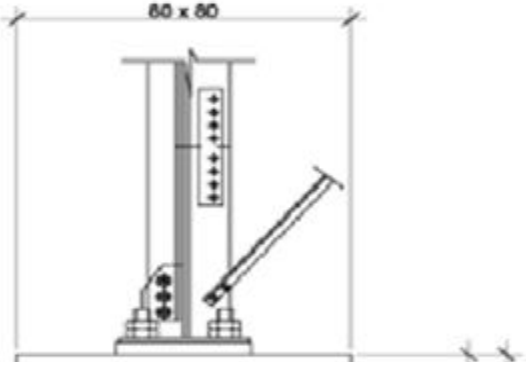
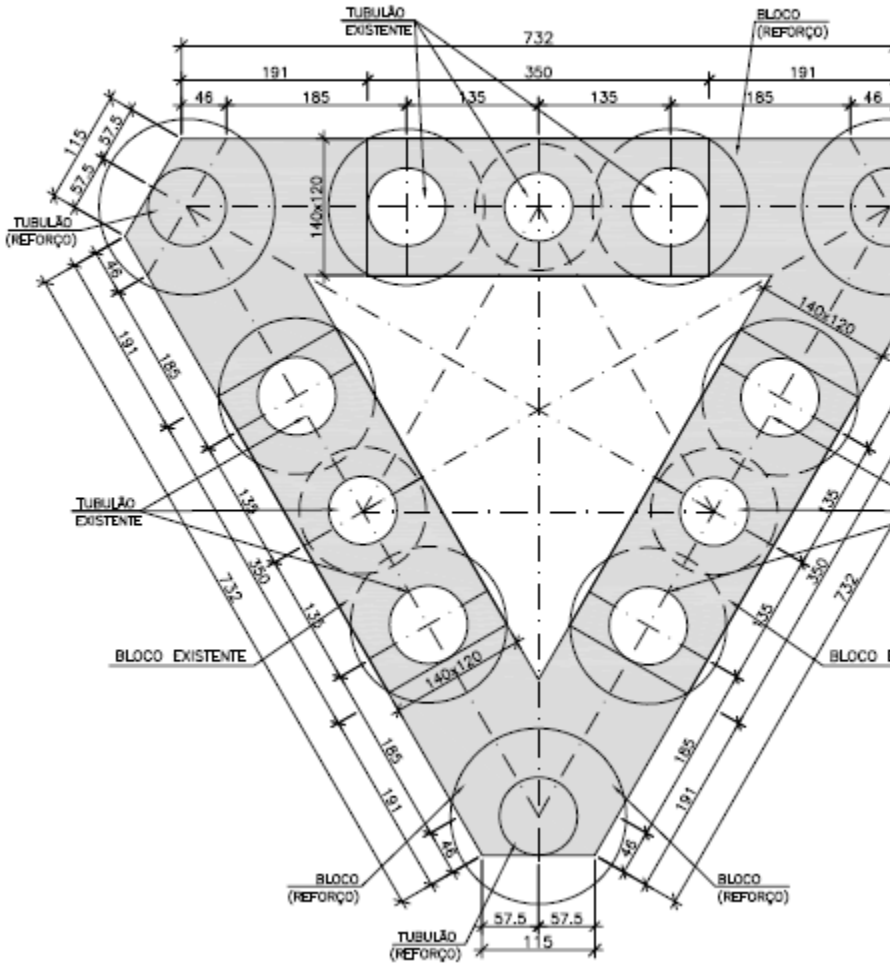
Problem

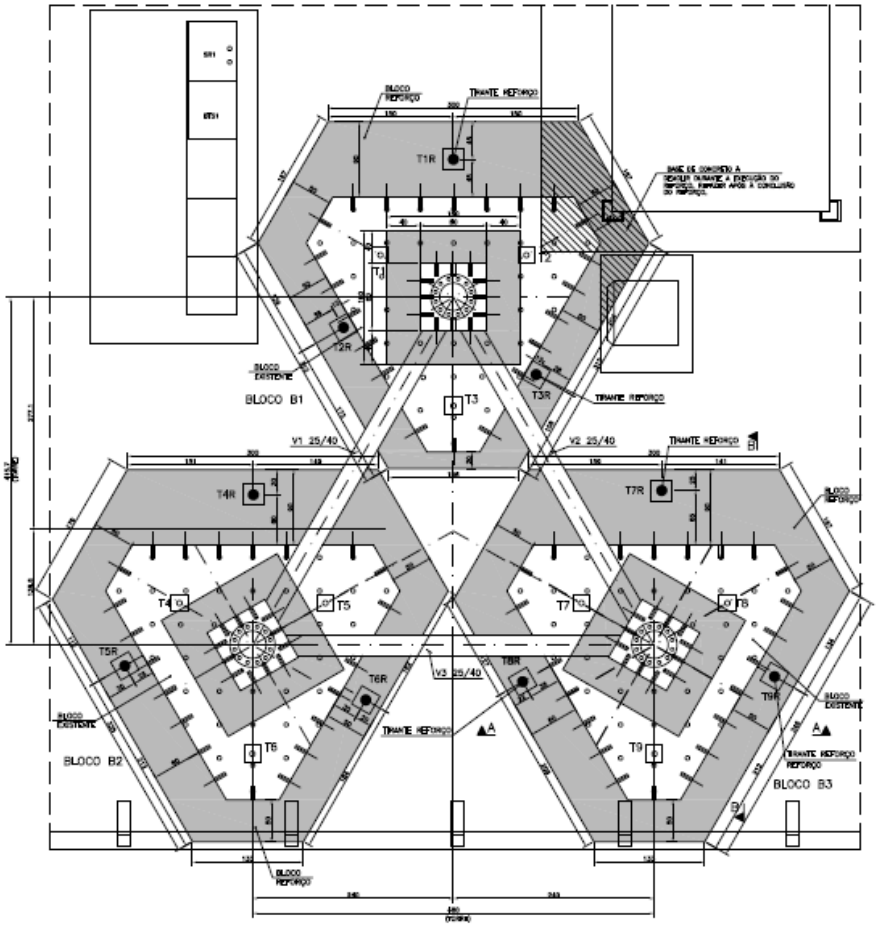


LOCAÇÃO DO REFORÇO

DETALHE DO REFORÇO

ESC.1:50





INSTITUTO DE ENGENHARIA

DETERMINAÇÃO DE COMPRIMENTO DE FUNDAÇÕES EXISTENTES COM ENSAIOS GEOFÍSICOS – NOVAS TENDÊNCIAS

Tiago Souza
Engenheiro Civil, MSc. (USP), PhD. Stud. (ITA)

solotechnique CONSULTORIA E ENGENHARIA GEOTÉCNICA

Engenharia e Consultoria LTDA Somando valores à vida

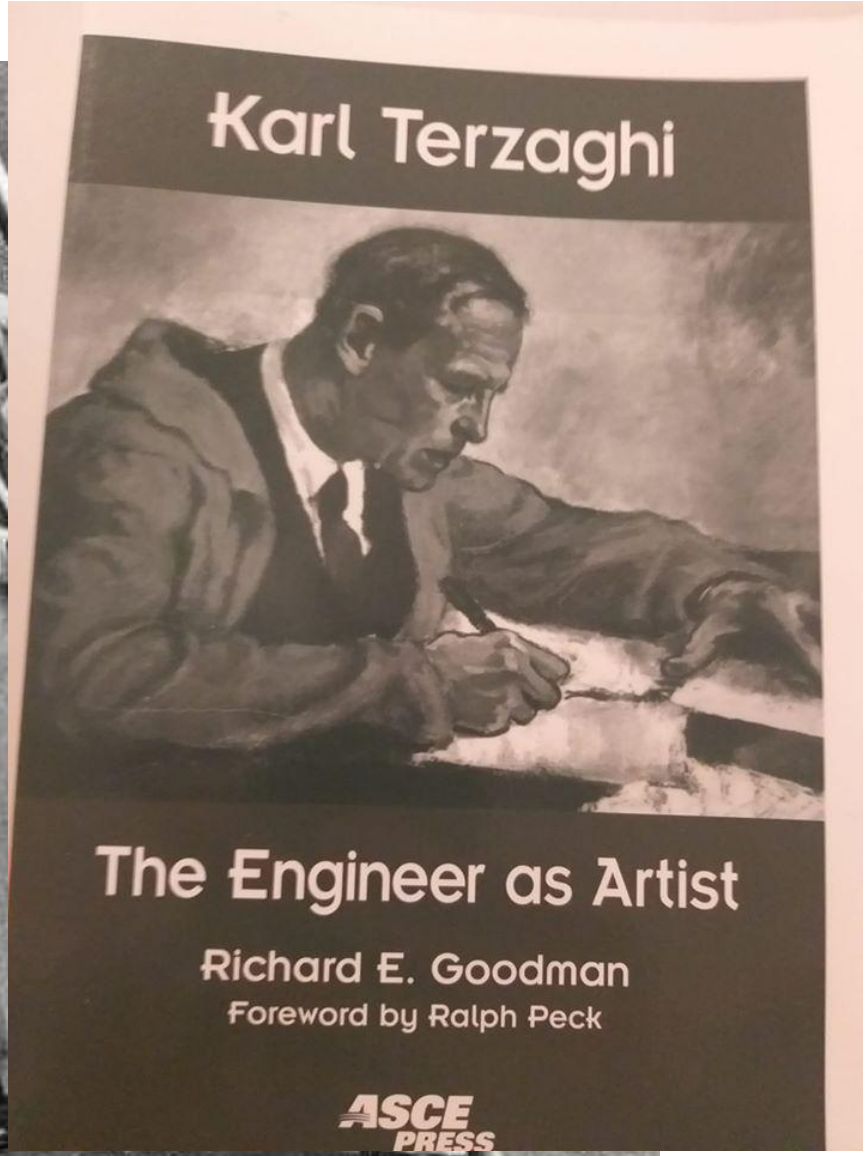
TQS Informática Ltda.

ENGETI

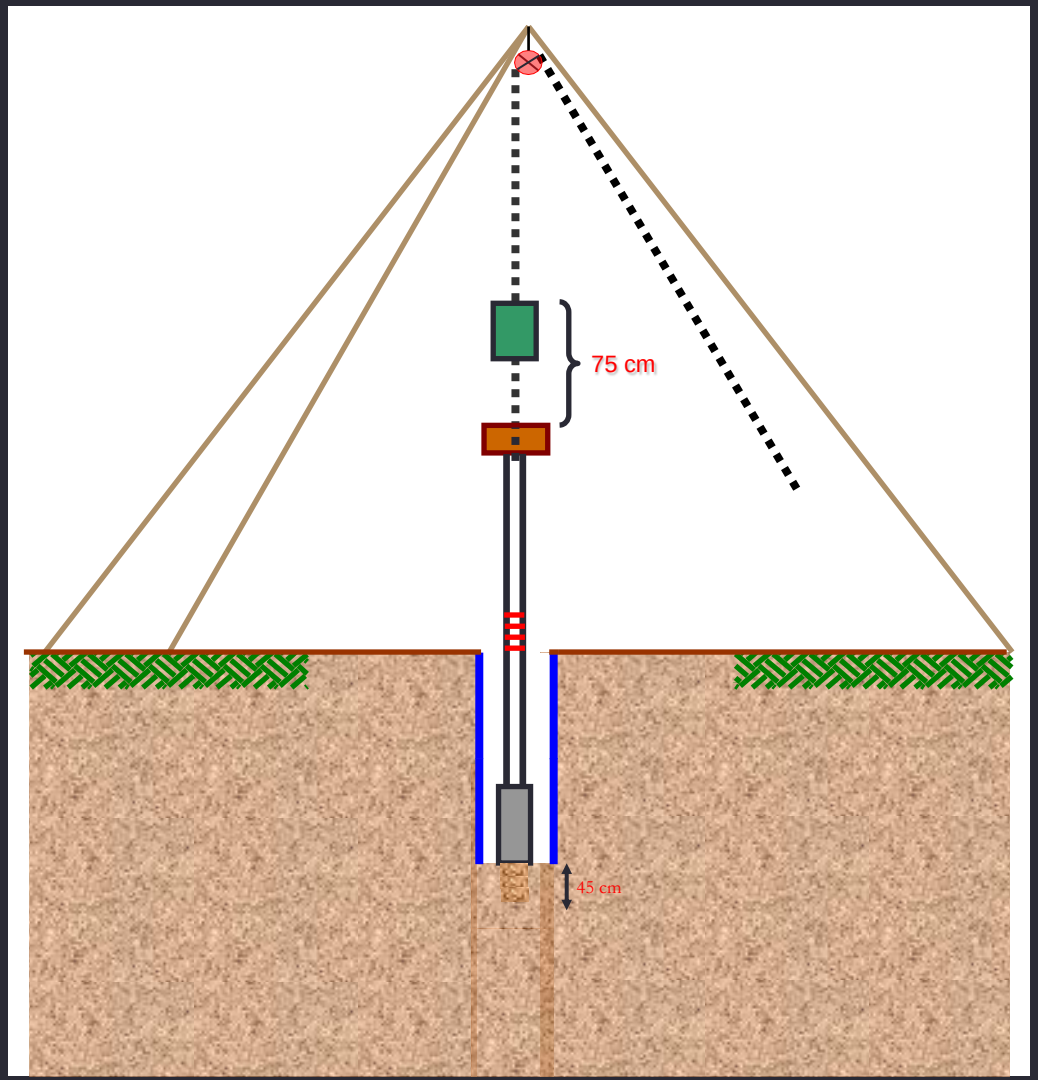
IBRACON

ASSOCIAÇÃO BRASILEIRA DE ENGENHARIA E CONSULTORIA ESTRUTURAL ABECE

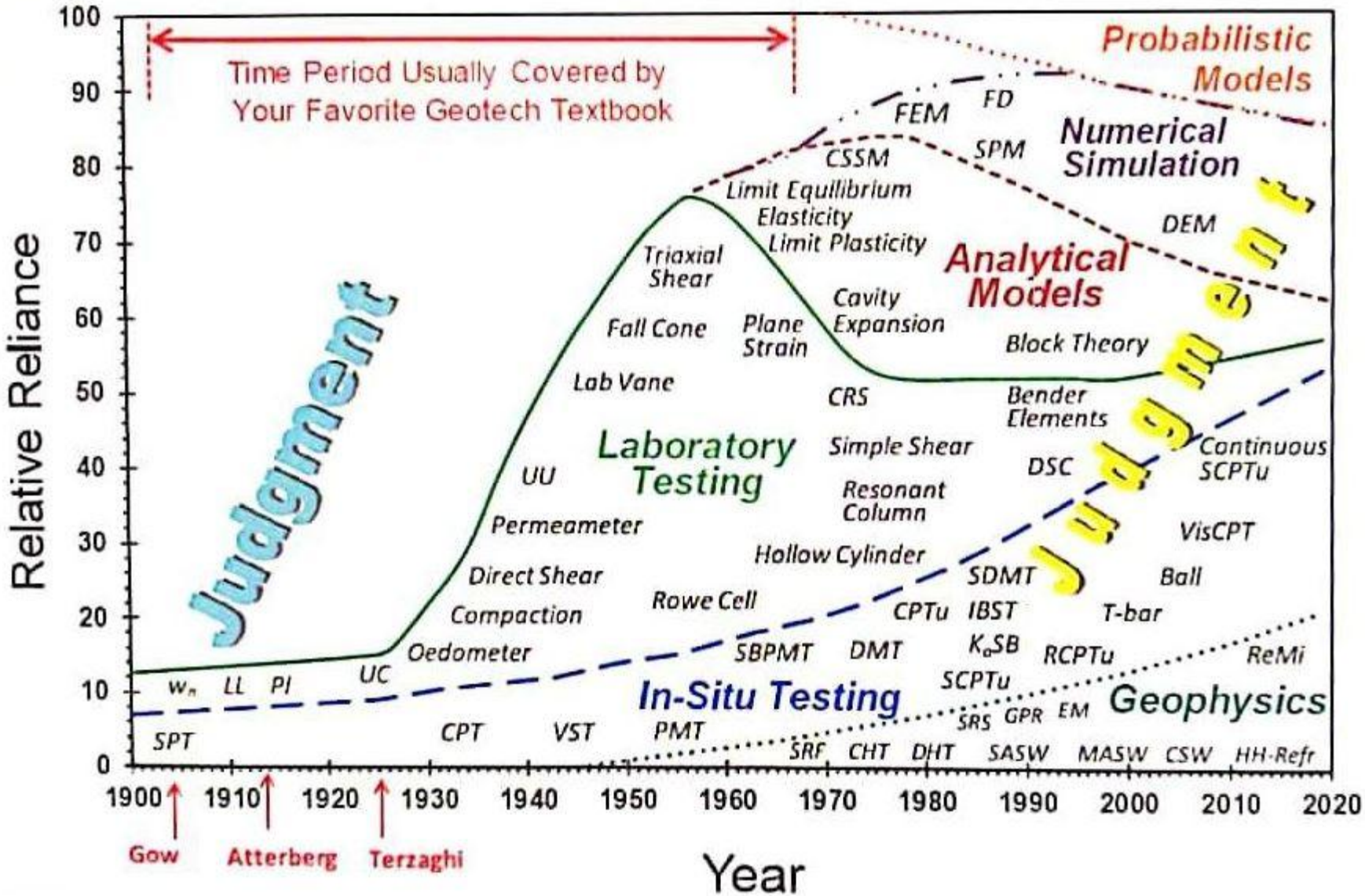
CREA-SP


Karl Terzaghi
The Engineer as Artist
Richard E. Goodman
Foreword by Ralph Peck
ASCE PRESS

EXECUÇÃO DO ENSAIO SPT

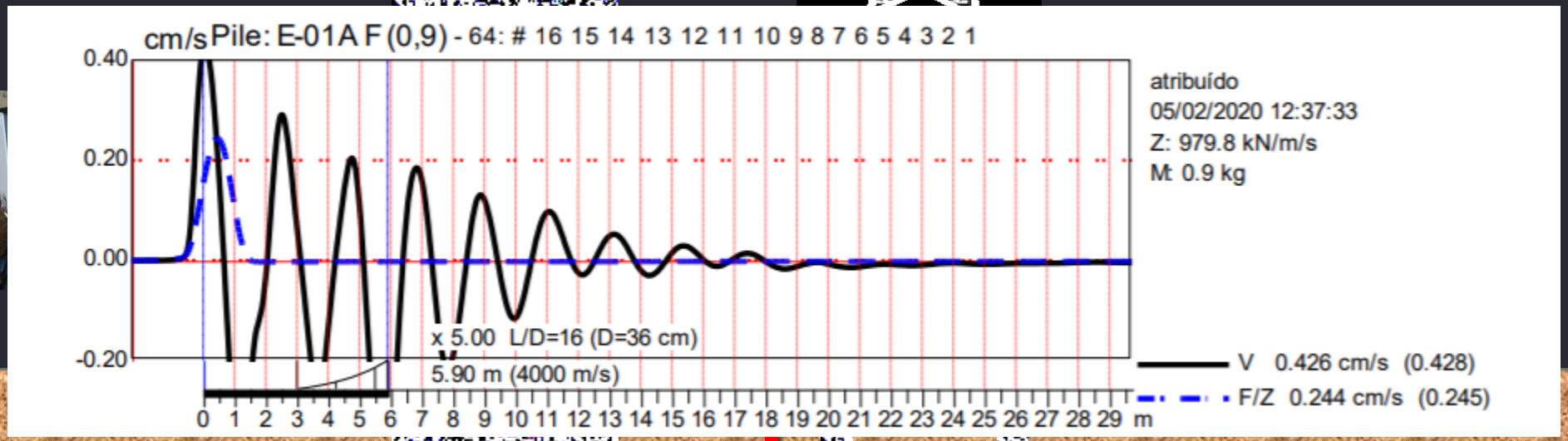


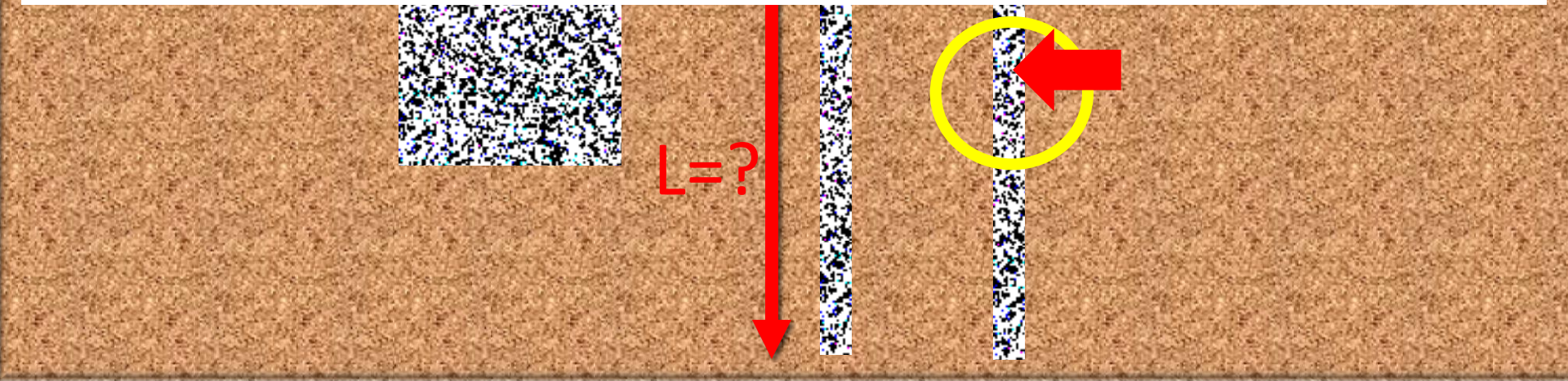
EVOLUTION OF GEOTECHNICAL INFORMATION FOR DESIGN BASIS (ADAPTED FROM LACASSE 1985).

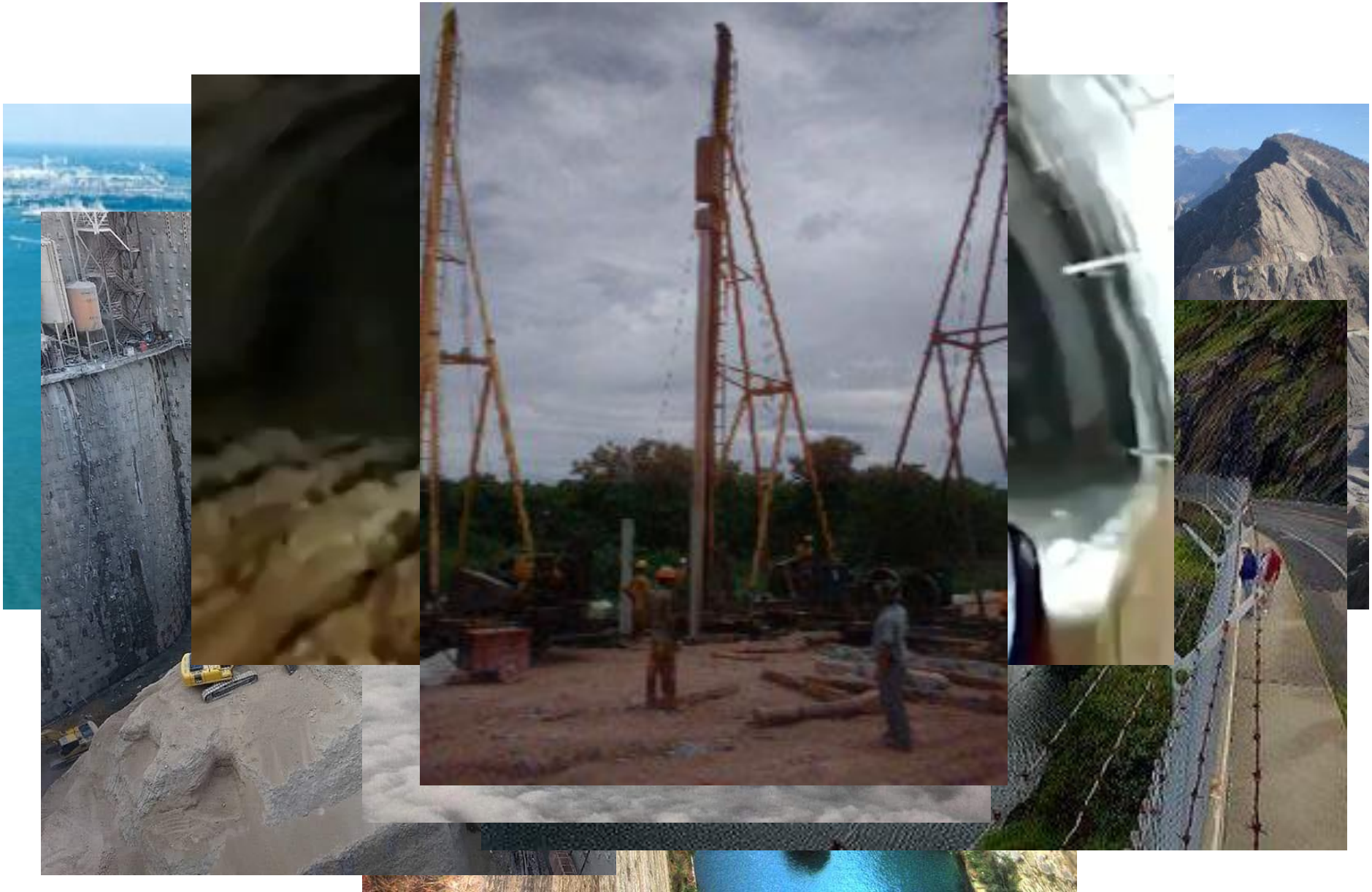


Solution 1

Pile Integrity Test







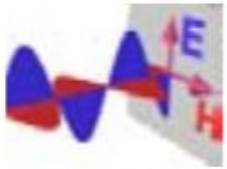
O que é Geofísica ?

"... a Geofísica é uma ciência que se ocupa do estudo das estruturas do interior da Terra e da localização nesta, de corpos delimitados pelos contrastes de algumas de suas propriedades físicas com as do meio circundante, por meio de medidas realizadas na superfície da Terra..."

(modificada de Orellana, 1972)

Informática

Geologia



Física

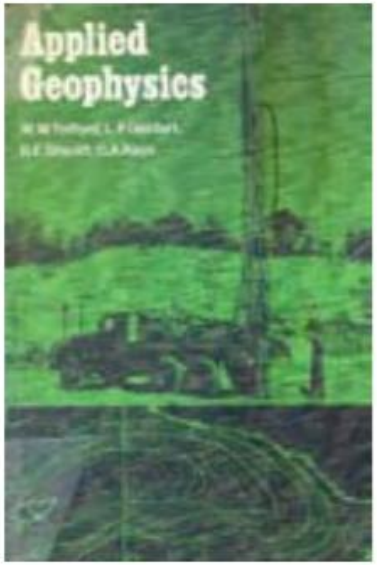
$$\nabla^2\psi = \frac{1}{v^2}\frac{\partial^2\psi}{\partial t^2}$$

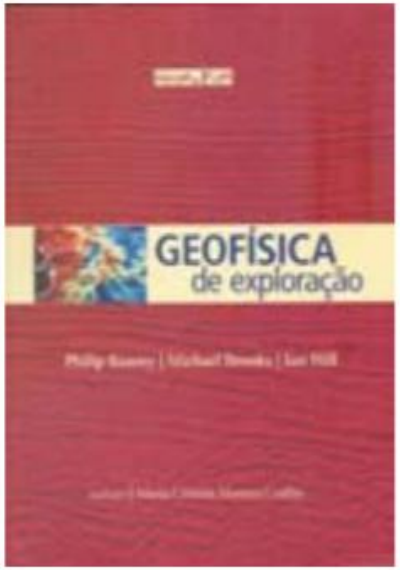
Matemática

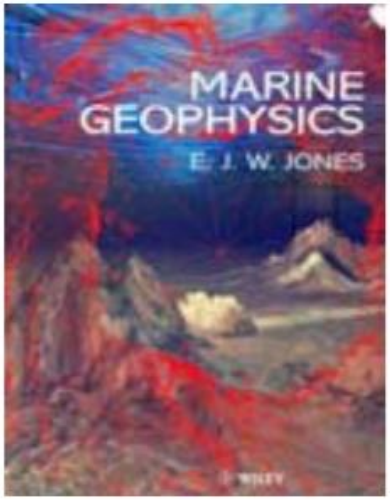
Química

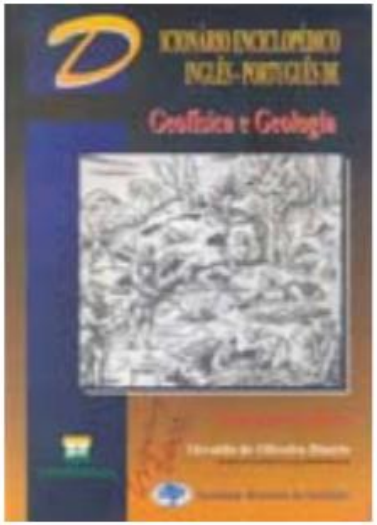
Instrumentação

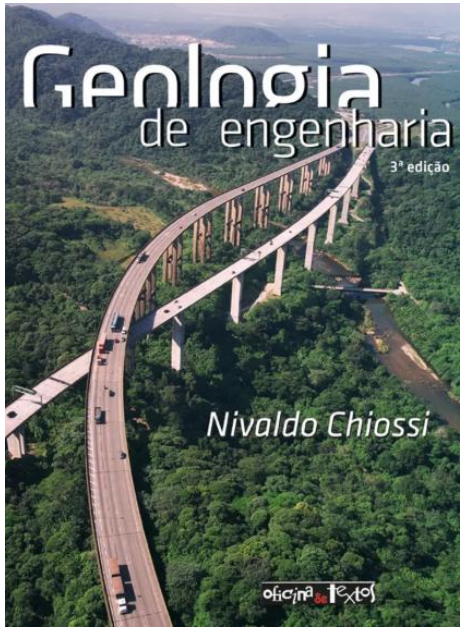
LEITURA OBRIGATÓRIA









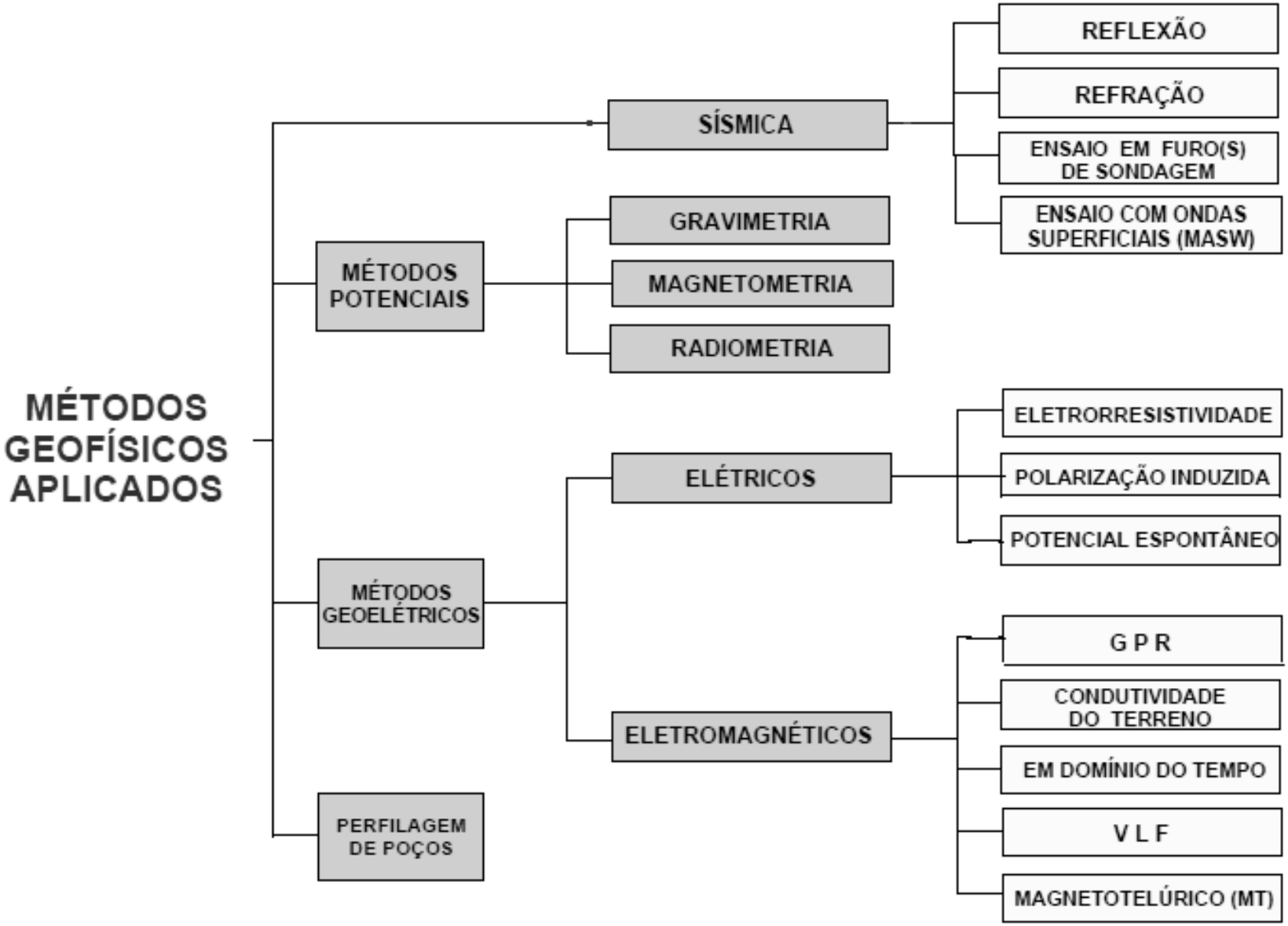


MOBILIZAÇÃO DO MEIO TÉCNICO

writer and teacher, he has been a consultant on a variety of (mainly dynamic) geotechnical problems. The recipient of prestigious awards for his research contributions, he has given the Coulomb (2009) and Ishihara (2013) Lectures, and received the Excellence in University Teaching Award in Greece (2015).

Barry M. Lehane,

CENÁRIO GEOFÍSICO



Engenharia Geotécnica

- O que é Engenharia Geotécnica? É uma ciência? Exata?
- “Projeto x Realidade” – Por que o trabalho multidisciplinar?
- Estruturas geológicas x geotécnicas: tipos e peculiaridades
- Ensaios mais tradicionais: PIT, PDA e PCE (Tradicional e O-CELL).
- Tendências atuais

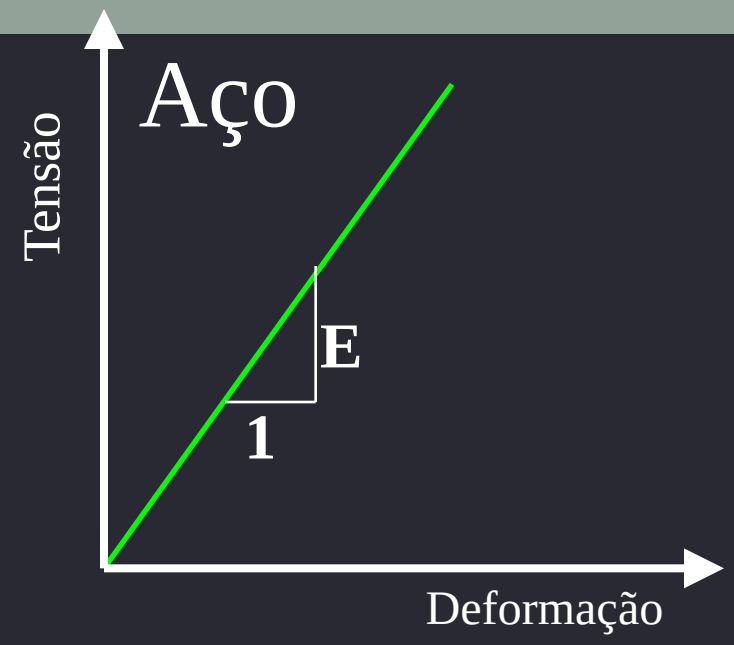
Premissas Importantes

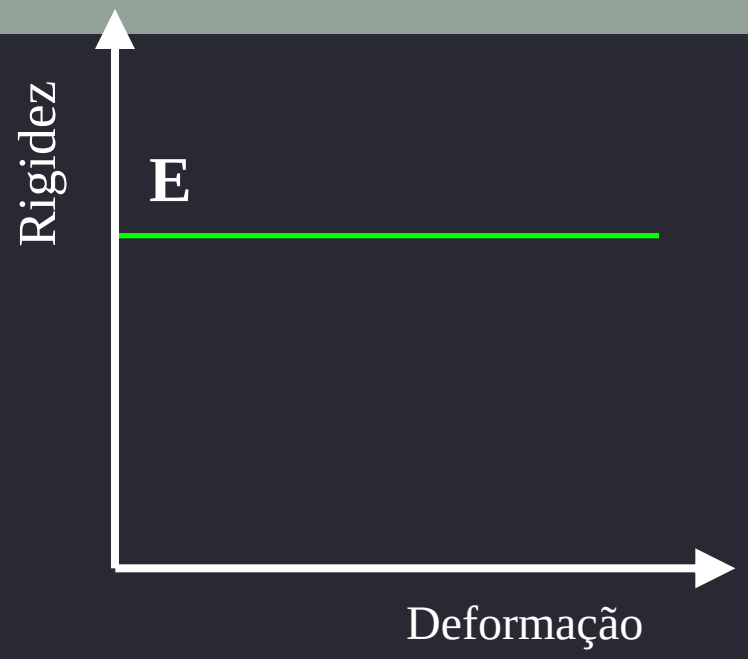
- Os ensaios em geral são componentes indispensáveis para o projeto, a certificação e a verificação dos elementos geotécnicos
- Os engenheiros tem um vasto leque de métodos técnicos disponíveis para controlar a obra
- Não existe ensaio totalmente perfeito e incontestável
- Para cada obra o engenheiro deve escolher a combinação de métodos que forneça a melhor forma de verificação levando-se em conta a precisão, a relação custo-benefício e também as peculiaridades locais da obra em questão.

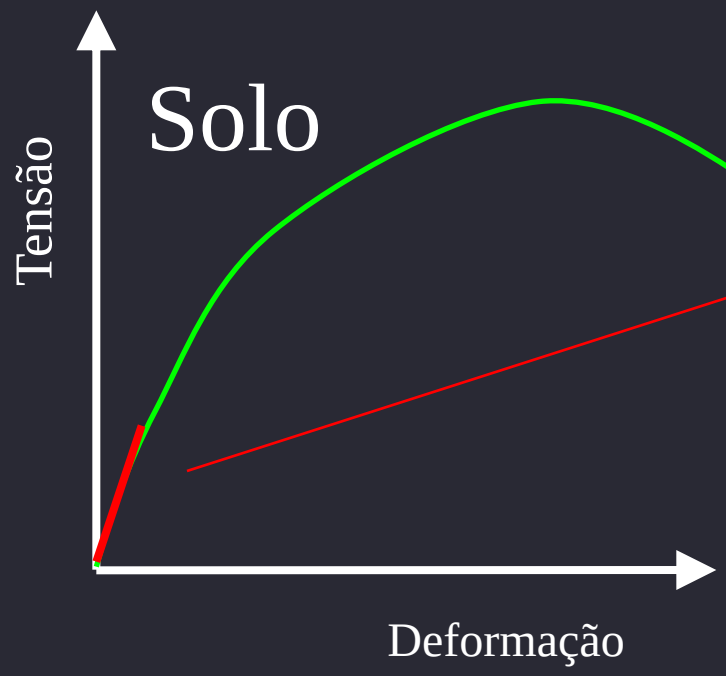
SOLOS TÍPICOS BRASILEIROS

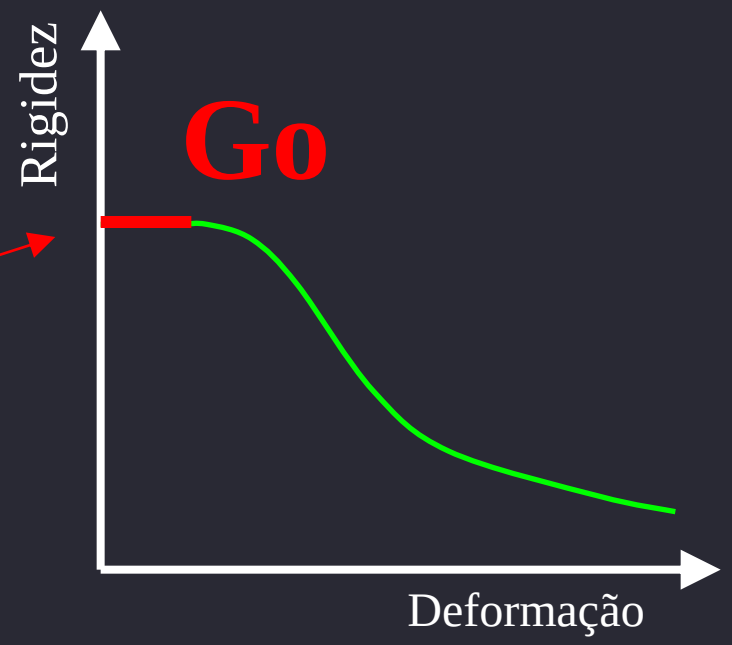
GEOTECHNICAL VARIABILITY

Marine Clay


Aço
Tensão
E
1
Deformação

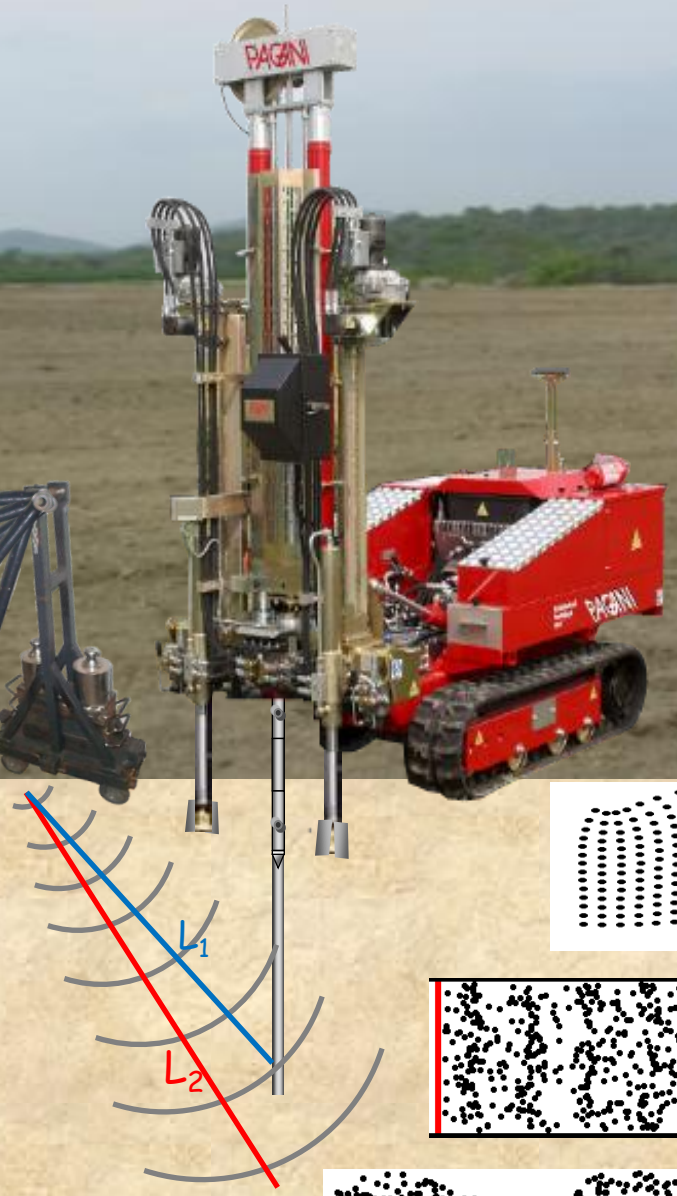

Rigidez
E
Deformação

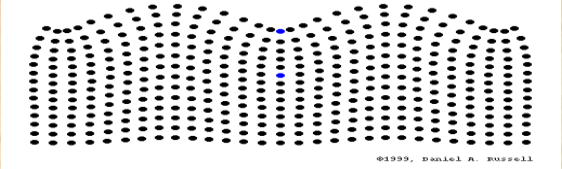

Solo
Tensão
Deformação

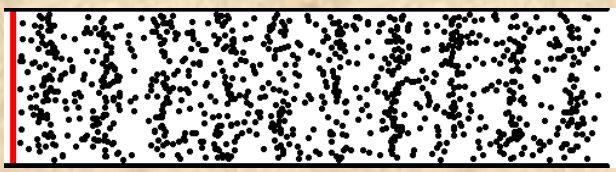

Rigidez
Go
Deformação

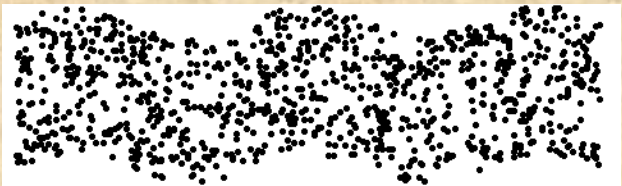
$$V_s = \frac{\Delta s}{\Delta t}$$

$$G_{max} = \rho \cdot V_s^2$$

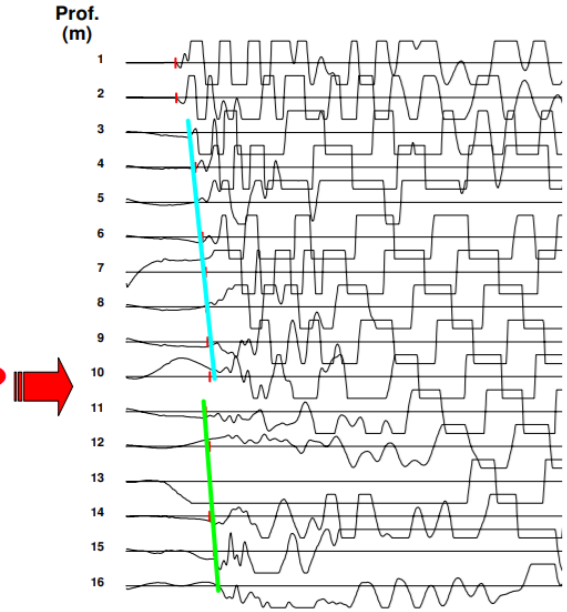




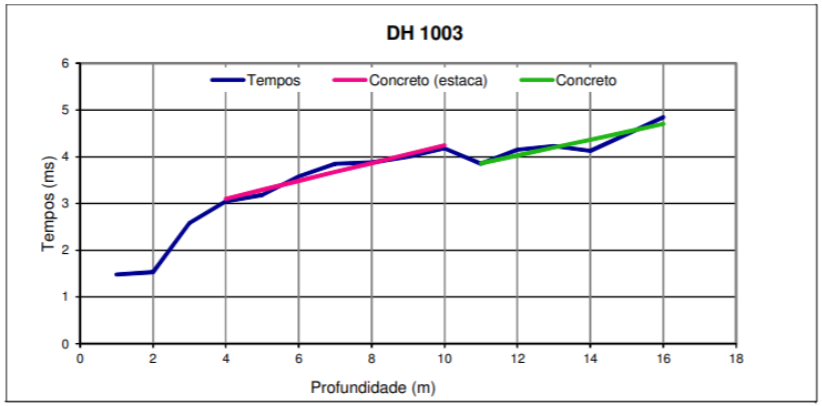




CASO 1



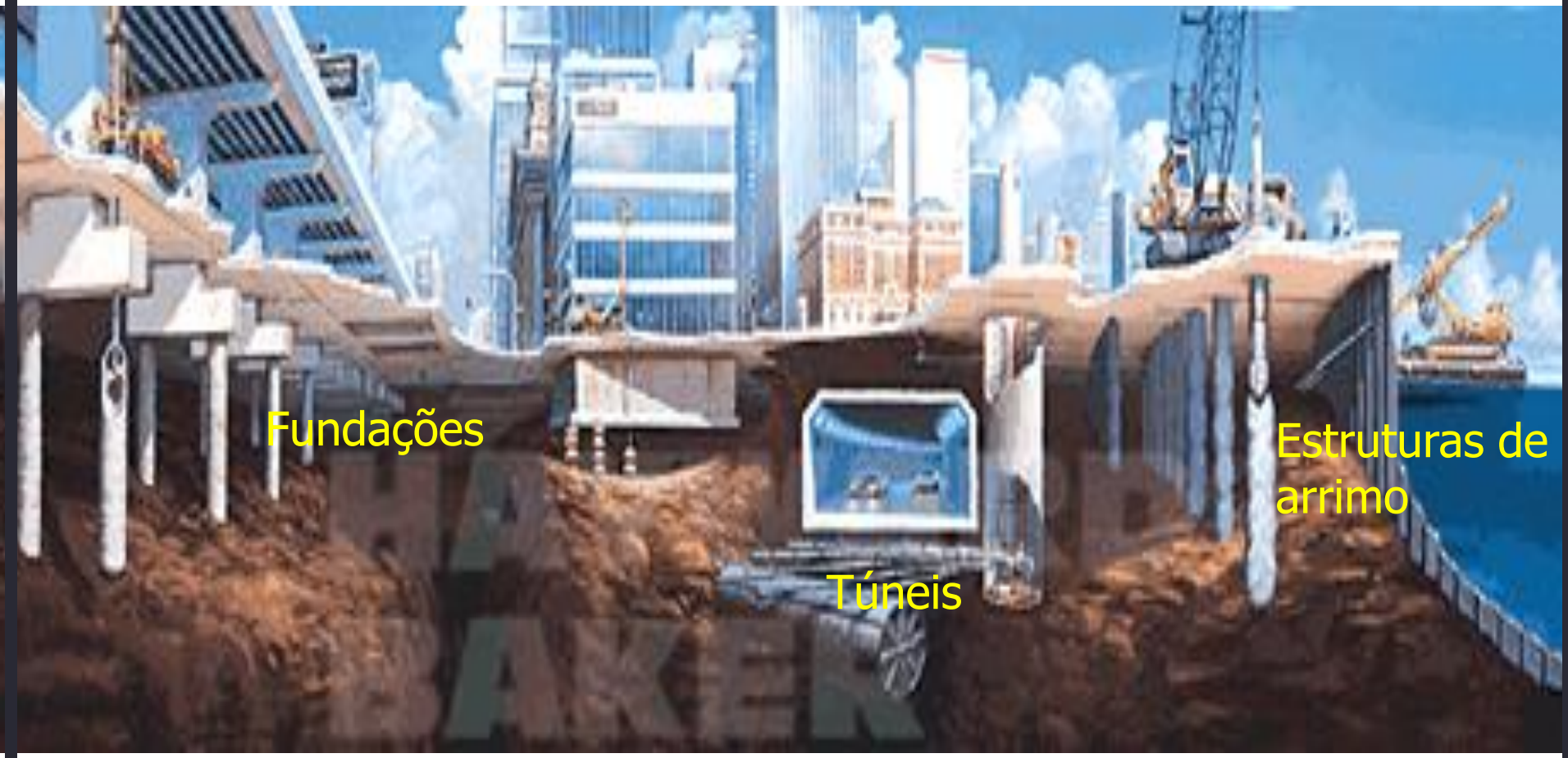
DH Furo F1003		
m	Vel (km/s)	q
0.190357143	5.25	2.3417857
0.168285714	5.94	2.0098095
Prof. (m)	Tempo (ms)	m*Prof.+q
1	1.48	2.53
2	1.53	2.72
3	2.58	2.91
4	3.05	3.10
5	3.18	3.29
6	3.58	3.48
7	3.85	3.67
8	3.88	3.86
9	4	4.06
10	4.18	4.25
11	3.85	3.86
12	4.15	4.03
13	4.23	4.20
14	4.13	4.37
15	4.48	4.53
16	4.85	4.70



Execução, interpretação e aplicação dos ensaios na investigação geotécnica

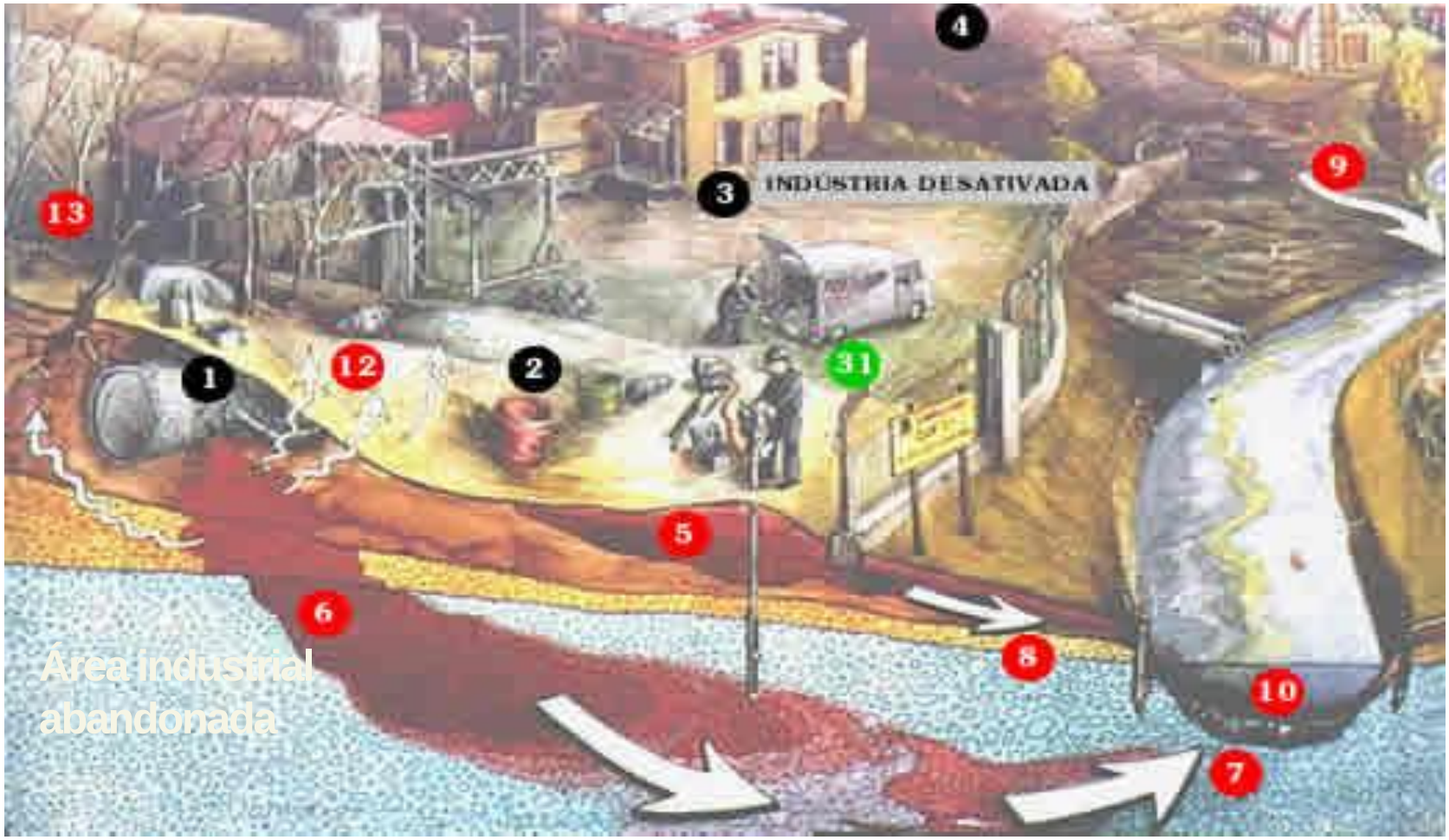
Investigação do subsolo…

Obras Geotécnicas



… onde é necessário ?

Investigação do subsolo… Problemas ambientais



Fontes de perigo

Cenários

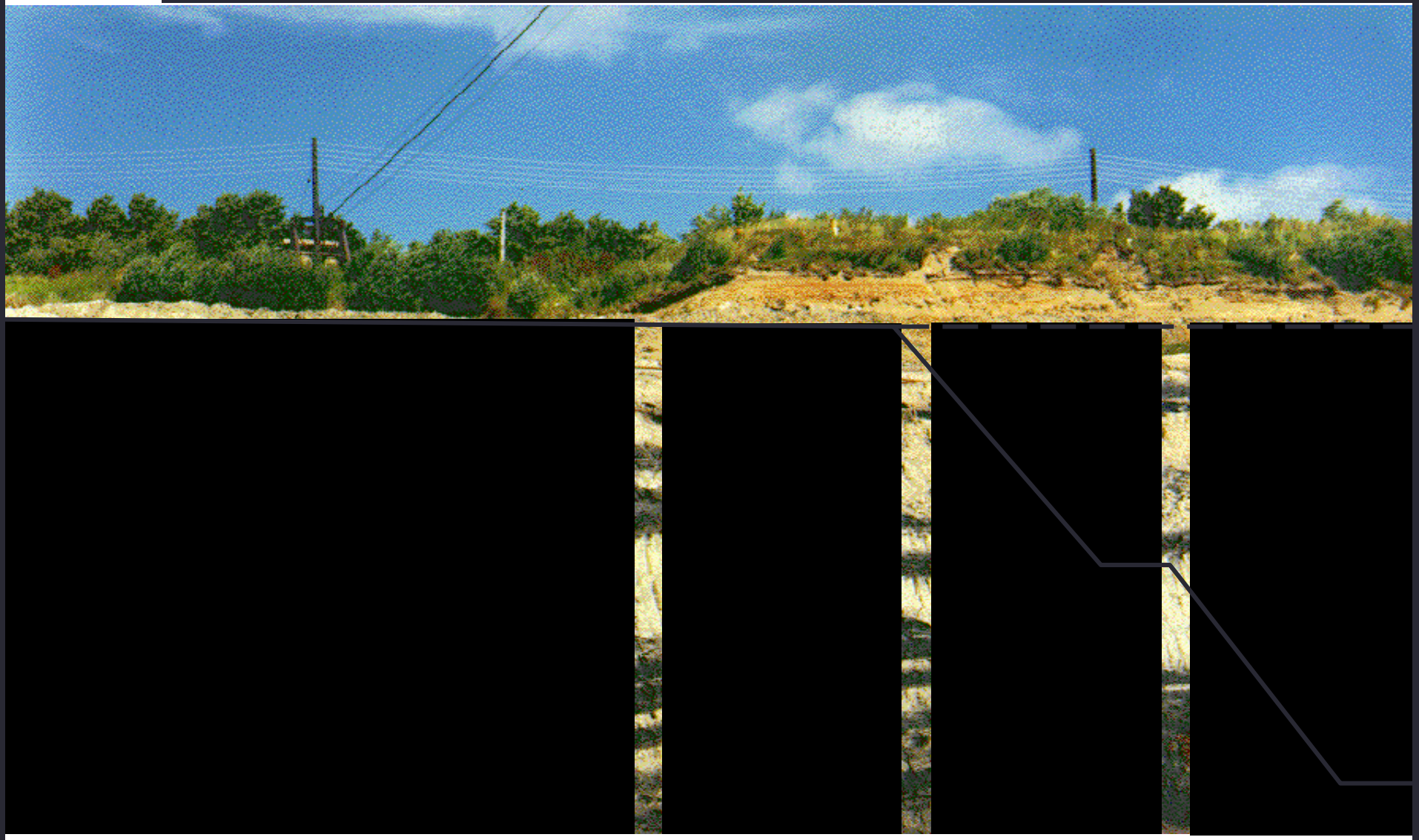
Medidas de investigação do problema

INVESTIGAÇÃO DO SUBSOLO

Um exemplo

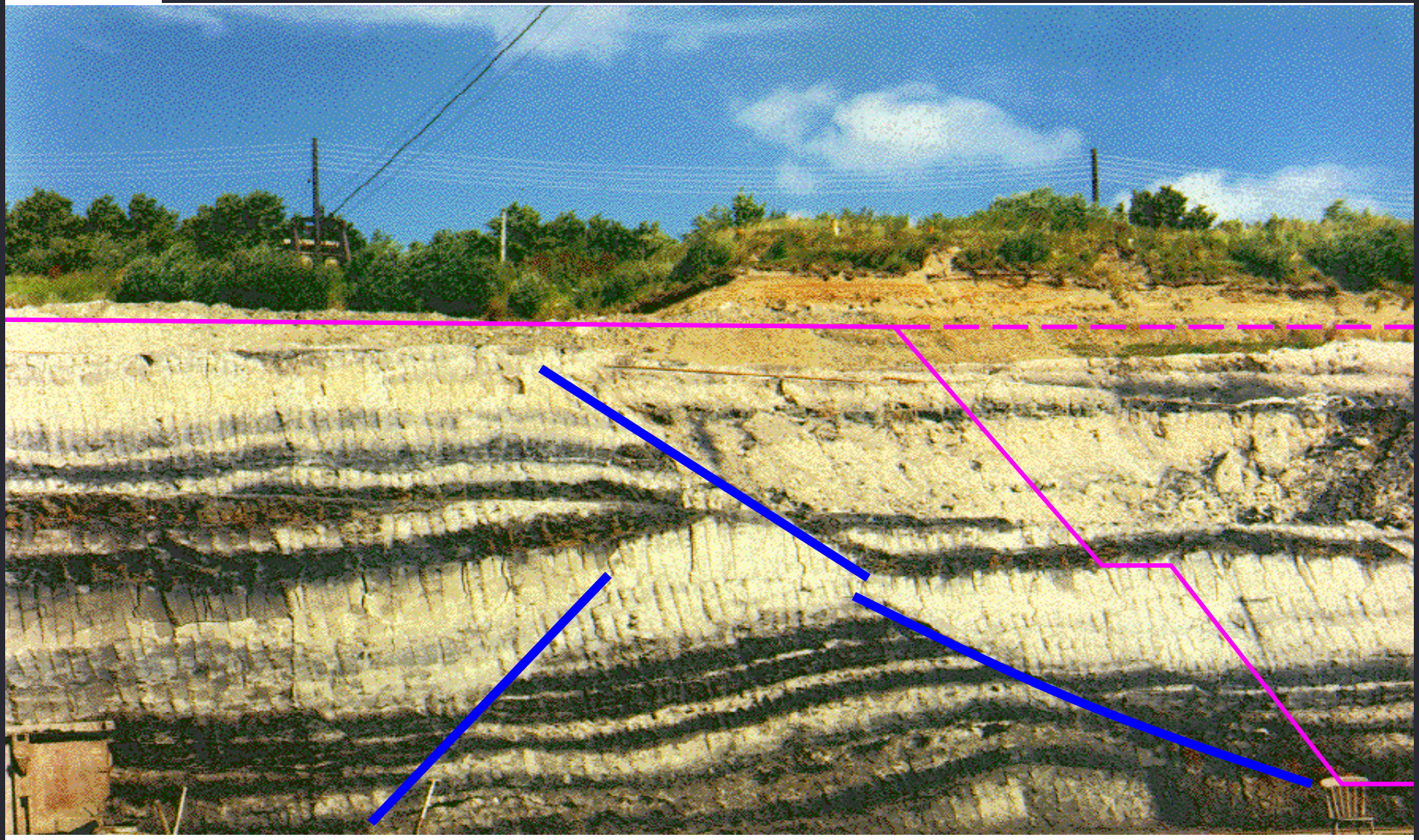
Material confidencial.

Escavar Solo em um local → Quais as condições do subsolo?



“mesmo uma perfuração perfeita fornece informações de posições específicas”

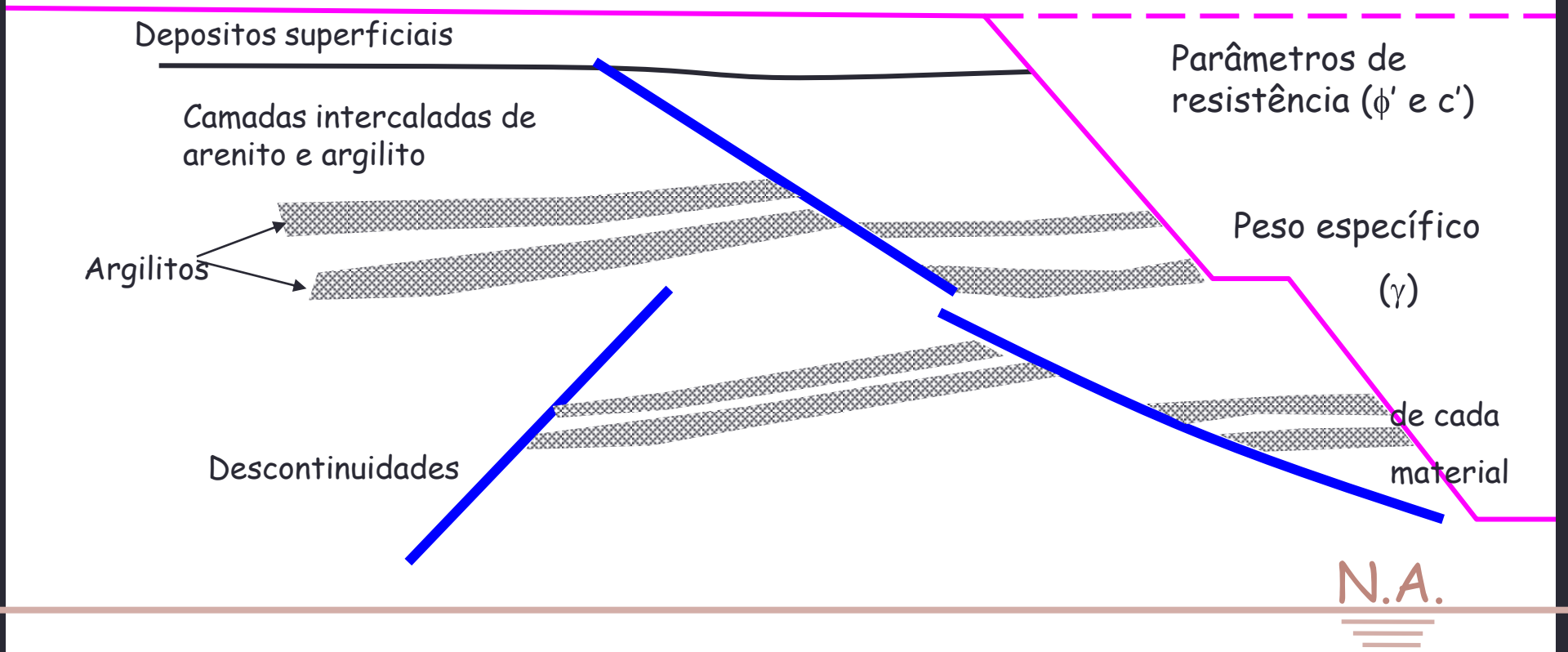
É possível prever corretamente as condição atuais a partir de apenas dos 3 furos?



Engenharia: Simplificação para modelar o comportamento e resolver o problema

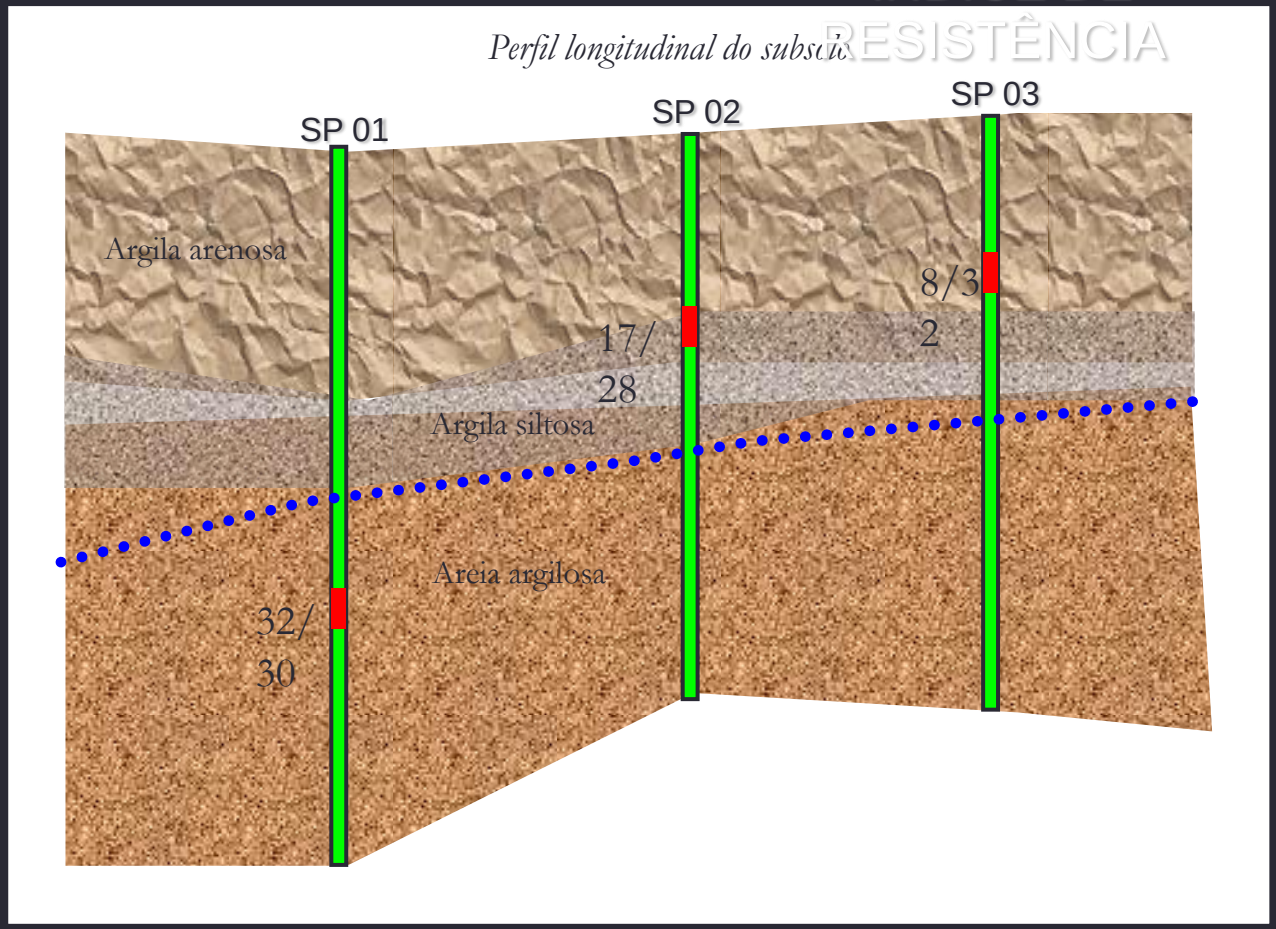
R
g

Definir ainda os parâmetros geotécnicos



OBJETIVOS DO ENSAIO GEOTÉCNICO

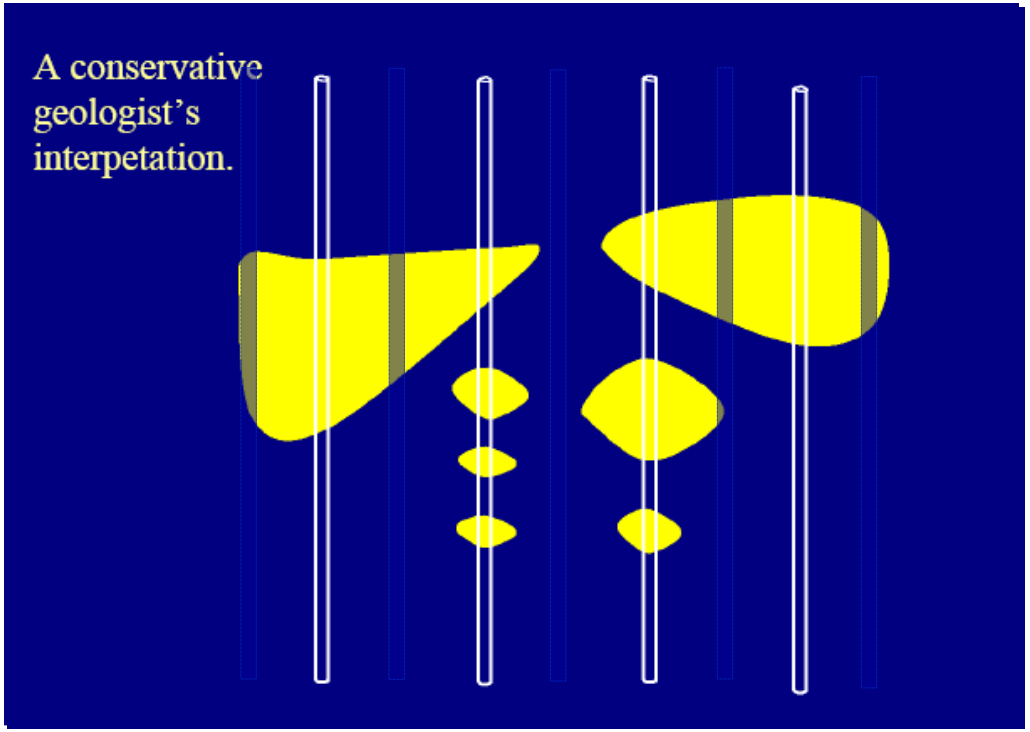
- ✓ IDENTIFICAR CAMADAS
- ✓ NÍVEL D'ÁGUA
- ✓ ÍNDICE DE RESISTÊNCIA

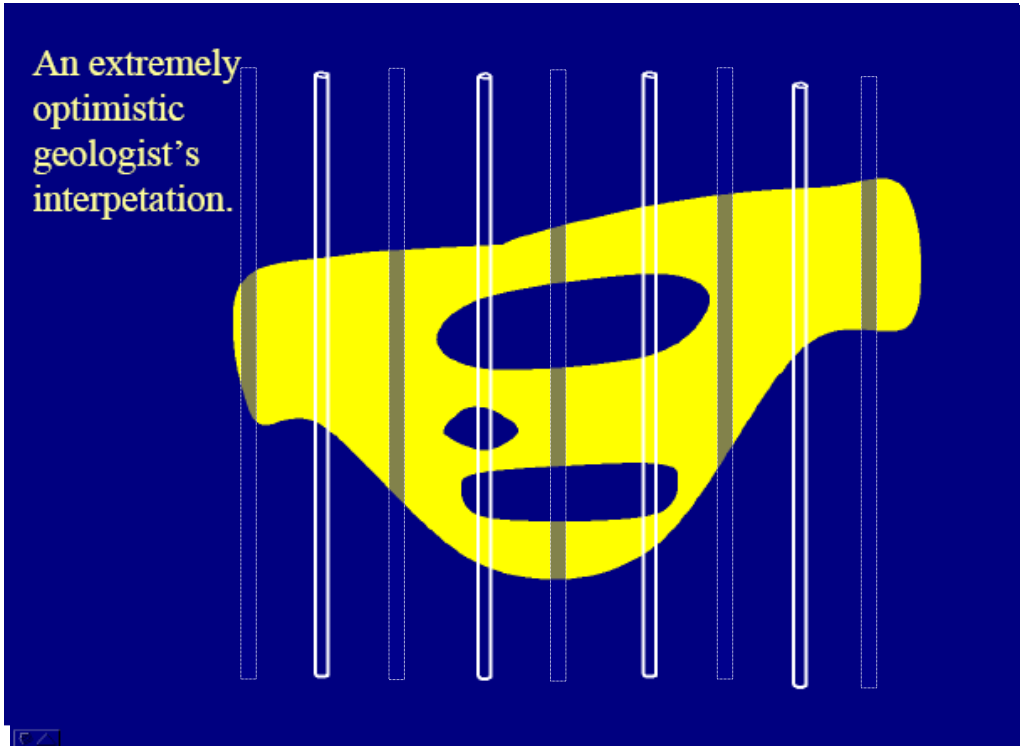


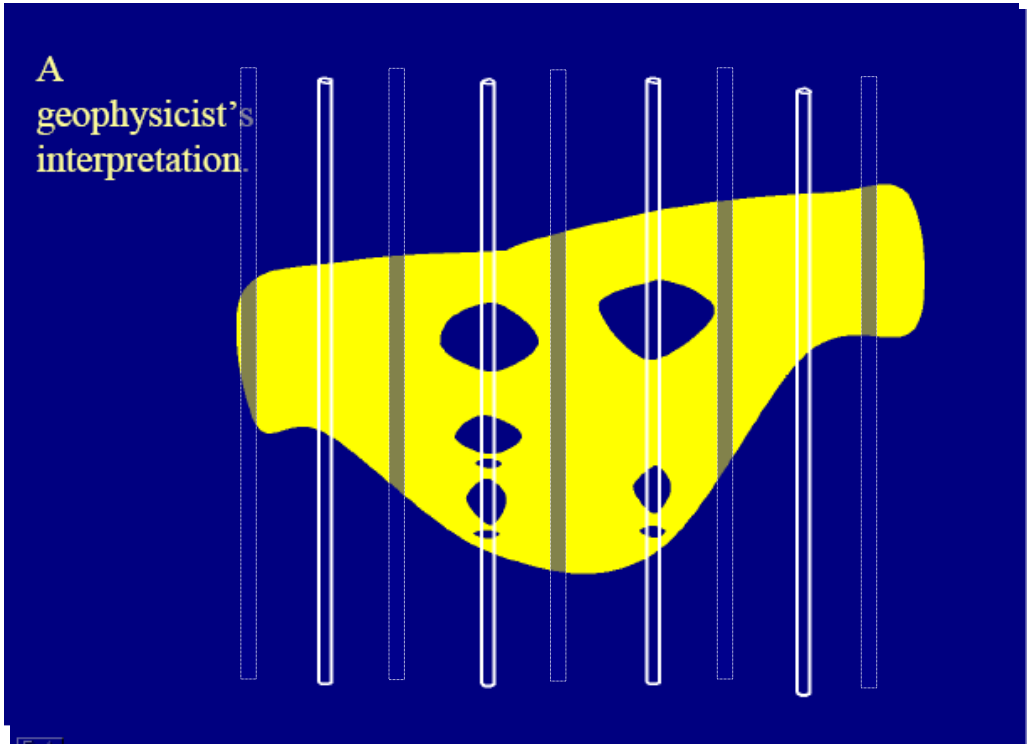
OBJETO DE ESTUDO

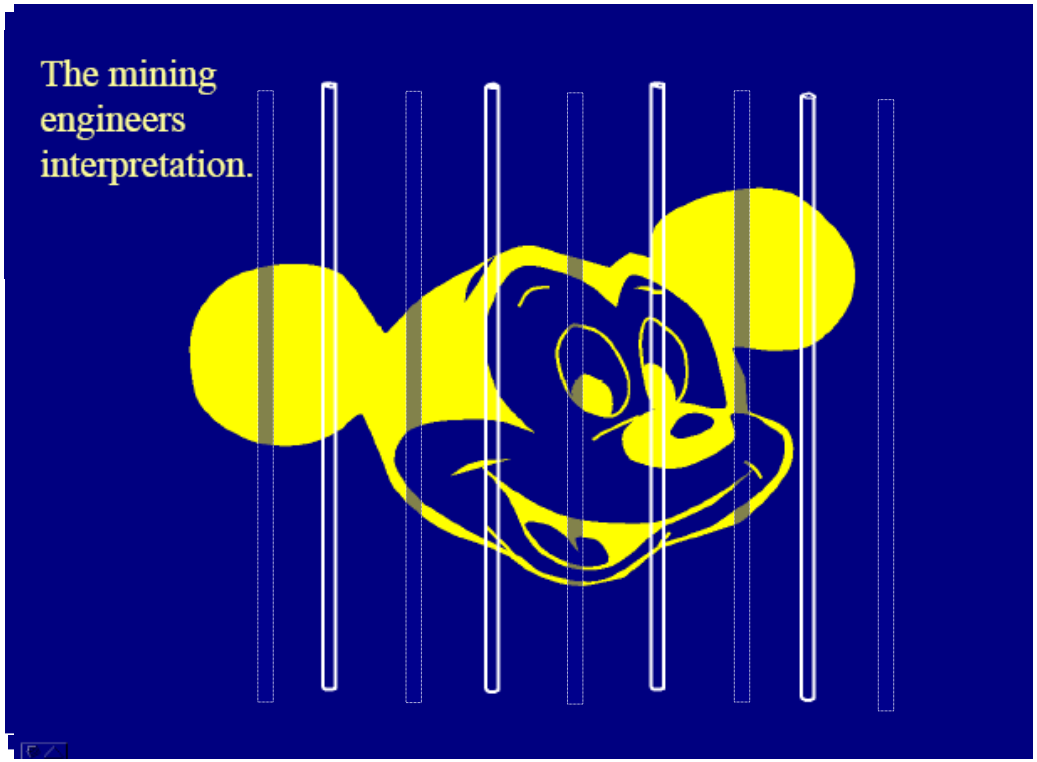
SUPERFÍCIE BASE DAS FUNDAÇÕES

(TRECHO DESCONHECIDO: MODELO MENTAL PESSOAL)
(TRECHO CONHECIDO: REVELADO NAS SONDAGENS)


A conservative
geologist's
interpetation.


An extremely optimistic geologist's interpetation.


A
geophysicist's
interpretation.


The mining
engineers
interpretation.

Case 1-Kivikk o in Helsinki, Finland
Parking place and industrial area into the swamp area

Test mass stabilisation in summer 2000

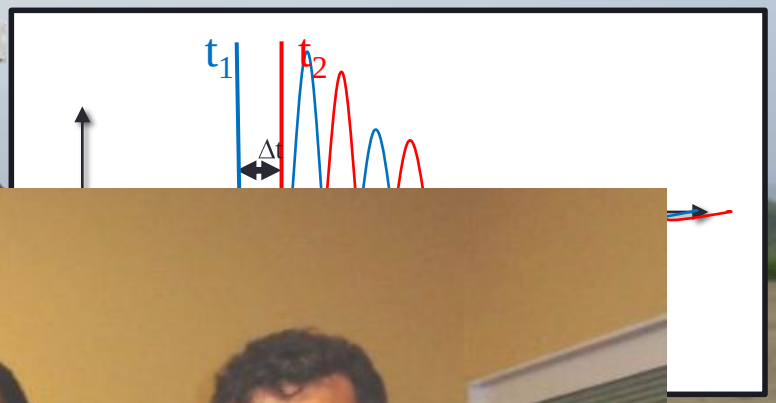
Mass stabilisation in 2001-2003

Case 2-Trondhe im Harbour, Norway
Stabilisation of contaminated sediments during 2002-2004

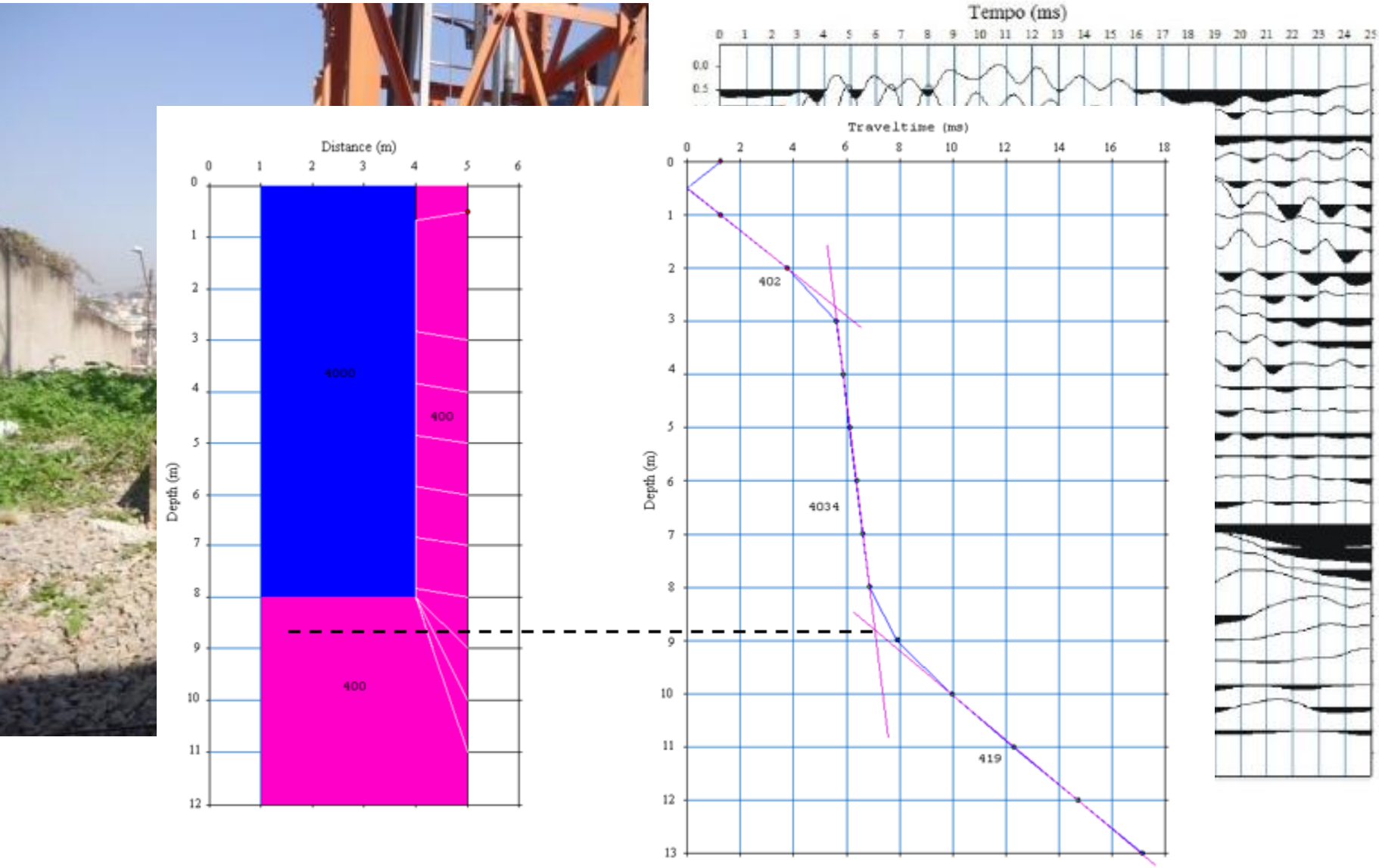
ALLU®

One Step Ahead

PS TEST

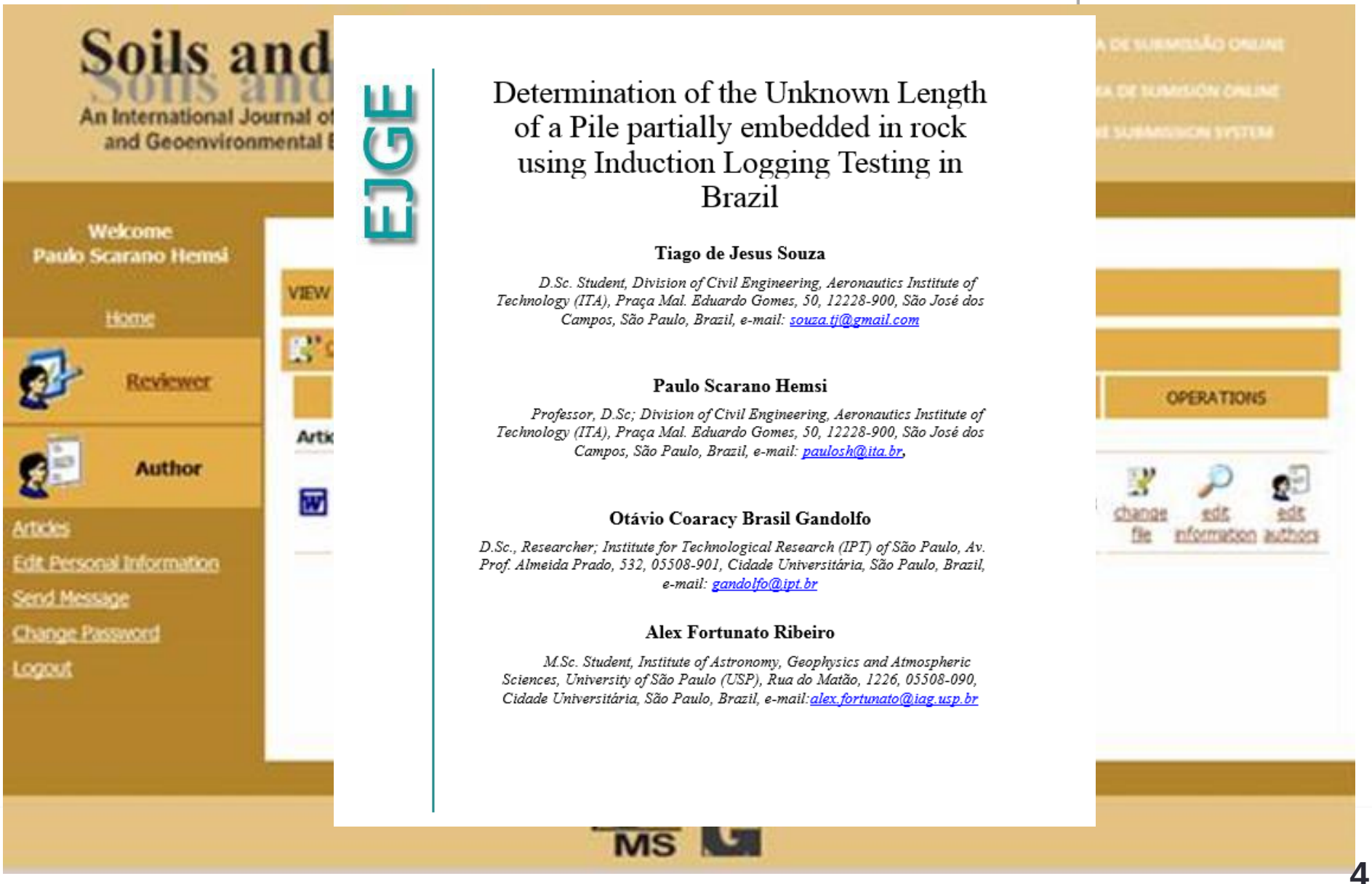


Case 1- Jardim São Paulo



Artigos submetidos

ARTIGO



EJGE

Determination of the Unknown Length of a Pile partially embedded in rock using Induction Logging Testing in Brazil

Tiago de Jesus Souza

D.Sc. Student, Division of Civil Engineering, Aeronautics Institute of Technology (ITA), Praça Mal. Eduardo Gomes, 50, 12228-900, São José dos Campos, São Paulo, Brazil, e-mail: souza.tj@gmail.com

Paulo Scarano Hemsi

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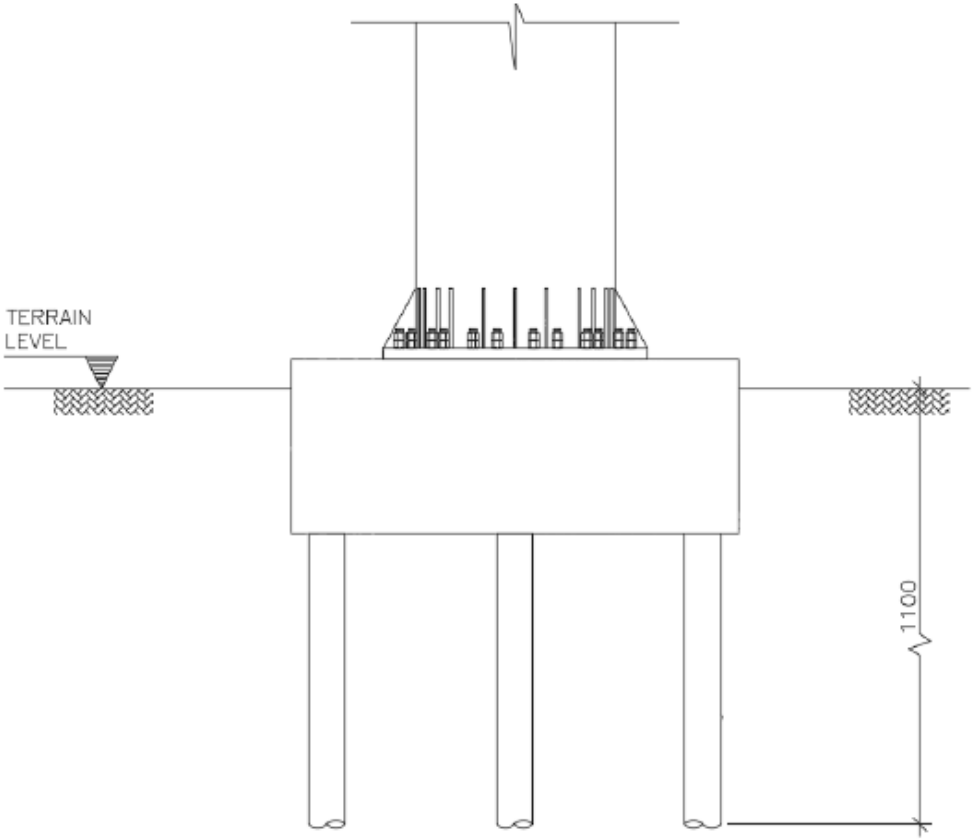
Otávio Coaracy Brasil Gandolfo

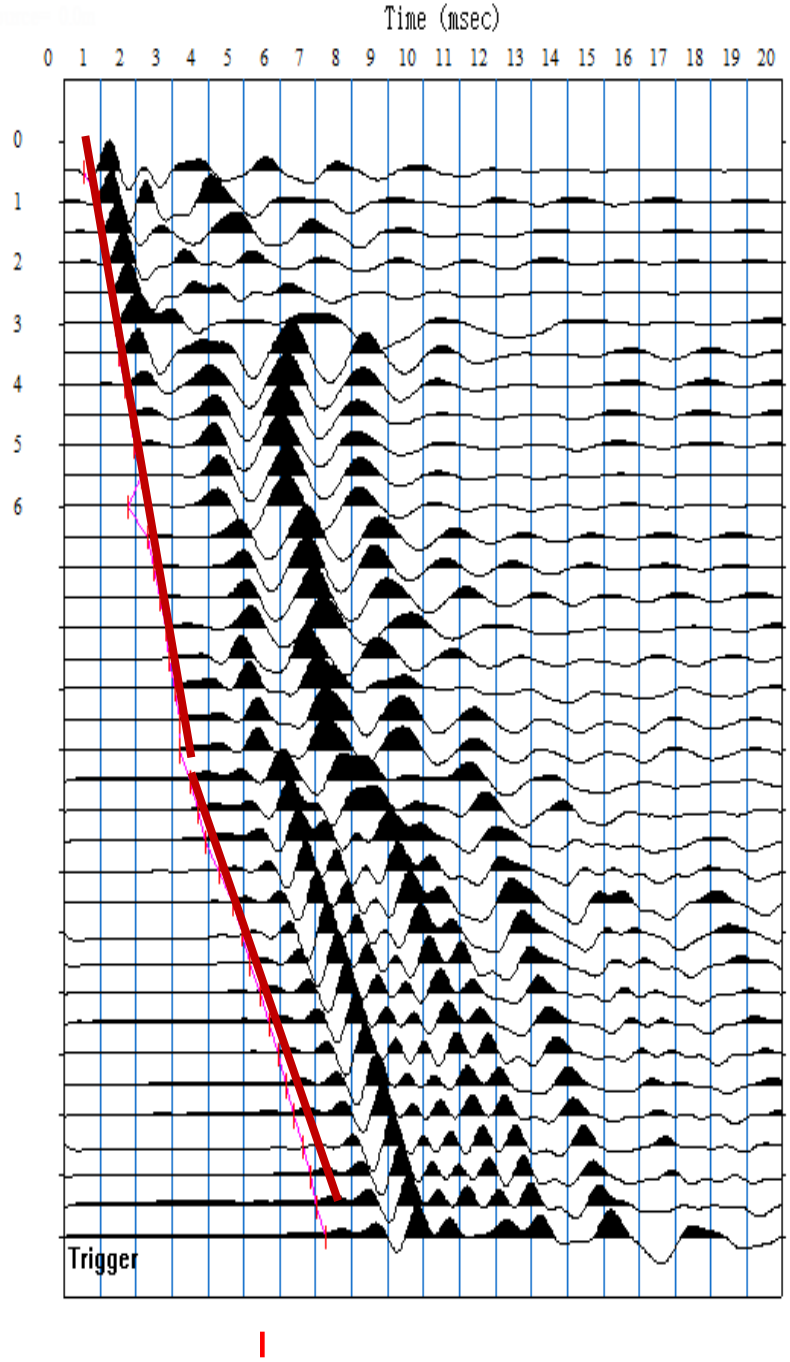
D.Sc., Researcher; Institute for Technological Research (IPT) of São Paulo, Av. Prof. Almeida Prado, 532, 05508-901, Cidade Universitária, São Paulo, Brazil, e-mail: gandolfo@ipt.br

Alex Fortunato Ribeiro

M.Sc. Student, Institute of Astronomy, Geophysics and Atmospheric Sciences, University of São Paulo (USP), Rua do Matão, 1226, 05508-090, Cidade Universitária, São Paulo, Brazil, e-mail:alex.fortunato@iag.usp.br

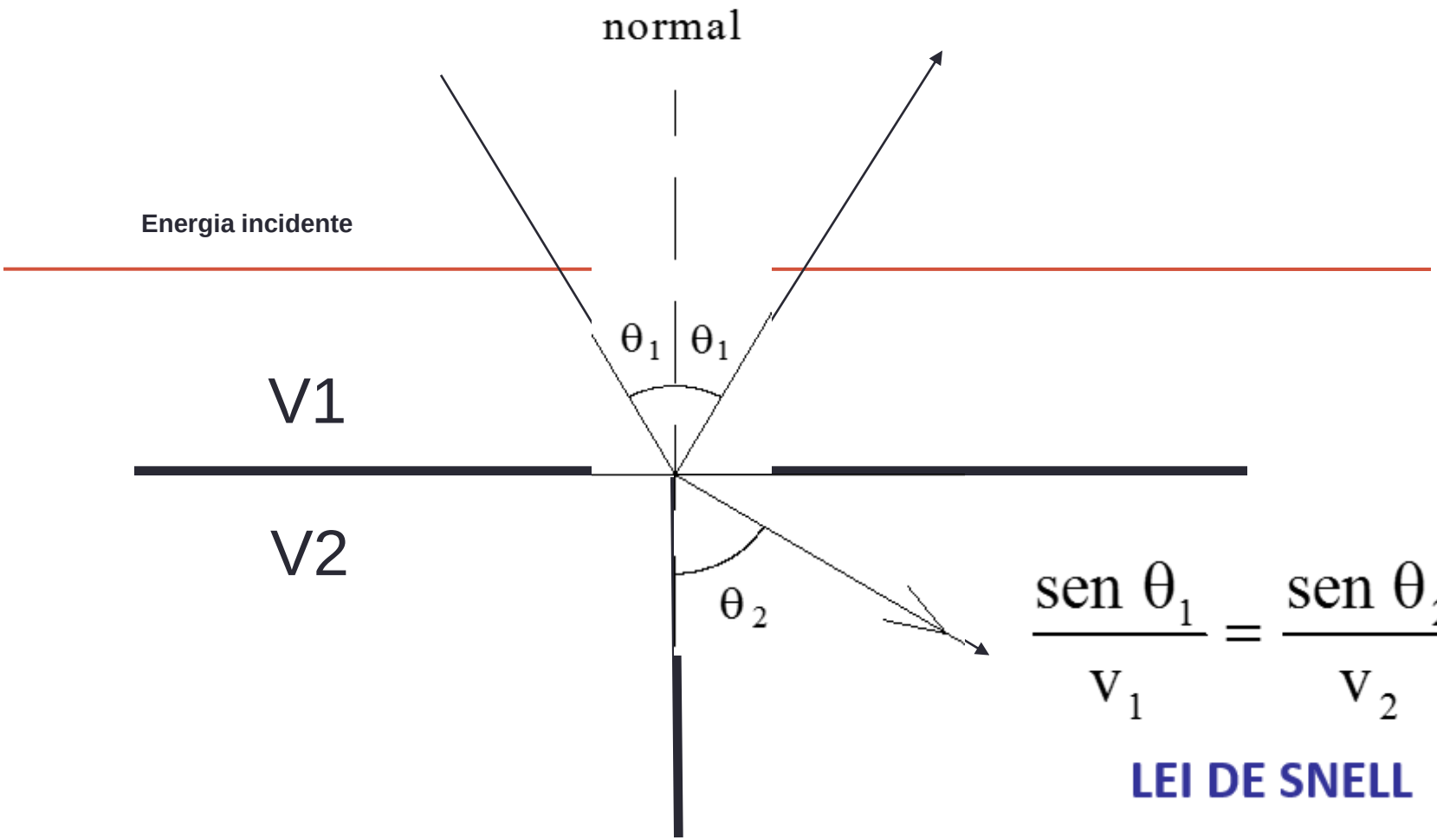
Case 2- ARTUR ALVIM





ENSAIO SÍSMICO PARALELO: fundamentos

Quando um raio atinge uma interface que separa dois meios com distintas propriedades físicas (descontinuidade de velocidade), pode sofrer refração (transmissão) ou reflexão

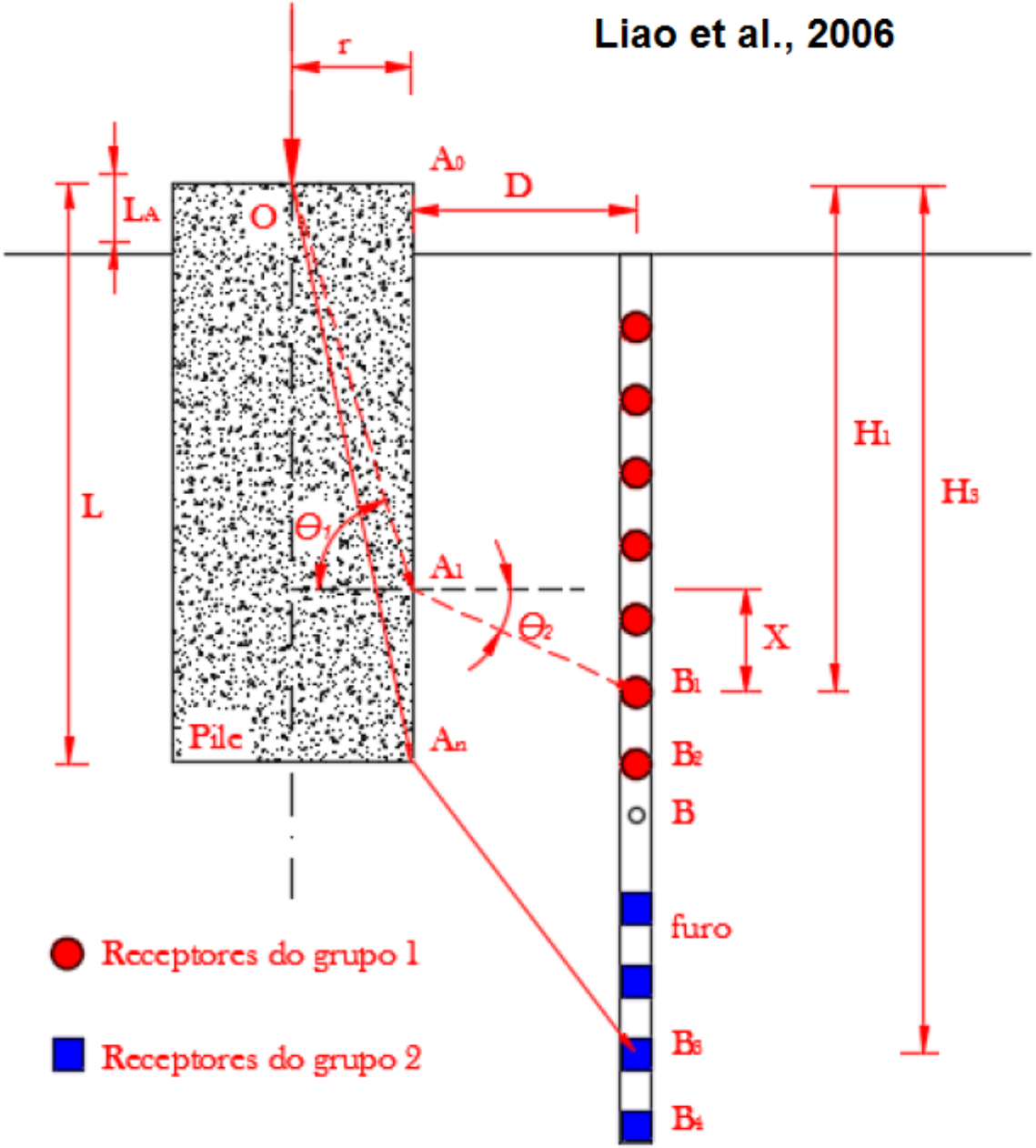


$$\frac{\text{sen}\ \theta_1}{v_1} = \frac{\text{sen}\ \theta_2}{v_2}$$

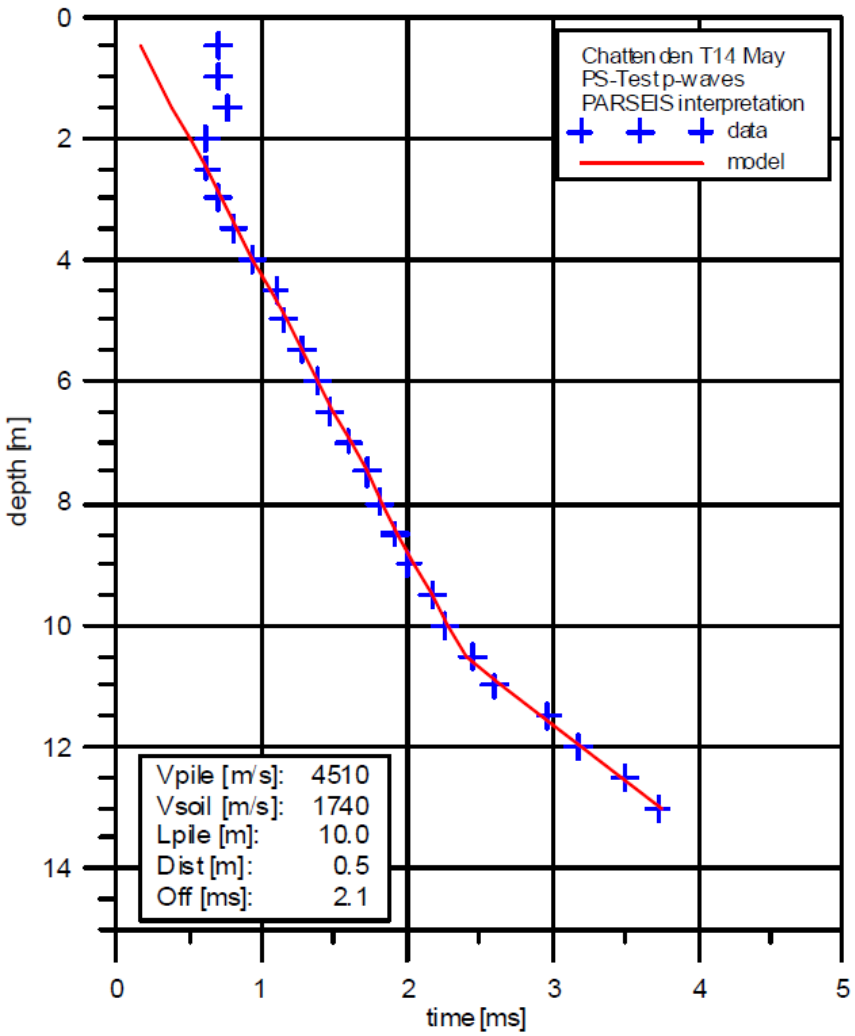
LEI DE SNELL

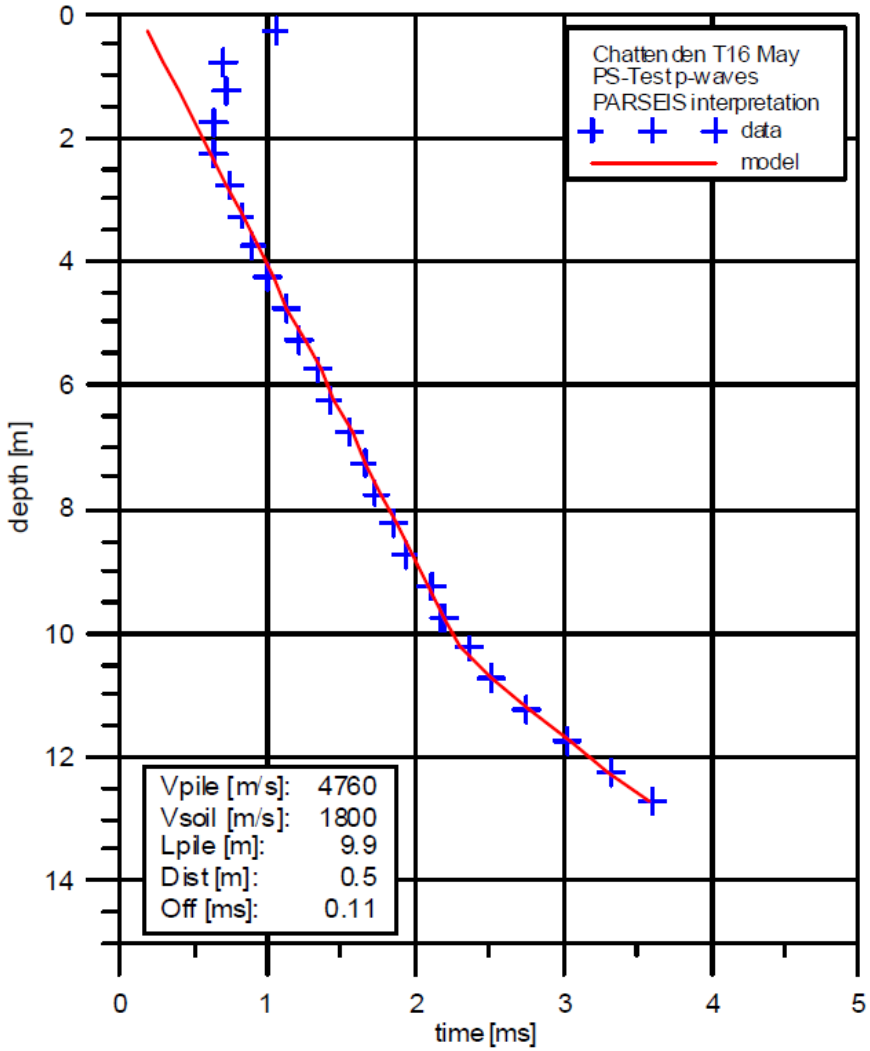
METODOLOGIA TEÓRICA

Liao et al., 2006

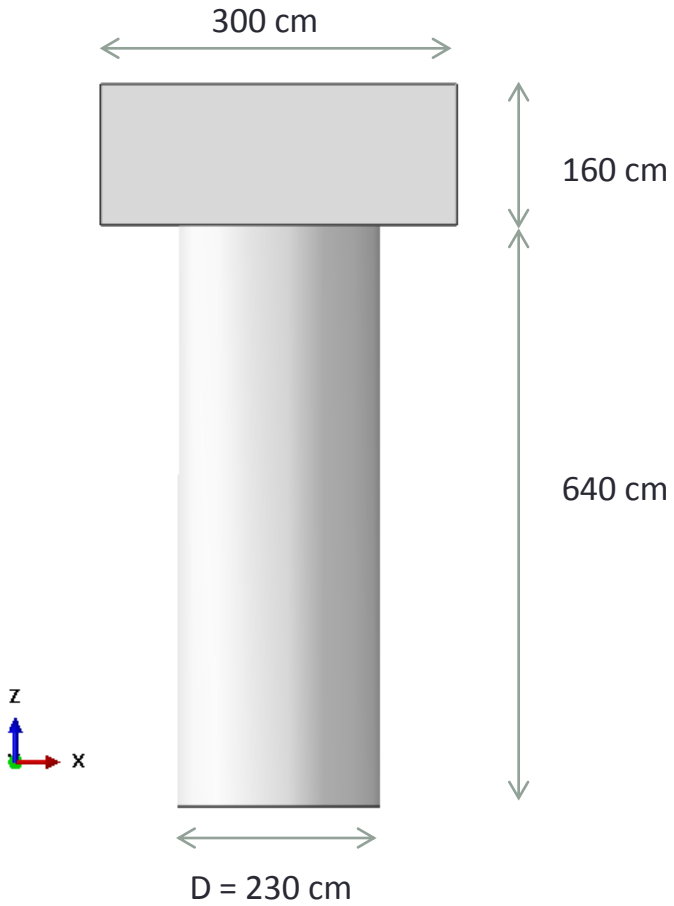


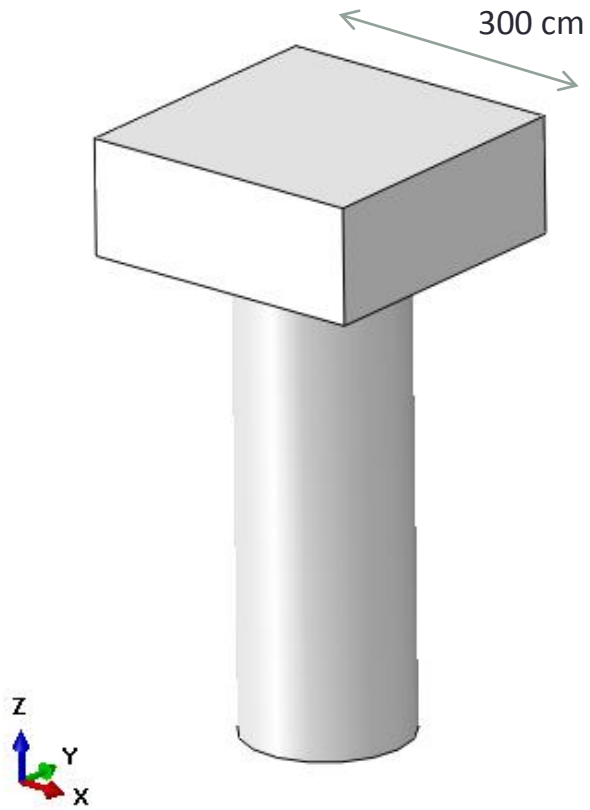
Curva Medida x Prevista - Niederleithinger, (2012a)



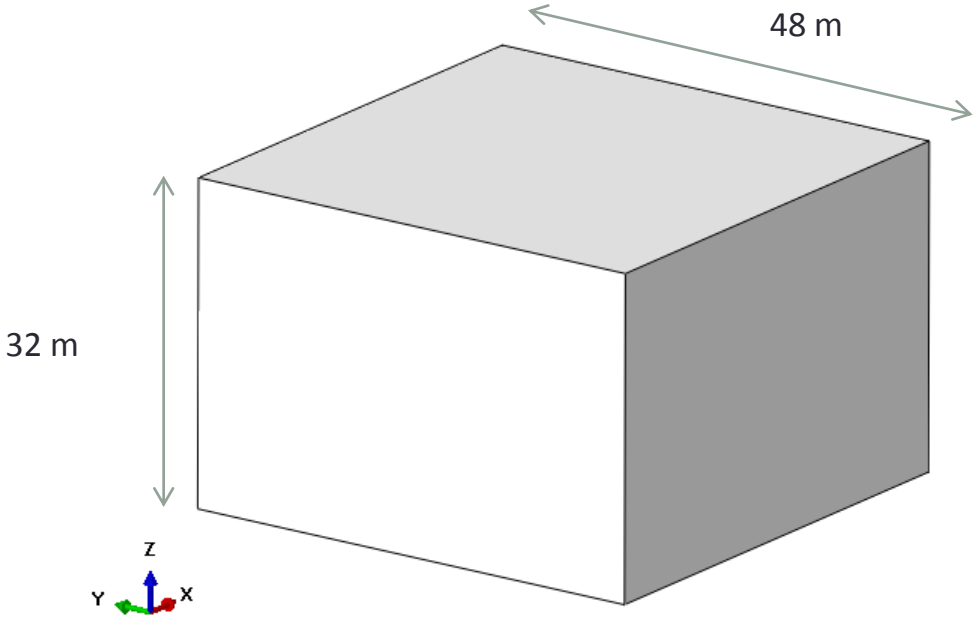


Modelagem numérica

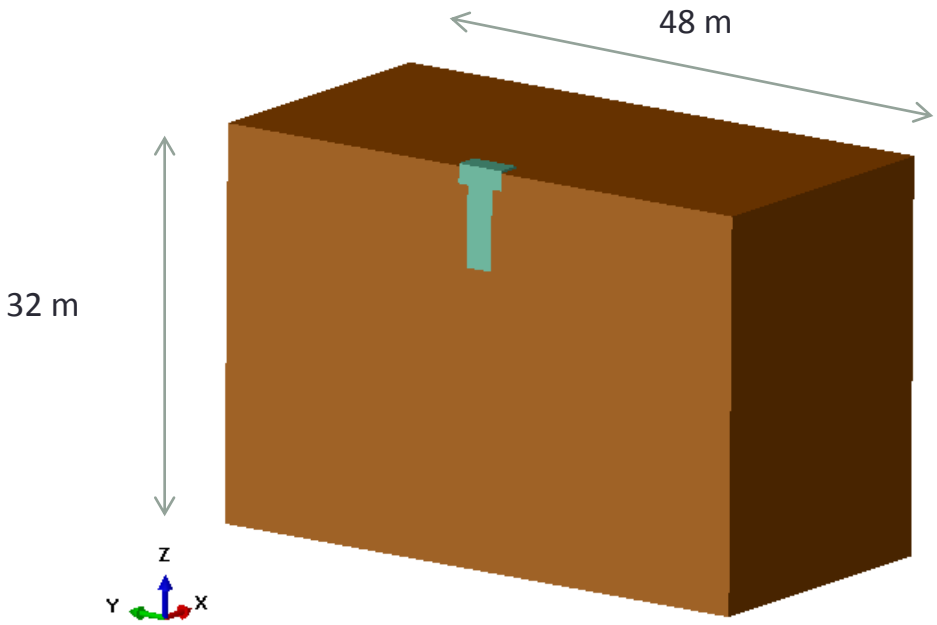




Modelagem numérica



Modelagem numérica

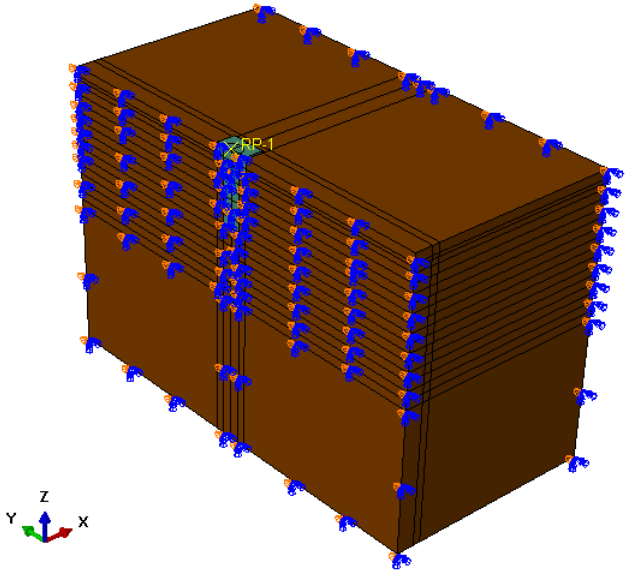


- Estaca (verde): Concreto
  - Modelo linear elástico
  - Densidade = 2.4e-9 ton/mm³
  - E = 29 Gpa
  - Poisson = 0.2
- Solo (marrom)
  - Modelo linear elástico
  - Densidade = 1.6e-9 ton/mm³
  - E = 1.6 GPa
  - Poisson = 0.3

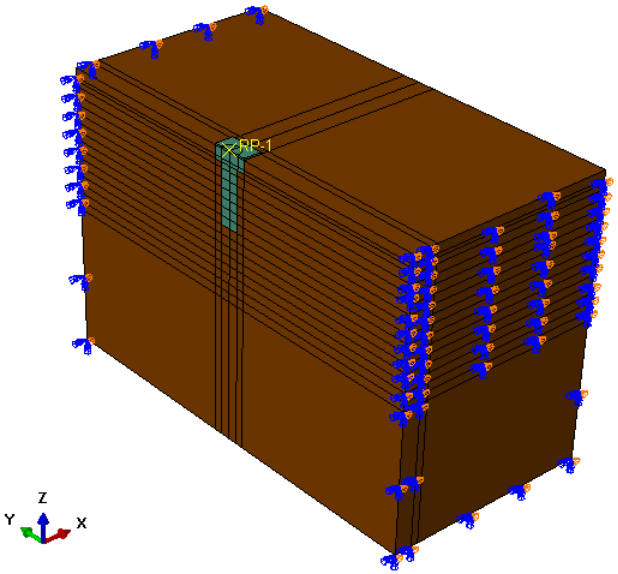
Considerações de análises

- Análise dinâmica com integração explícita
- Duração: 0.01 s
- Obtenção de acelerações/deslocamentos a cada 1e-4 segundos.
- Não considerou-se a possibilidade de deslocamento relativo entre o solo e a estaca. Na região de contato entre ambas as parts, utilizou-se um “tie”.

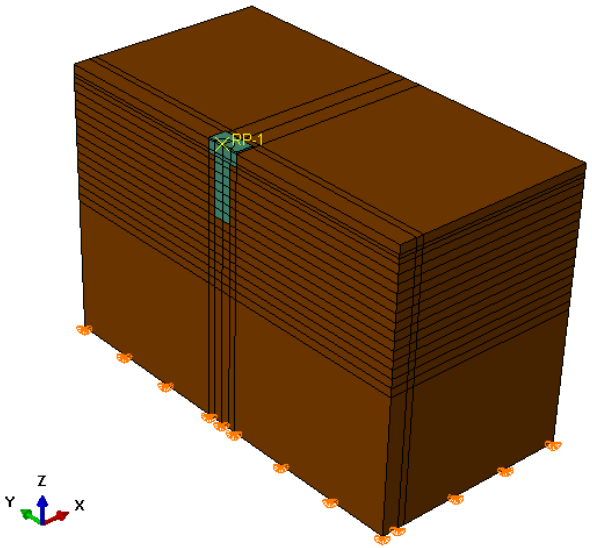
Considerações de análises



Simetria em x

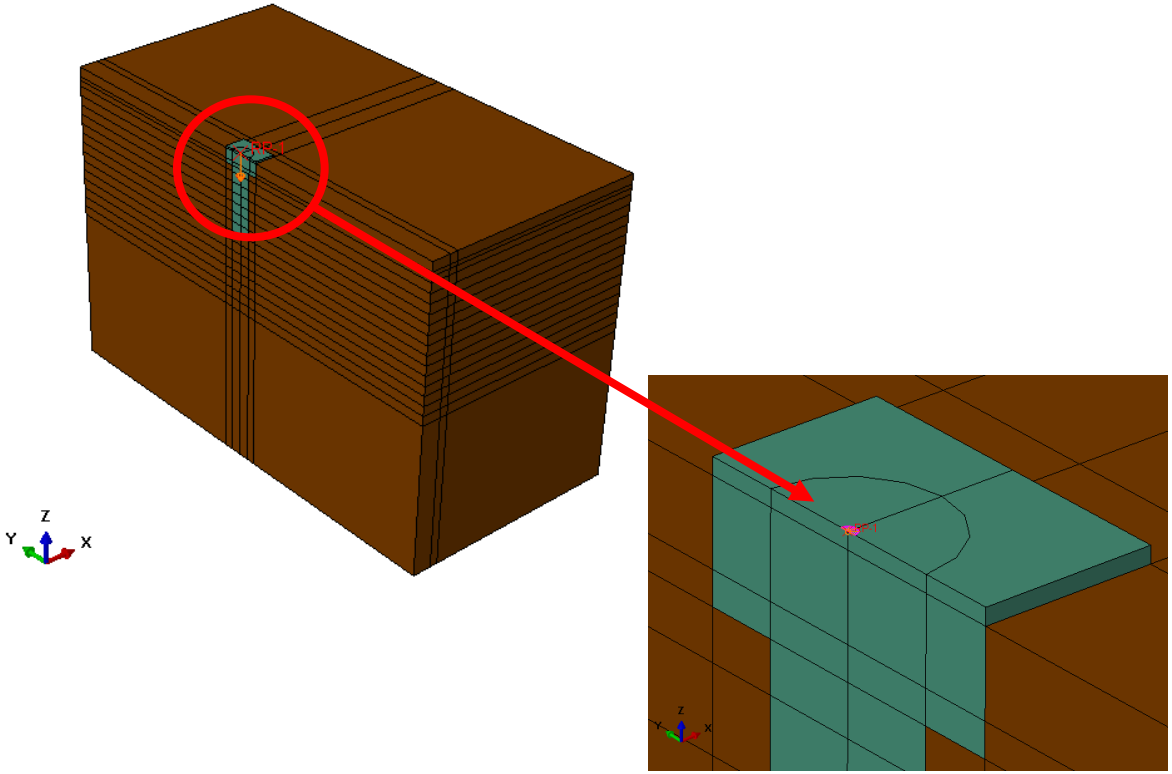


Simetria em y

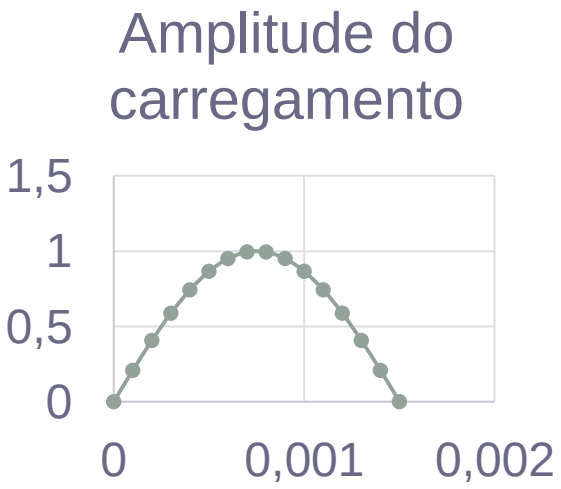


Solo apoiado na base

Considerações de análises

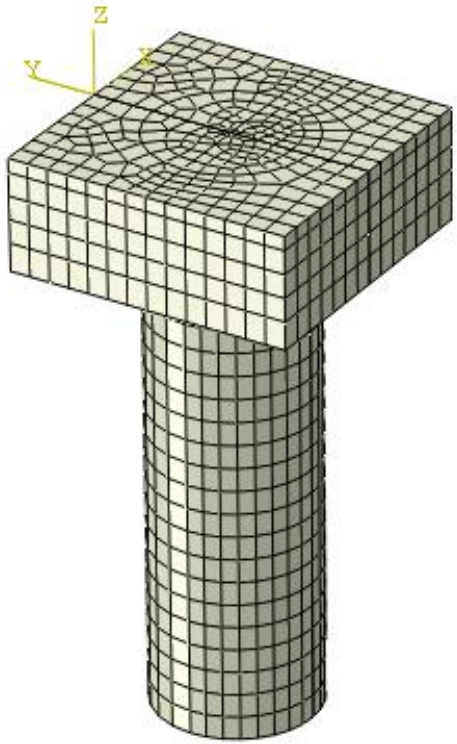


- Carregamento de 1 N aplicado na direção –z conforme amplitude abaixo:

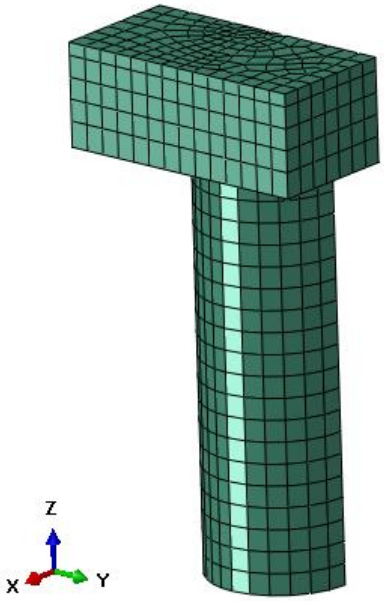


A carga unitário foi distribuída em uma área de raio de 100 mm ao redor do cg da seção através de um coupling

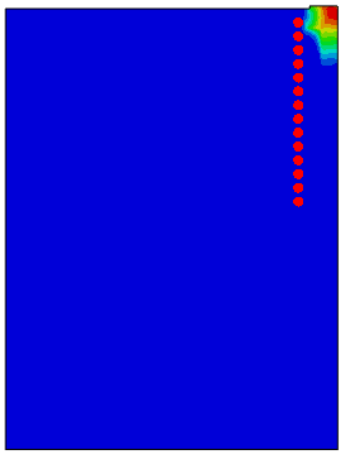
Considerações de análises



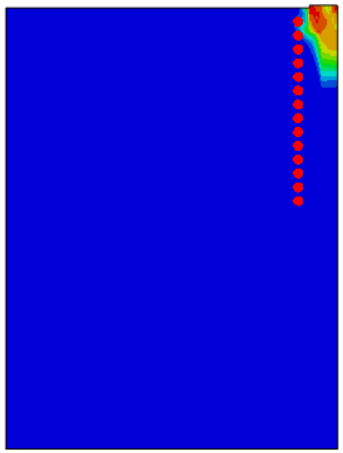
- Número de elementos = 1730 (apenas metade, o conjunto solo/estaca foi modelado utilizando-se condições de contorno de simetria)
- Número de nós = 2266 (metade)
- Tipo do elemento = C8D8R
- Tamanho médio do elemento = 300 mm



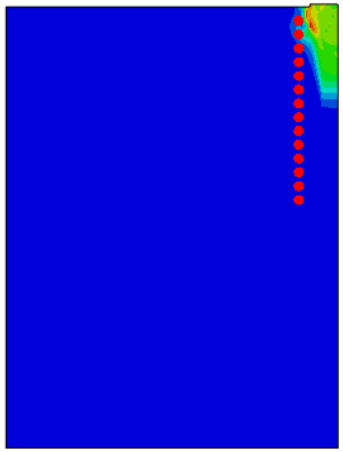
Resultados da Modelagem

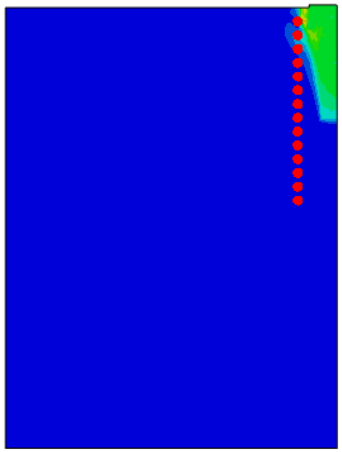


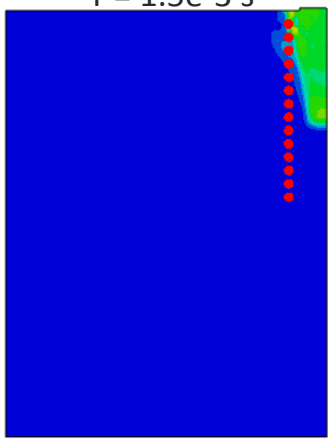
T = 1.5e-3 s



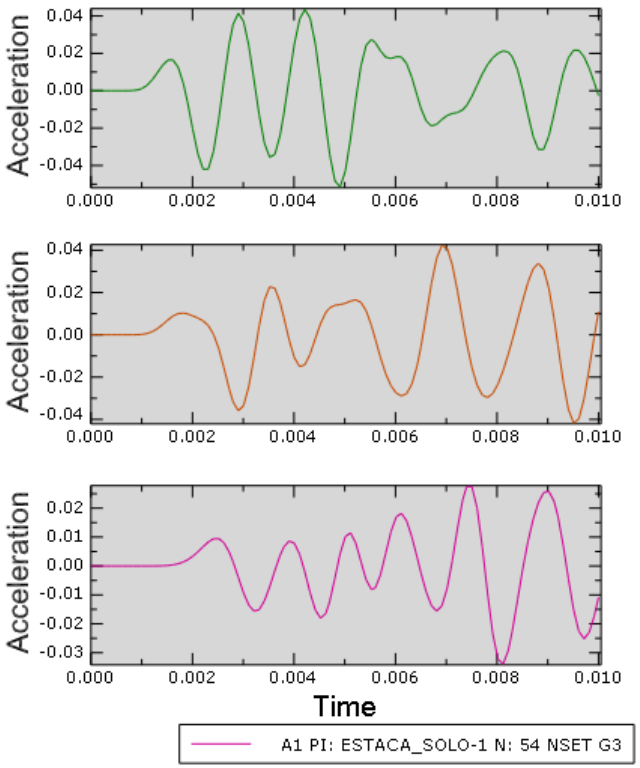
T = 2.0e-3 s

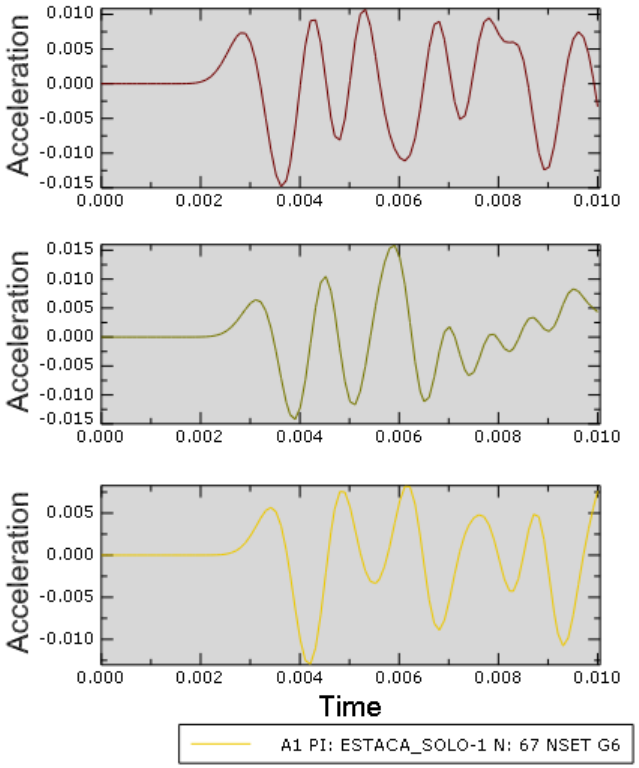




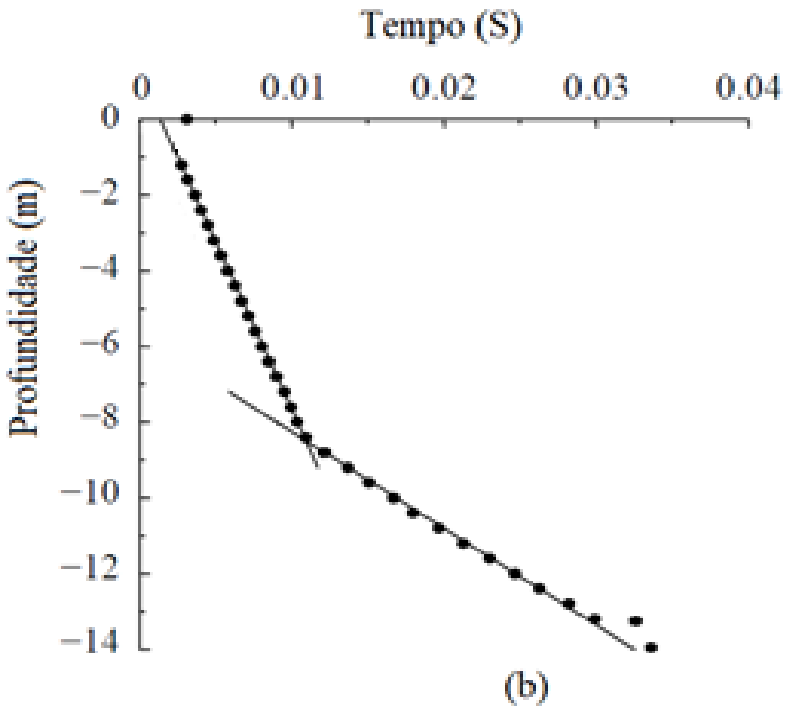


Resultados da Modelagem

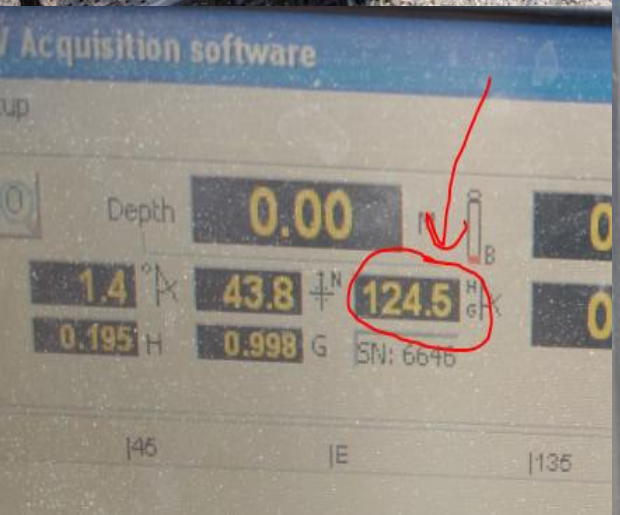


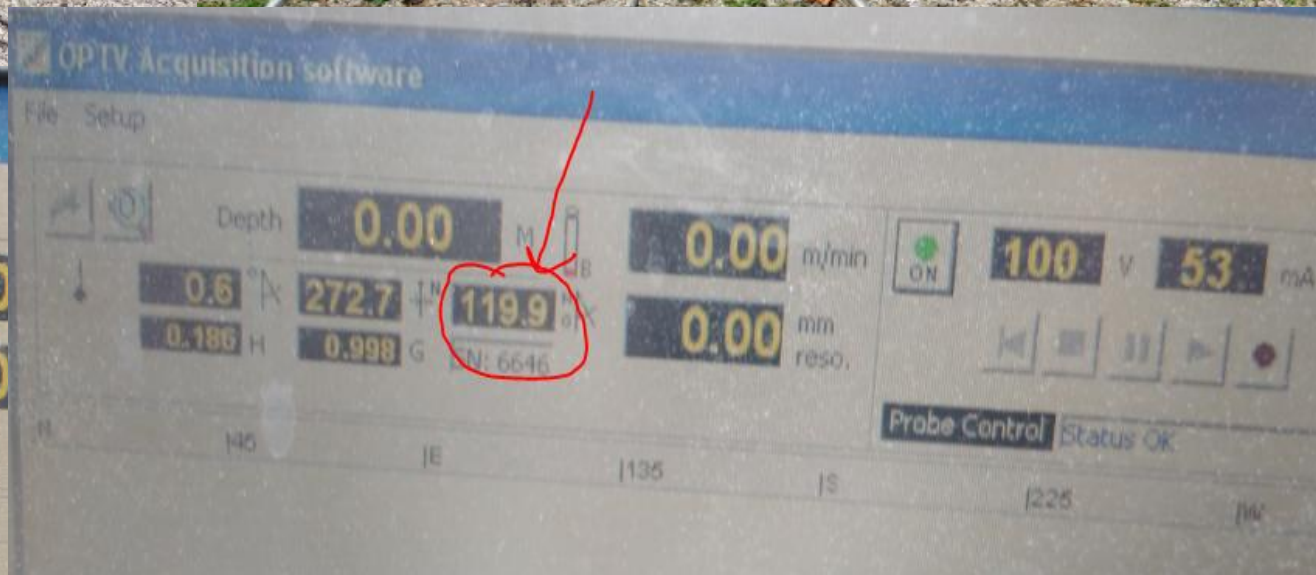


Resultados da Modelagem



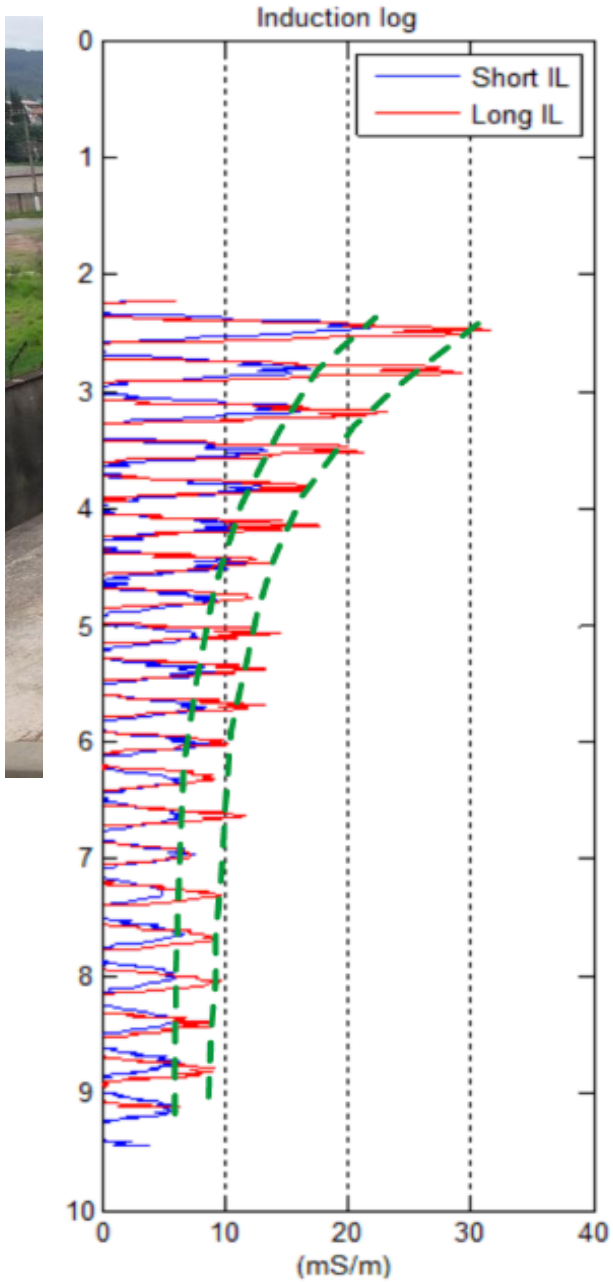
Parâmetros	Liao et al., (2006)	Niederleithinger (2005)	Modelagem numérica
V_1 (m/s)	4400	4400	4400
V_2 (m/s)	400	400	400
L (m)	8,0	8,0	8,2
RMSE (%)	9.1	8.4	9.6

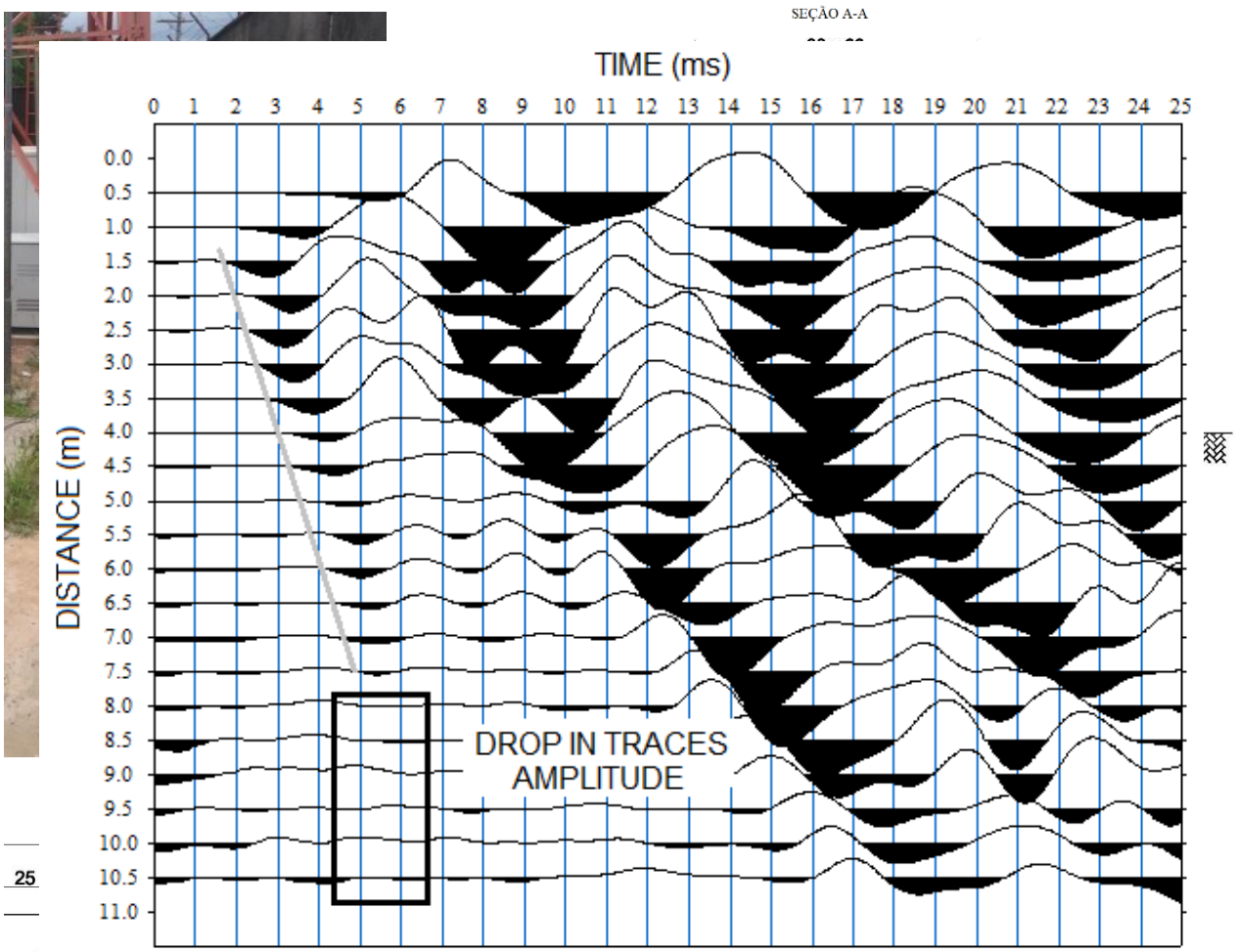

Acquisition software
Depth
0.00
1.4
43.8
124.5
0.195
0.998
SN: 6646
45
E
135


OPTV Acquisition software
File
Setup
Depth
0.00
0.00
m/min
100
V
53
mA
0.6
272.7
119.9
0.186
0.998
SN: 6646
0.00
mm
reso.
ON
Probe Control
Status OK
45
E
135
S
225

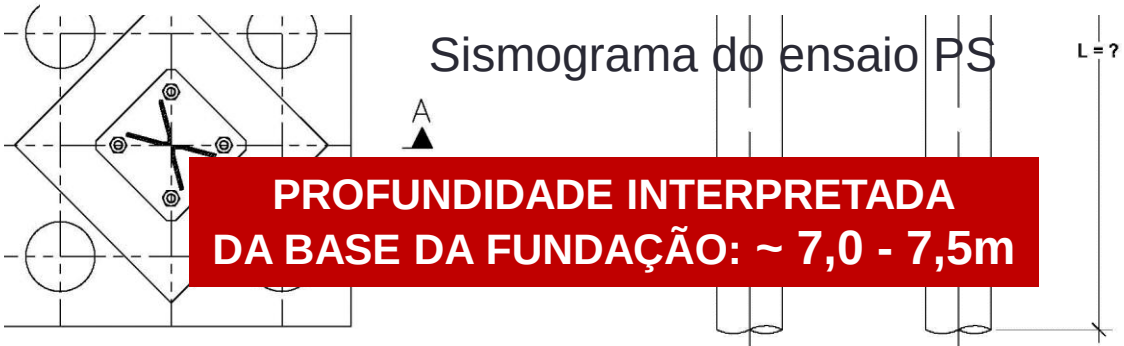
Perfil de indução

Caso 2-SANTANA DE PARNAÍBA



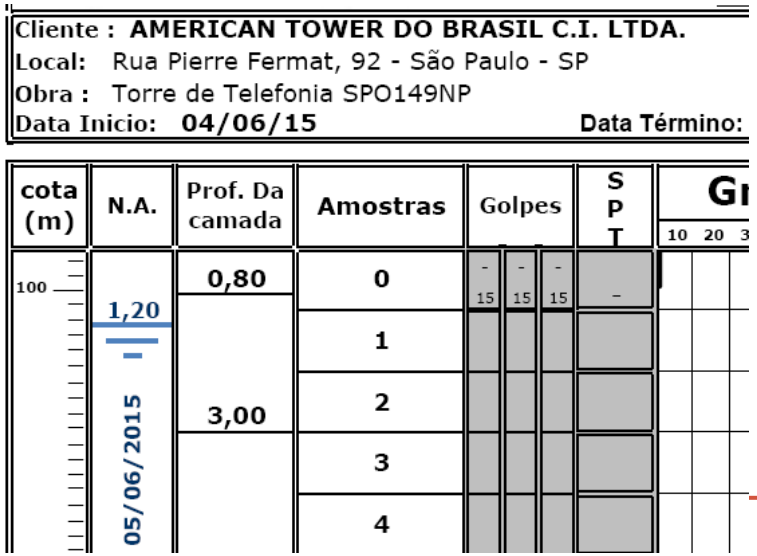


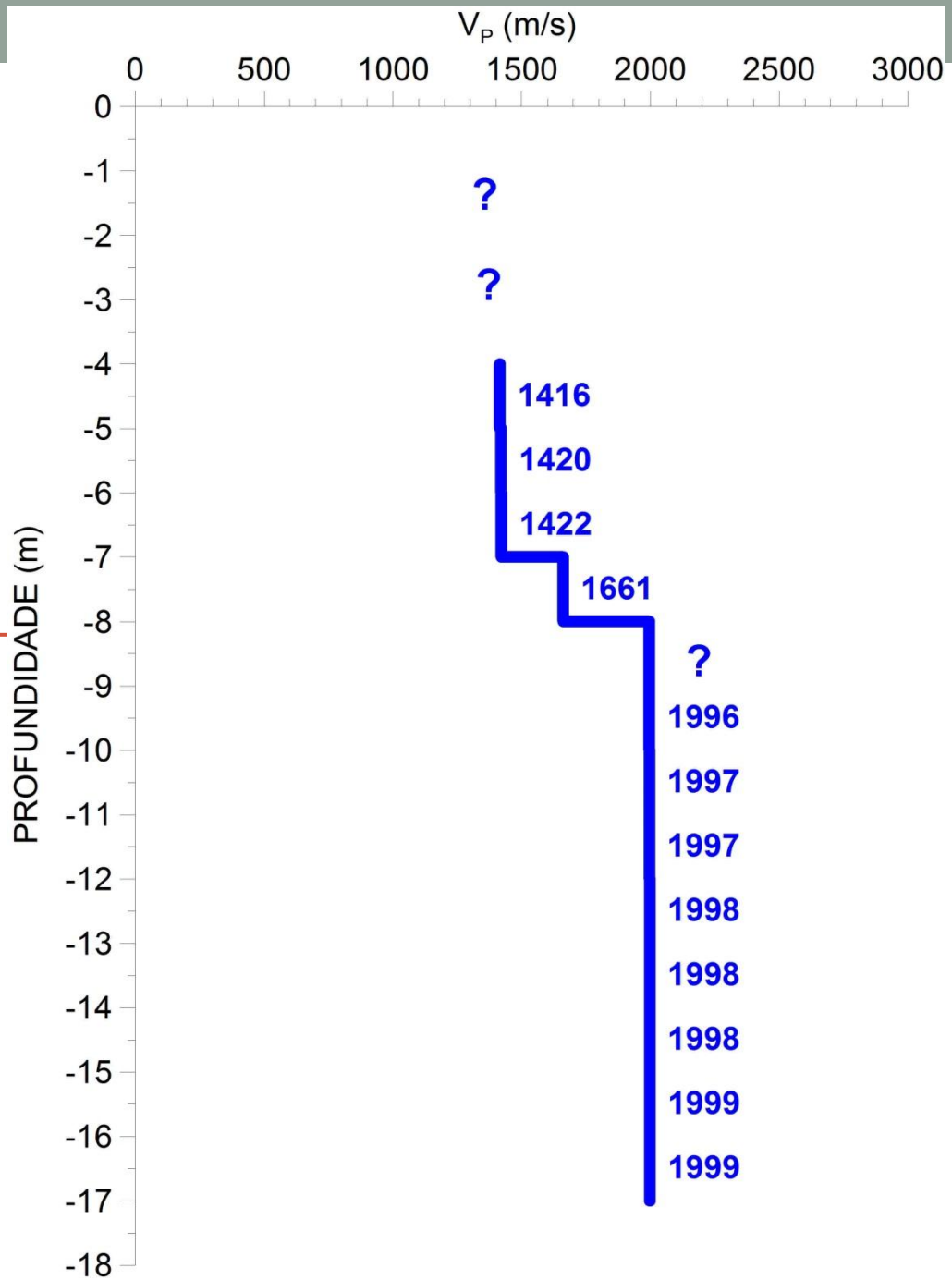
Sismograma do ensaio PS



PROFUNDIDADE INTERPRETADA DA BASE DA FUNDAÇÃO: ~ 7,0 - 7,5m

II) Ensaio *downhole*



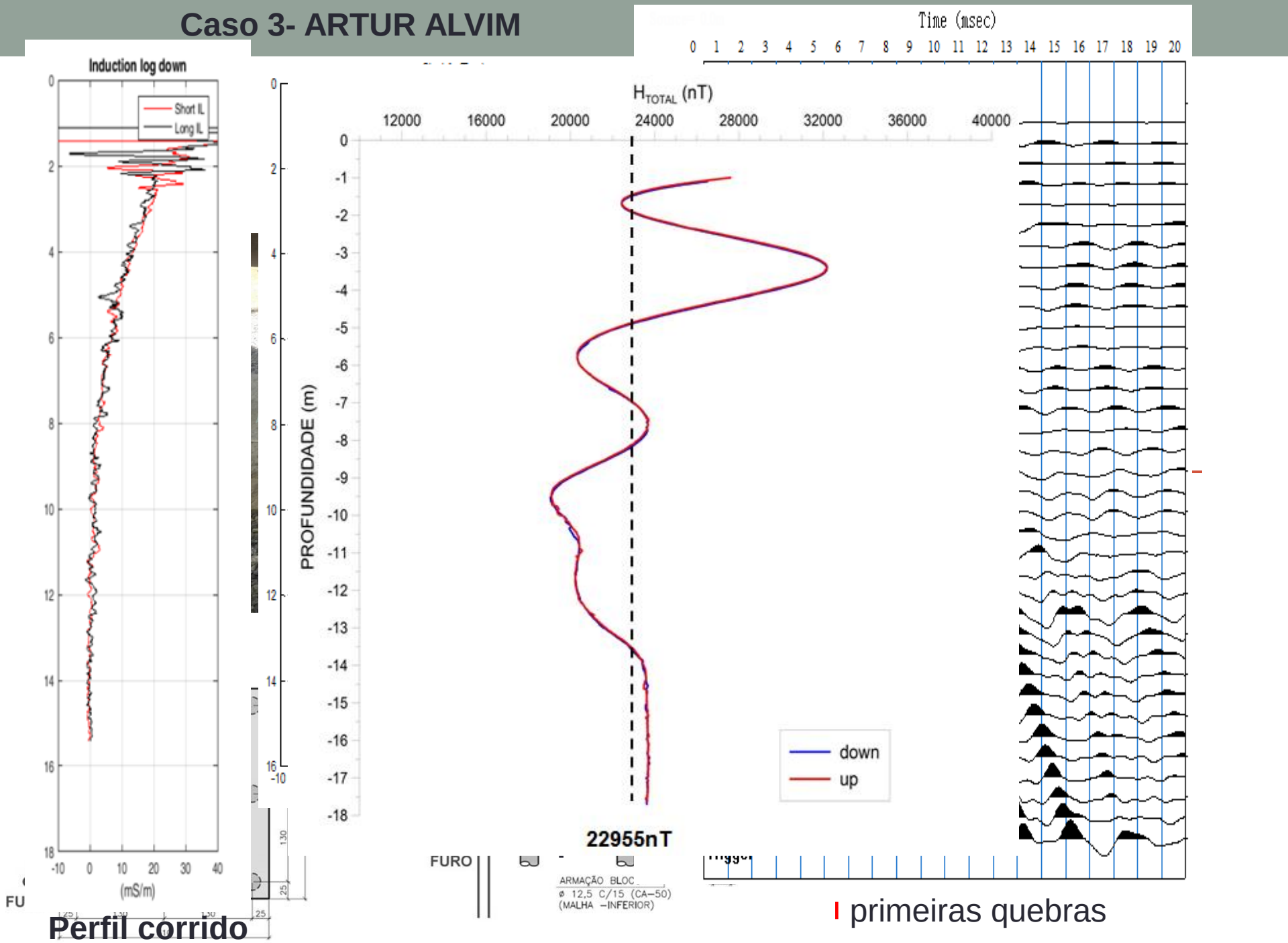


OBS VP EM SOLO SATURADO

(ABAIXO DO N.A.)

≅ 1400 a 1800 m/s

Caso 3- ARTUR ALVIM

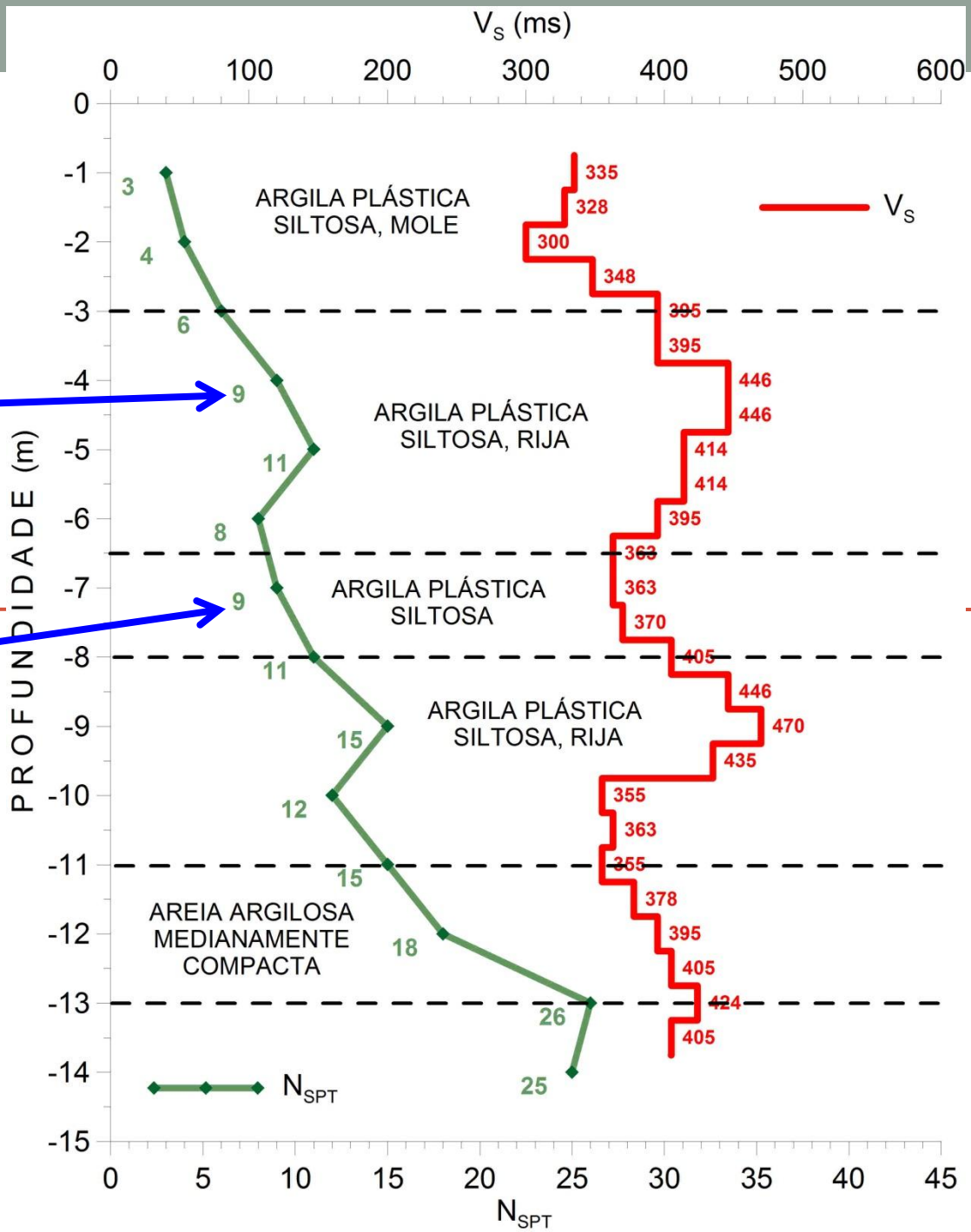


Perfil corrido

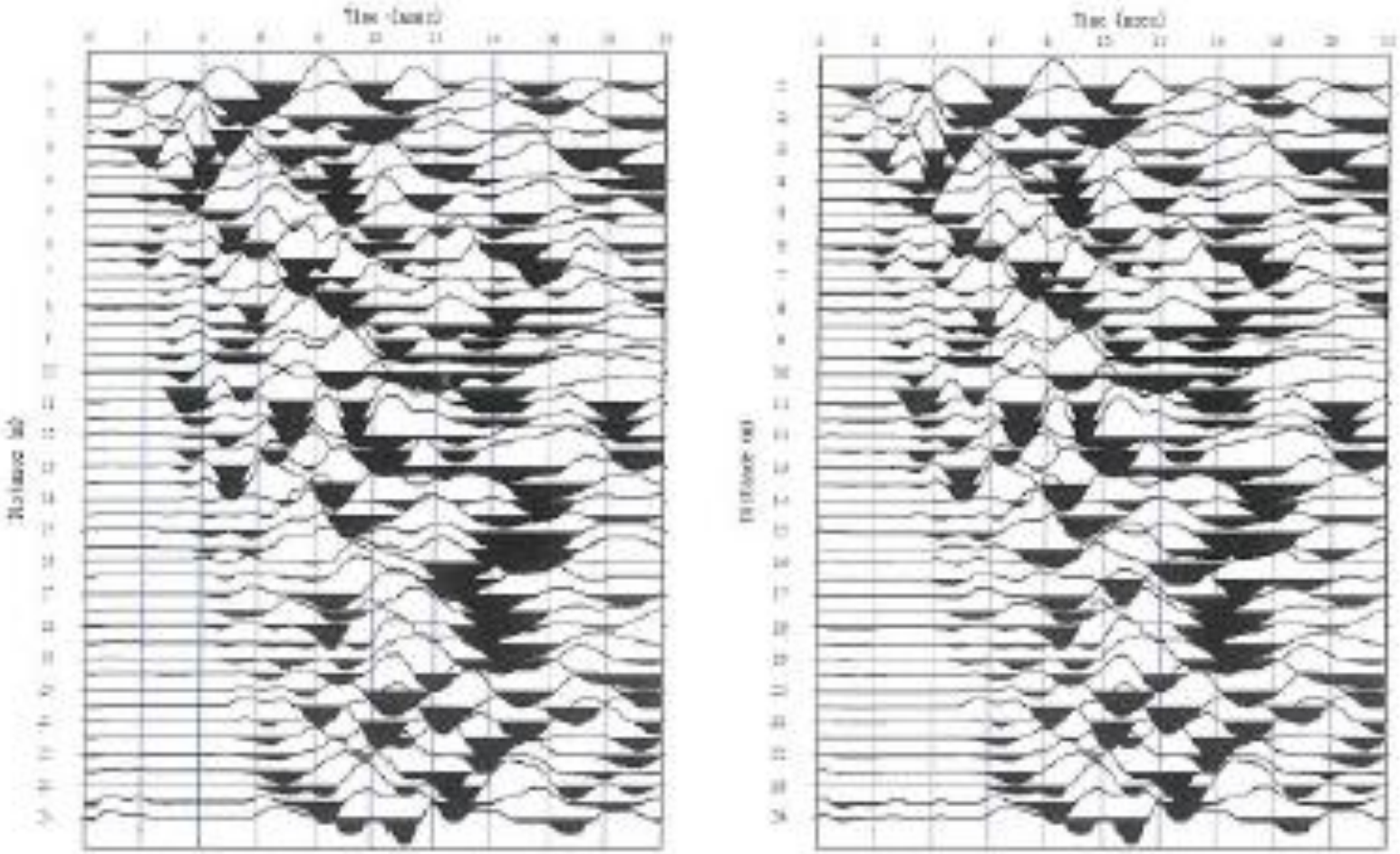
I) Ensaio *crosshole*

SPT = 9
V_S = 446 m/s
(argila mais rija)

SPT = 9
V_S = 363 m/s
(argila menos rija)



Caso 4- Santos



Sismogramas do ensaio PS obtido na 1ª aquisição com o sinal registrado utilizando as duas componentes horizontais do geofone.

CATAGUASES-MG

Como o SP pode contribuir ?

Na investigação dos processos de percolação em barragem por meio de:

- Monitoramento contínuo de fluxos em barragens de terra

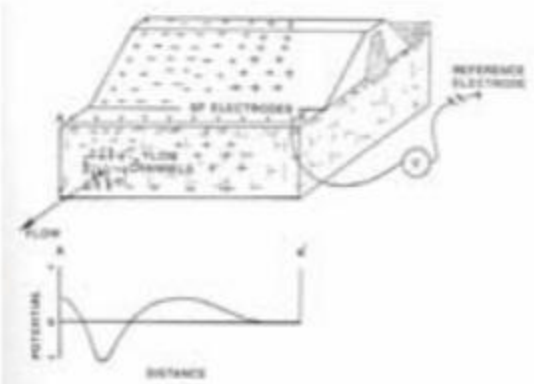
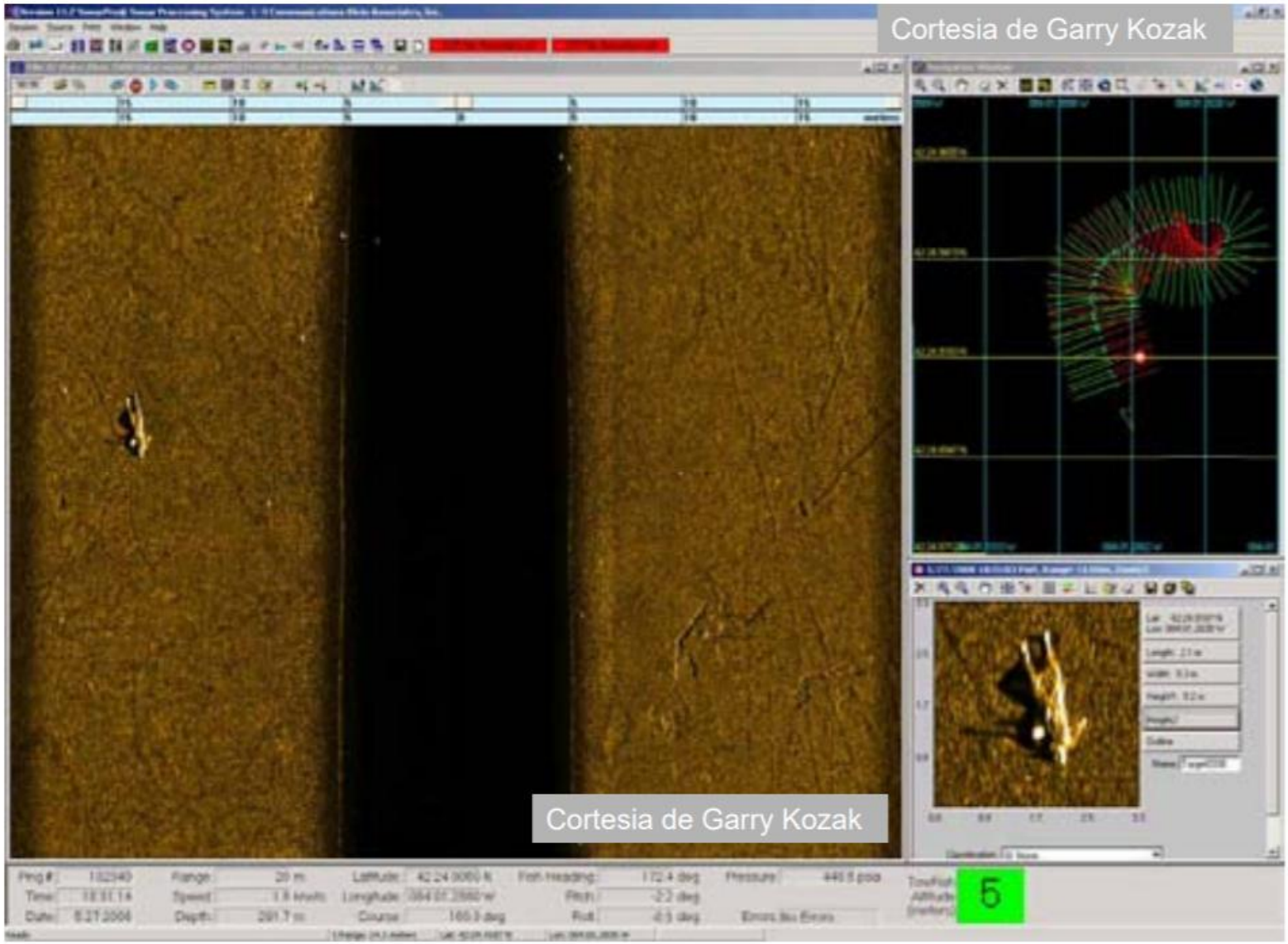


Figure 7. Idealized model of SP anomaly generation and its detection by an SP electrode array.

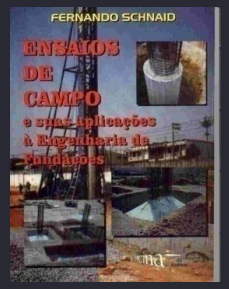
- Identificação de fluxos anômalos pelo corpo do barramento (ainda numa fase bastante inicial) possibilitando que reparos sejam feitos antes que danos ambientais se estabeleçam

O ACIDENTE AFETOU 3 ESTADOS, DEIXANDO 600 MIL PESSOAS SEM AGUA


Cortesia de Garry Kozak
Cortesia de Garry Kozak
5

A
B
C
FONTES SÍSMICAS < 2 kHz

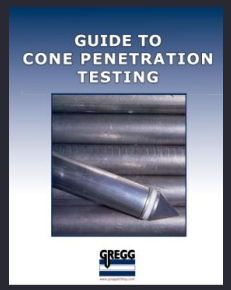
Leitura Recomendada



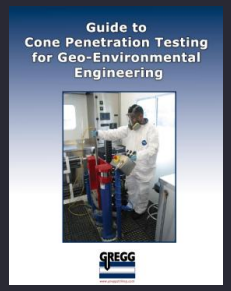
SCHNAID, F. (2000): Ensaios de campo e suas aplicações à engenharia de fundações, Ed. Oficina de Textos, São Paulo. 189 p

LUNNE, T.; ROBERTSON, P. K. & POWELL, J.J.M. (1997): Cone Penetration Testing In Geotechnical Practice , Taylor & Francis Group, London. 352 p.

Leitura Recomendada



ROBERTSON, P. K. (2009): Guide for cone penetration testing for geotechnical engineering, Gregg Drilling & Testing, Inc, *3ª. edição. 115 p*



ROBERTSON, P. K. (2008): Guide for cone penetration testing for geo-environmental engineering, Gregg Drilling & Testing, Inc, *2ª. edição. 84 p*

SINTESE

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(11) 966013982

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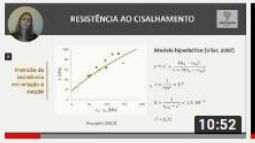

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