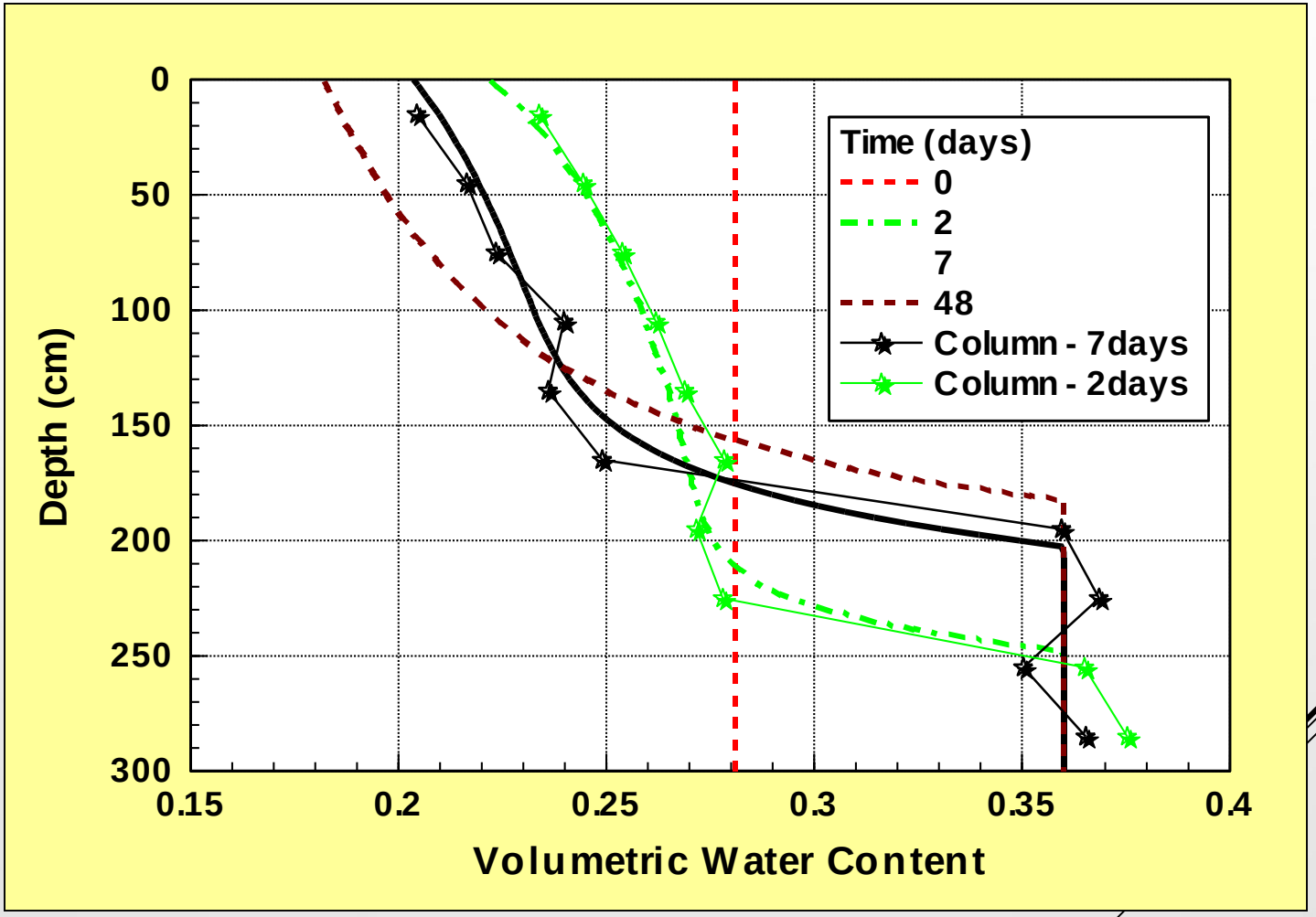
Previsão de Comportamento
Hydrus 1D





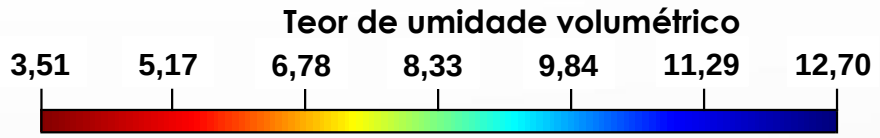
Marinho & Sousa Pinto (2002)

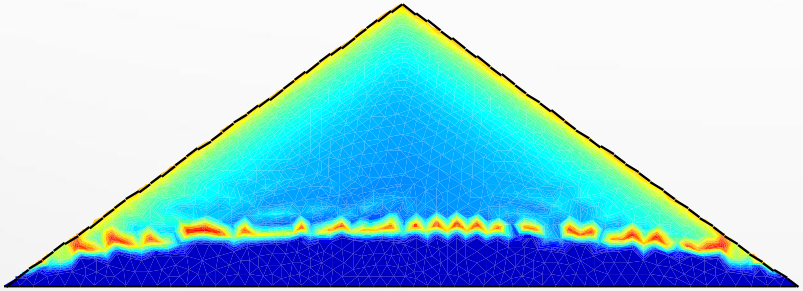
Análise Numérica versus Dados Experimentais
Calibração do Modelo



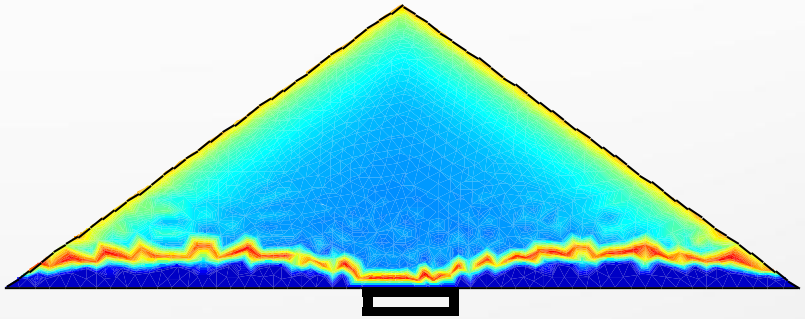
Casos Bidimensionais em Pilhas de Minério

T (dias) = 1

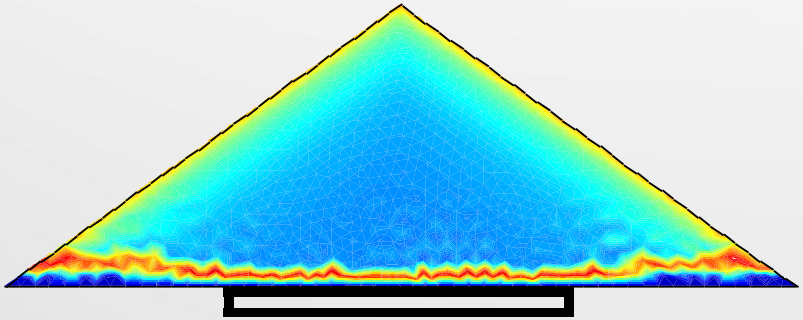




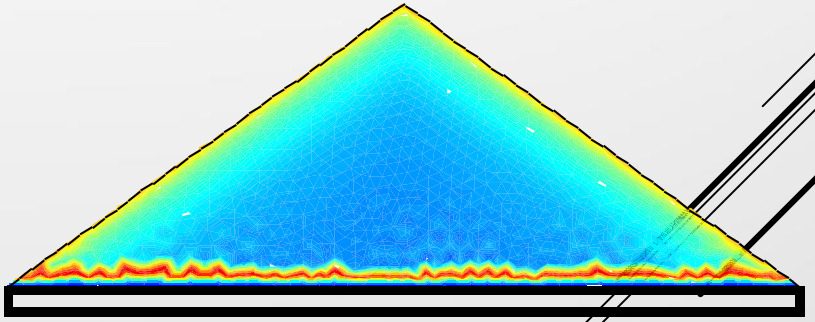
C = 0 m



C = 5,6 m



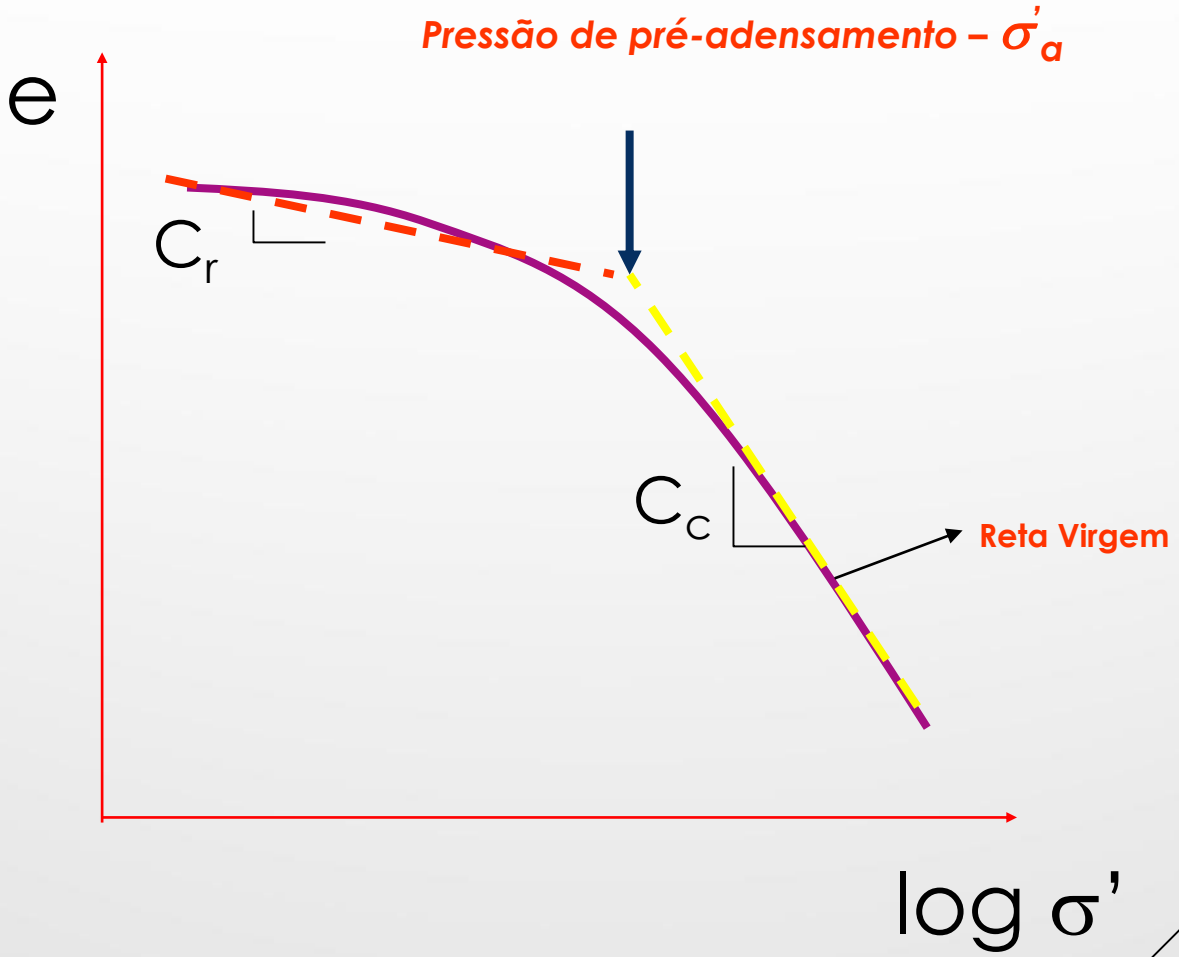
C = 28 m



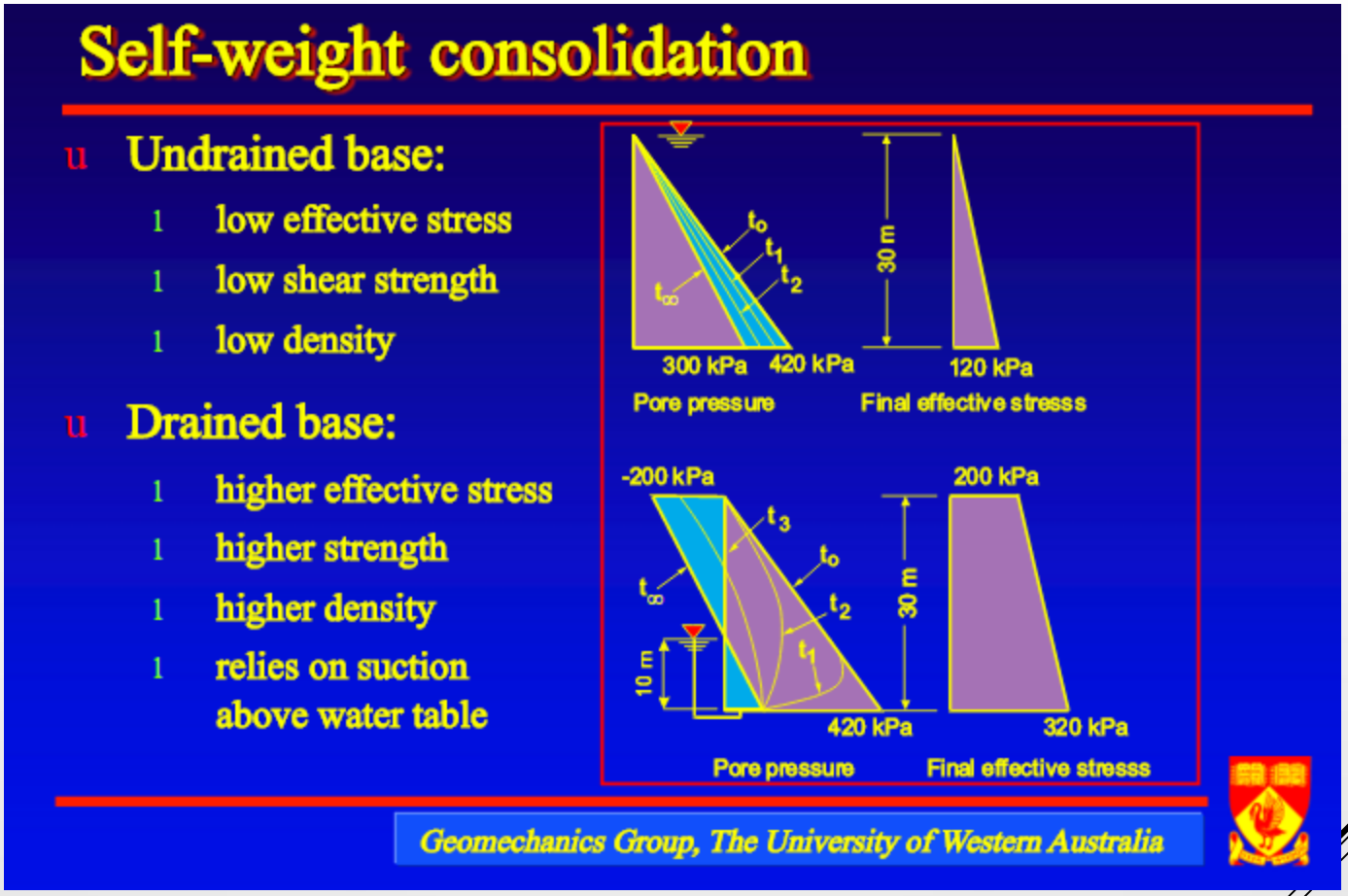
C = 56 m

Abrão & Marinho (2004)

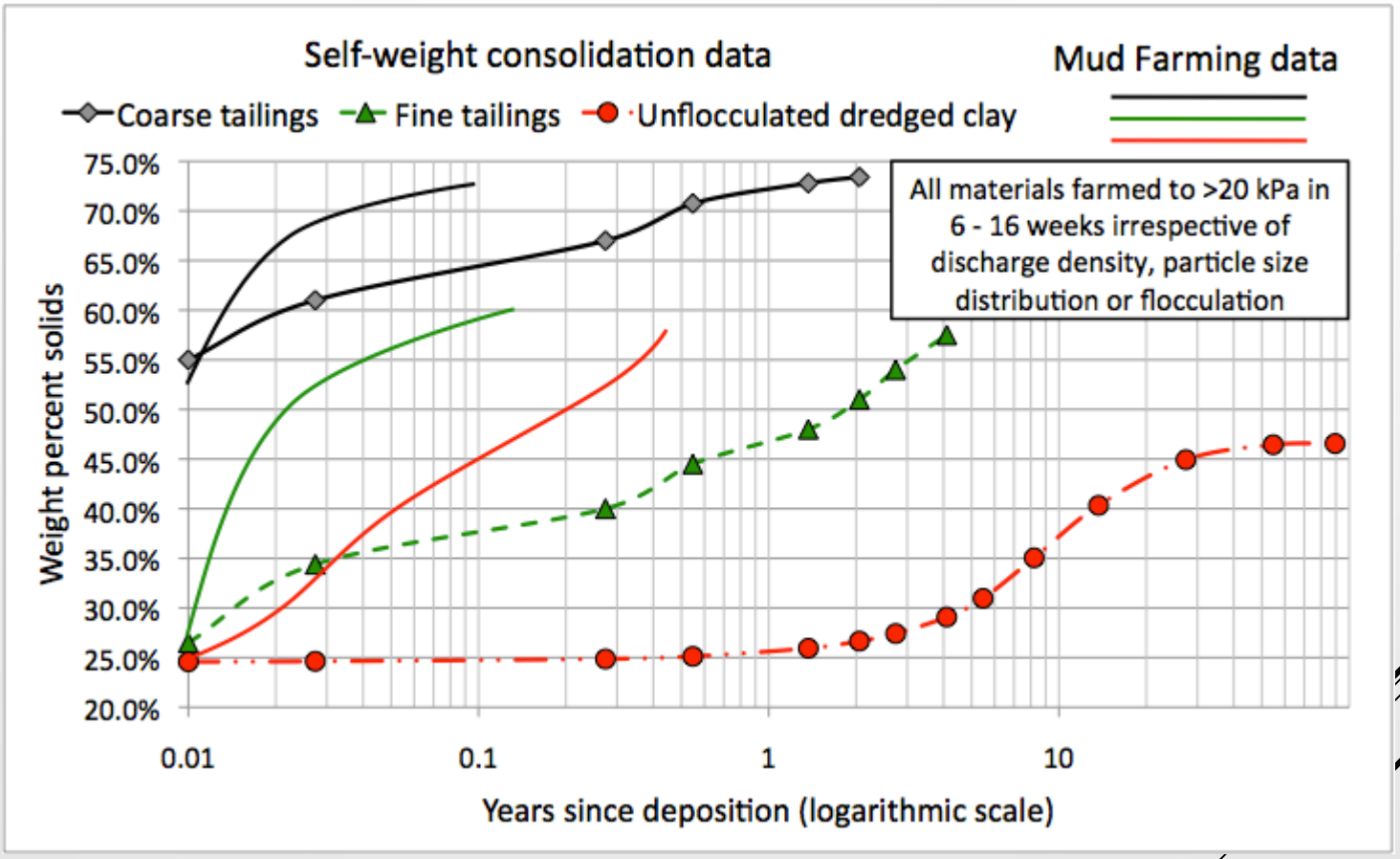
Adensamento



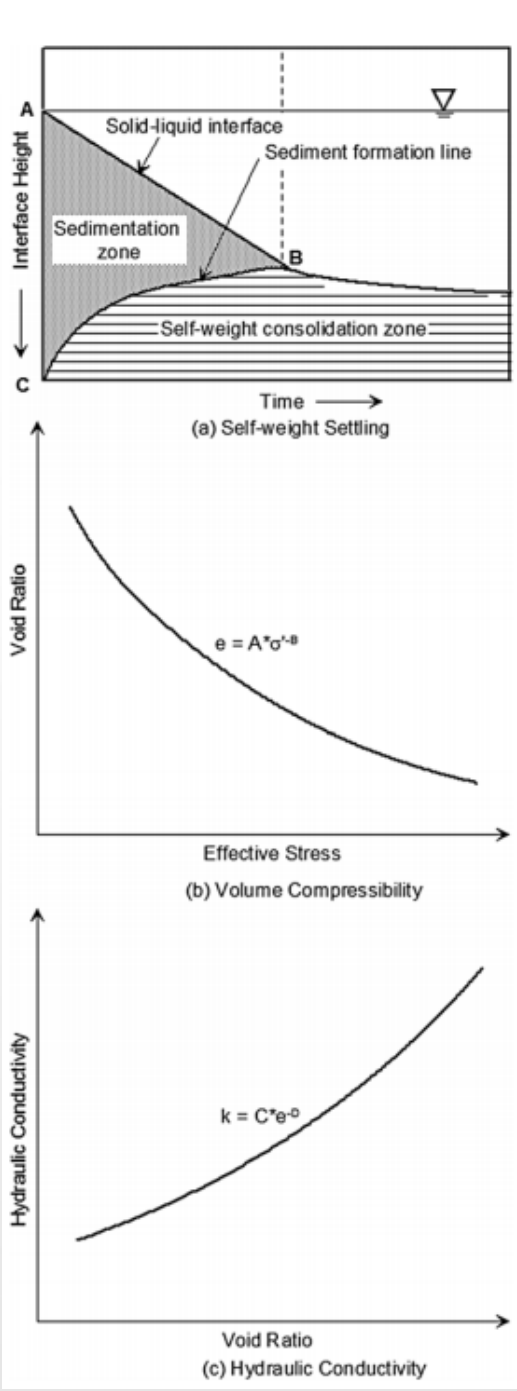
Adensamento



Adensamento



Adensamento



Ito & Azam (2013)

Modelos

Dois tipos:

Ilustrativos

Previsão

Modelo ilustrativo – Nos dá uma visão geral do comportamento do solo.

Modelo de Previsão – deve ser capaz de prever o comportamento do solo em condições reais.

Modelos Físicos

Usados quando a teoria apresenta grandes simplificações e aproximações ou quando a solução numérica é complexa e demorada

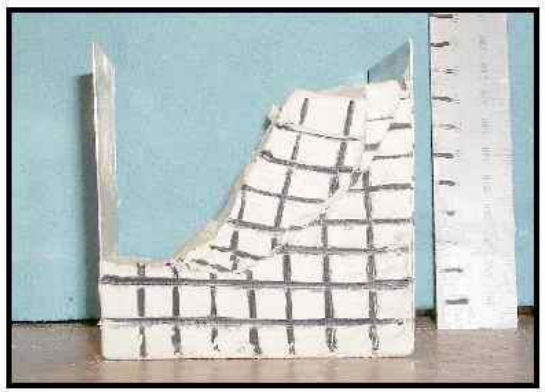
Os modelos físicos são pouco usados na geotecnia hoje em dia.

Exceto o modelo com centrífuga.

Estudos do comportamento mecânico da obra

Validação de análises numéricas

Estudos paramétrico







Modelos para os materiais

Modelo linear e elástico
Modelo não linear e elástico
Modelo Mohr-Coulomb
Modelo "Cam Clay"

Condições de contorno

Ancoragens, geotexteis, etc.

Carregamentos

Água



