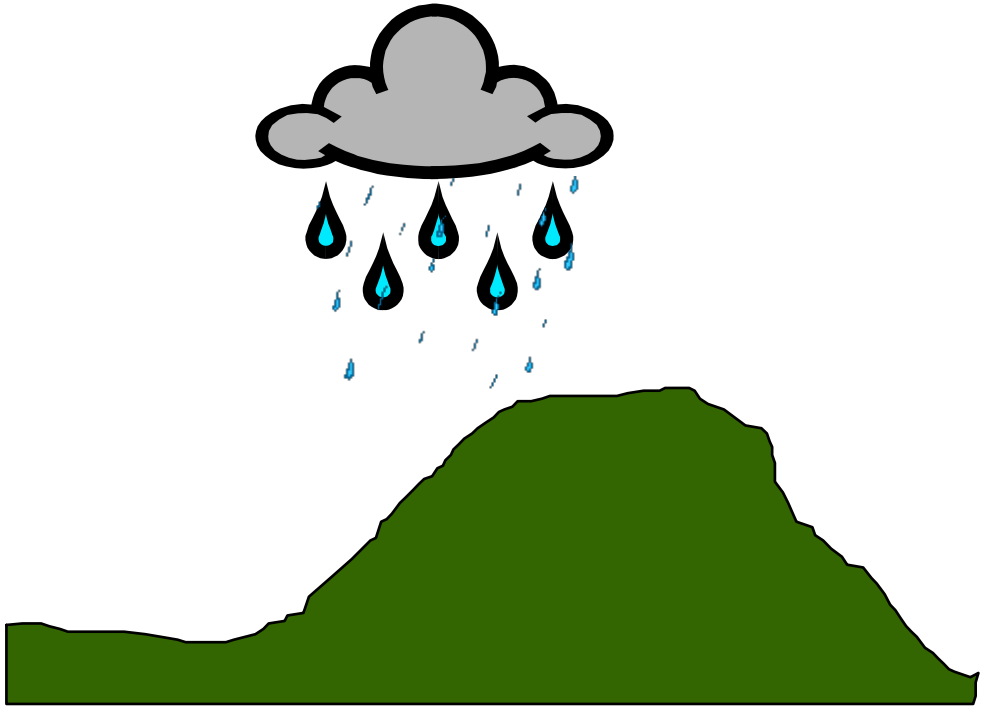
Flash flood control reservoirs in Rio de Janeiro

Alberto Ortigao, PhD, FICE, CEng, PE (US)

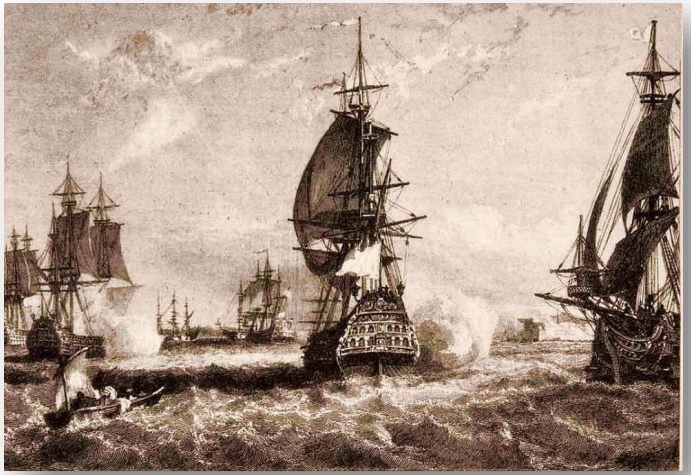
Storms in Rio de Janeiro



1580 Father Anchieta

1711 French invasion

Invasion of Rio de Janeiro

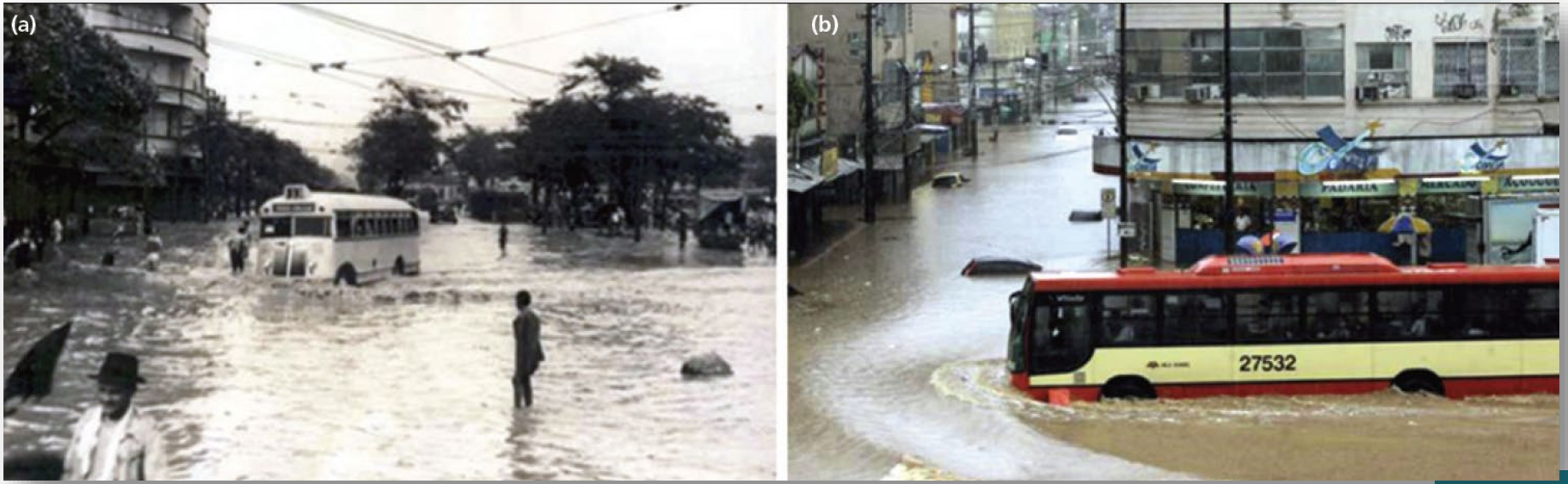


Renée Duguay-Trouin

Tijuca Basin

Flash floods 1940-1970

Bandeira Square



Game changing events

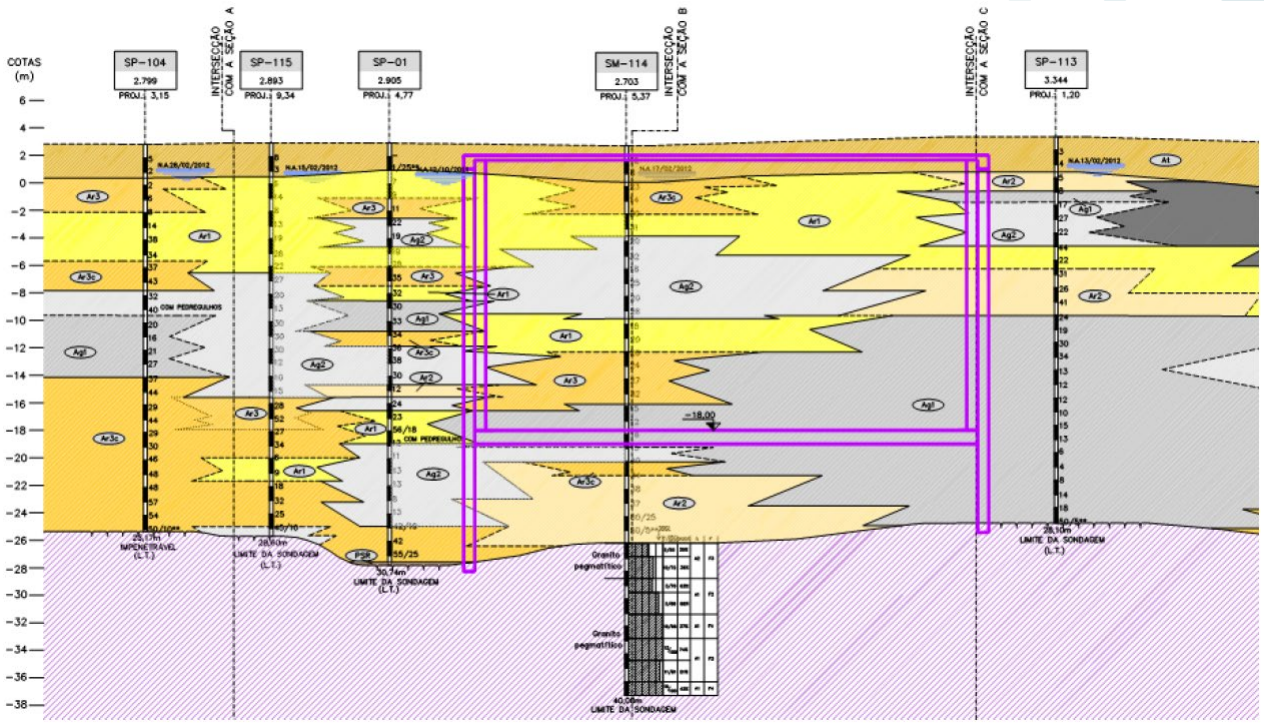
Reservoir location

Bandeira Square Reservoir

Reservoir design

- Diameter 40 m
- Depth 20 m
- Volume 20000 m^3
- Diaphragm wall
  - 80 cm thick
  - 30 m deep
- JG sealed joints
- Internal ring beams
- No bottom slab

Ground conditions

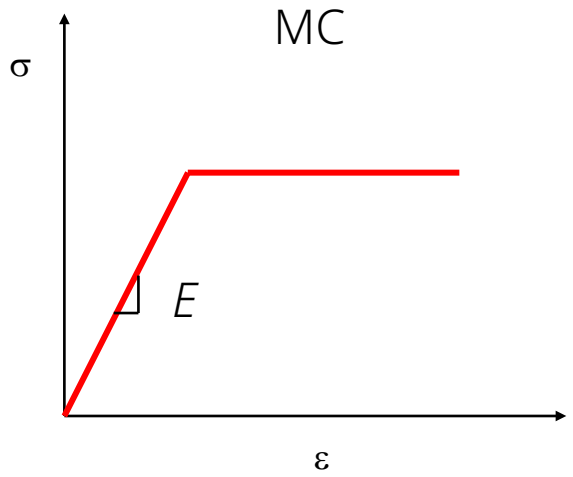


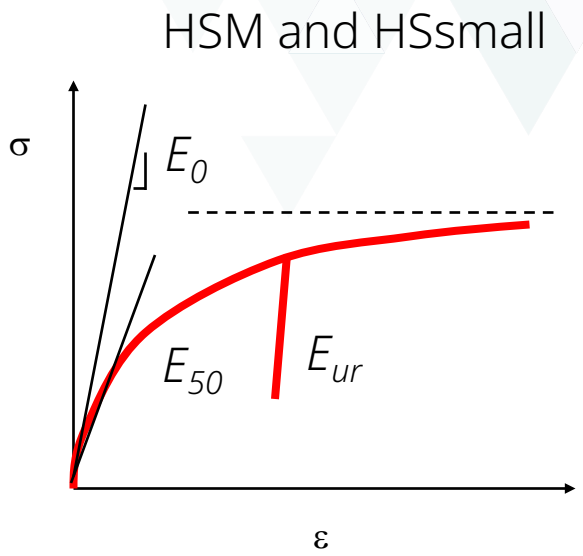
Loose fill $N = 5$

Hard soils $N > 20$

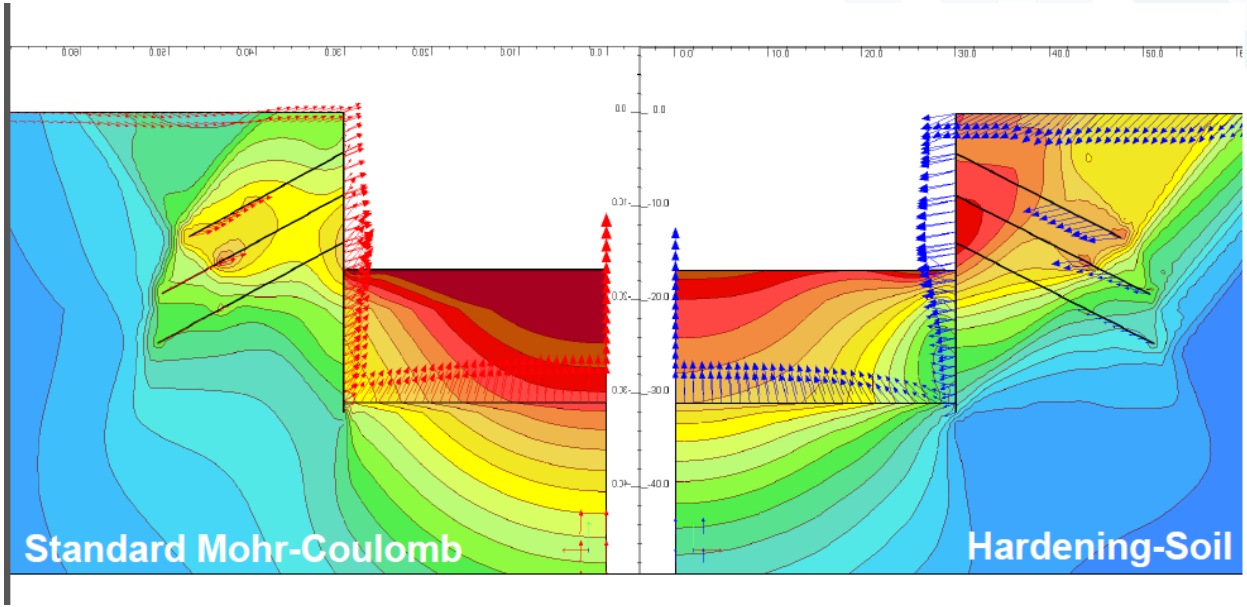
Granite

Constitutive models HSM & HSsmall



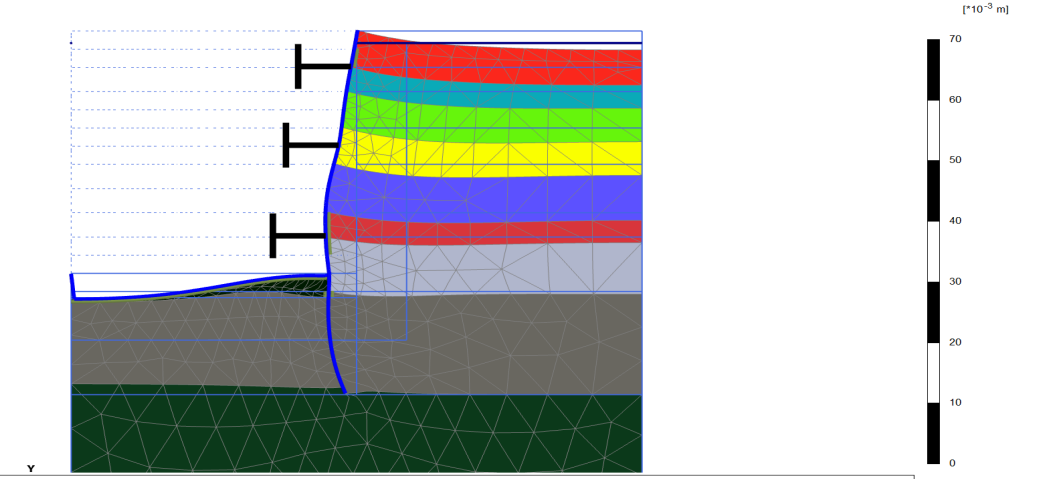


MC versus HSM



Plaxis 2D Numerical model

Output Version 2011.1.7671.7015

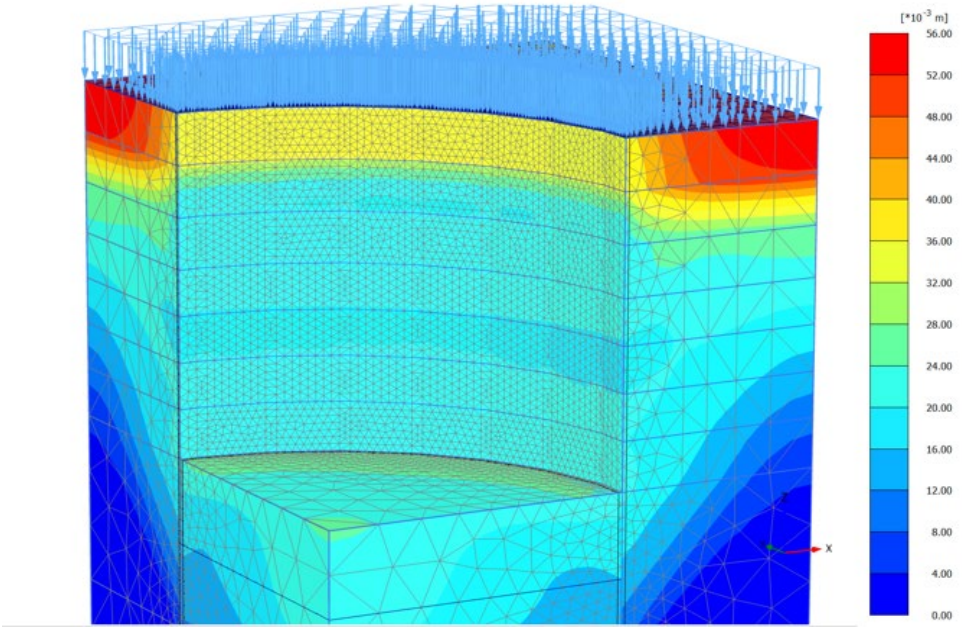


Deformed mesh |u| (scaled up 500 times)

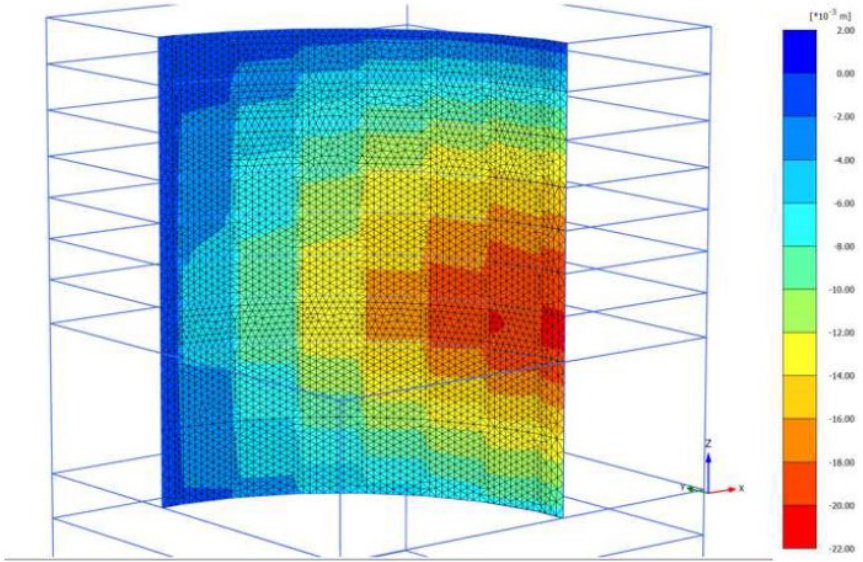
Maximum value = $4.557*10^{-3}$ m (Element 151 at Node 2681)

Terratek	Project description: Reservatório de retenção - Praça da Bandeira RJ		Date: 16/07/2012
	Project filename: RT Praça da Bandeira SP-117	Step: 125	User name: Terratek Ltd

3D numerical model



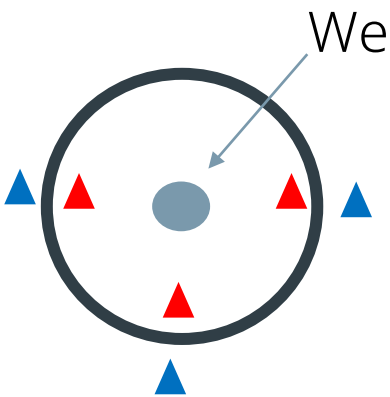
Horizontal displacements



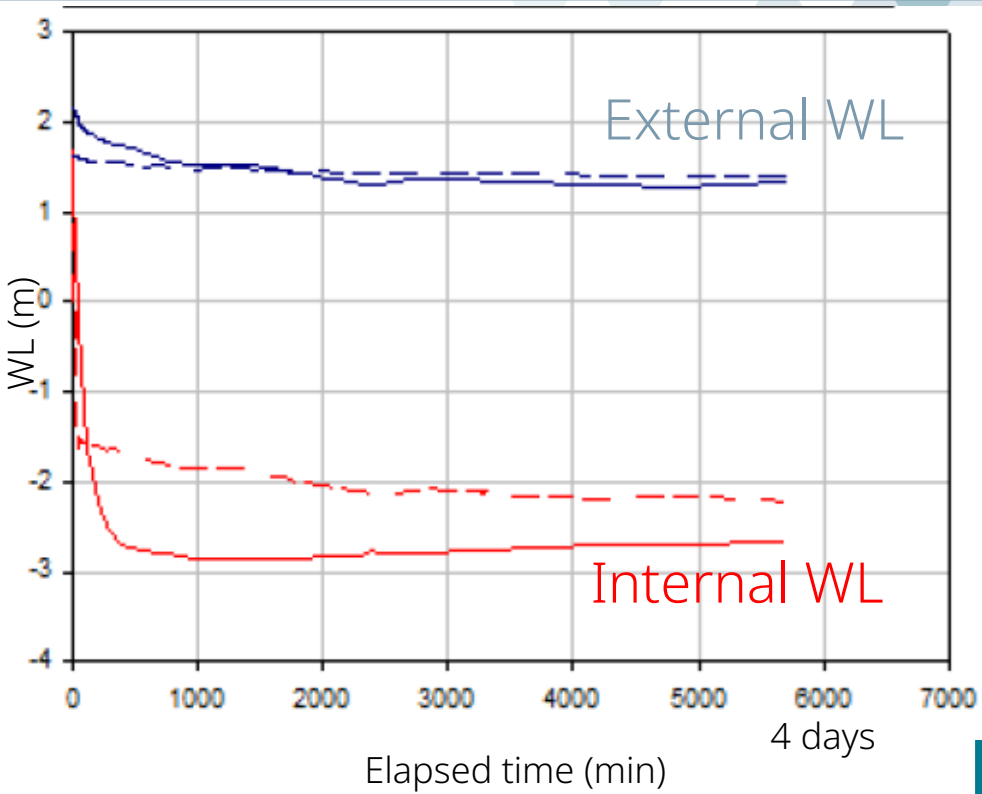
Max 20 mm

Diaphragm wall construction

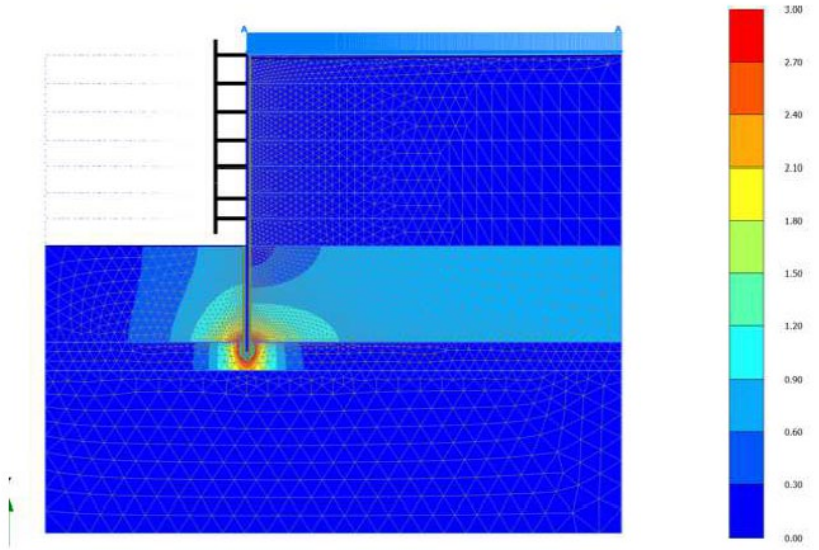
Pumping test



Observation wells



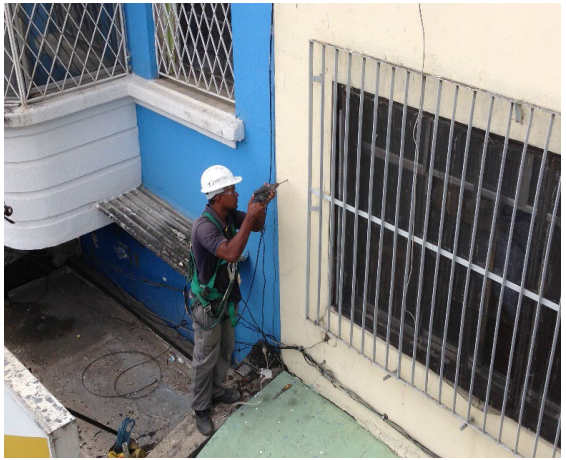
Seepage analysis



Max inflow 3 m^3/day

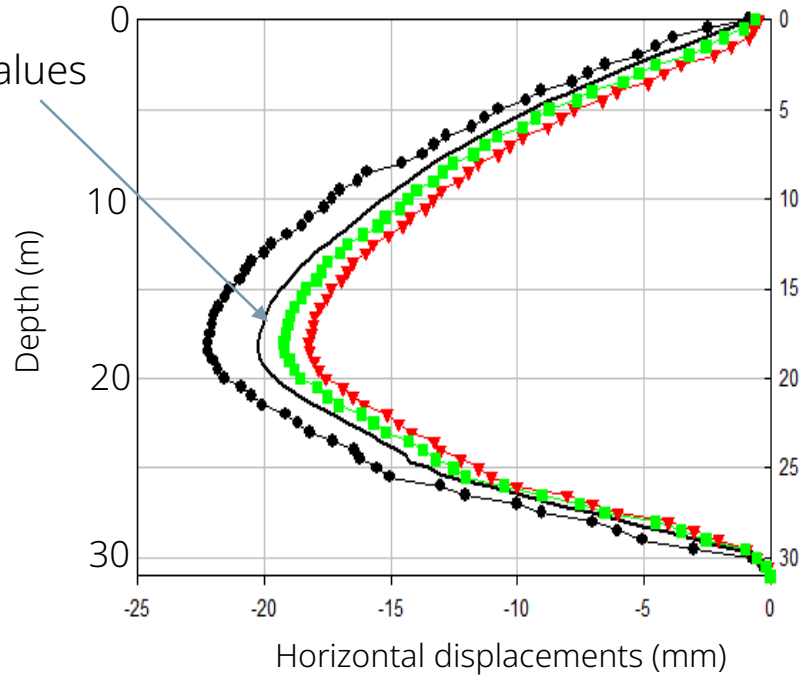
Instrumentation

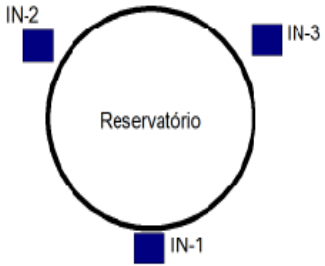
- Topographical targets and settlement pegs
- Inclinometers
- Piezometers

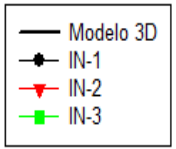


Inclinometers

Numerically calibrated values



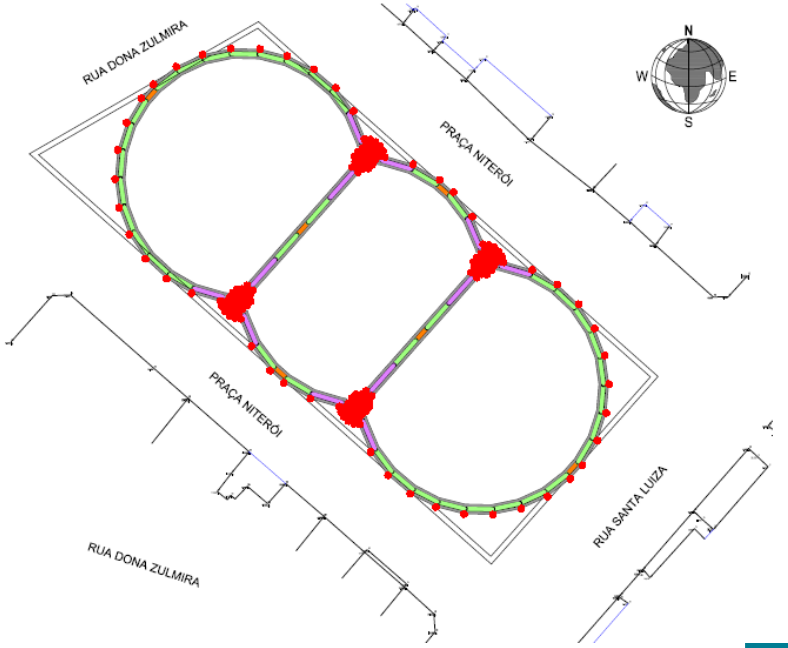




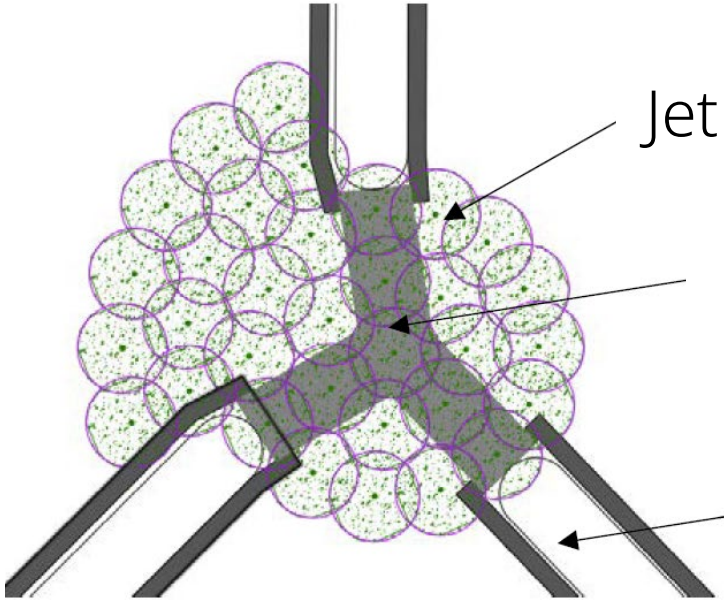
Bandeira Square Reservoir

Niteroi Square Reservoir

- Radius 17.5 m
- Depth 28 m
- Diaphragm wall 80 cm thick
- 5 levels of concrete rings
- Volume 60000 m^3



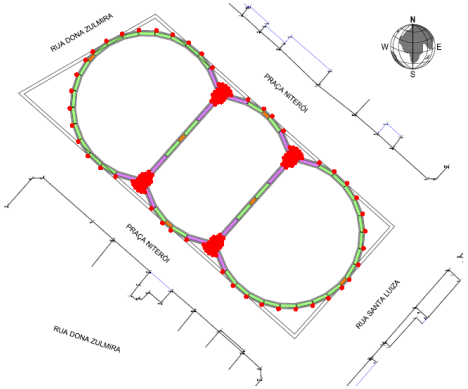
Diaphragm wall Y-joints



Jet grouting columns

Y-joints

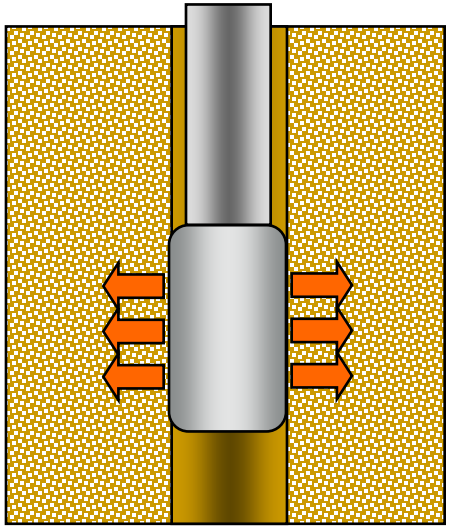
Diaphragm wall

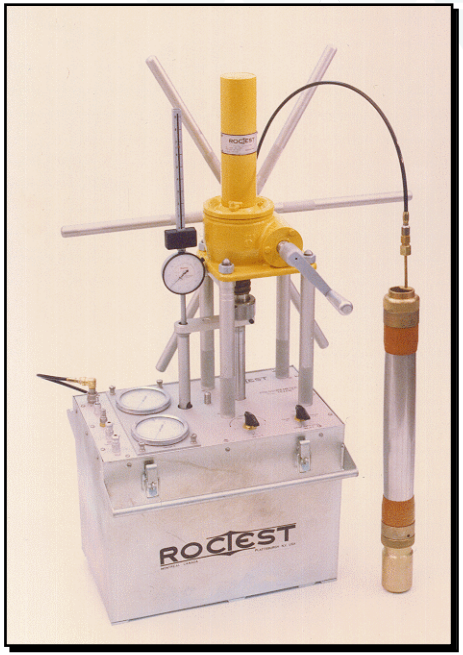


Site investigation

- Boreholes
- PMT testing
- MASW geophysics
- Pumping test

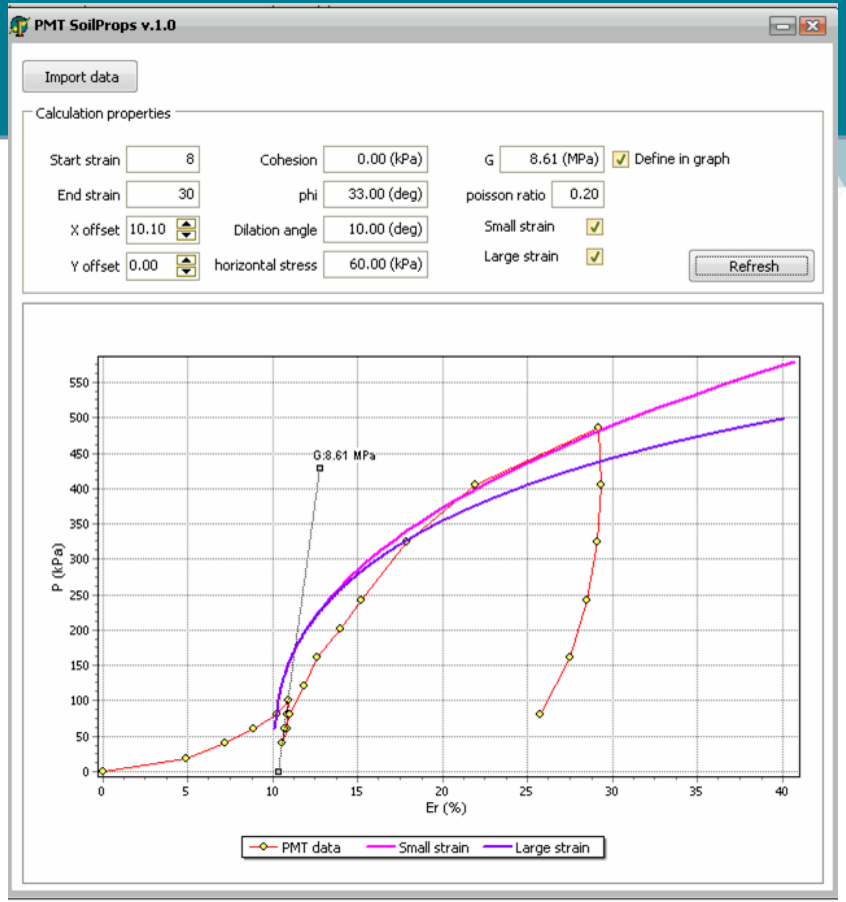
PMT



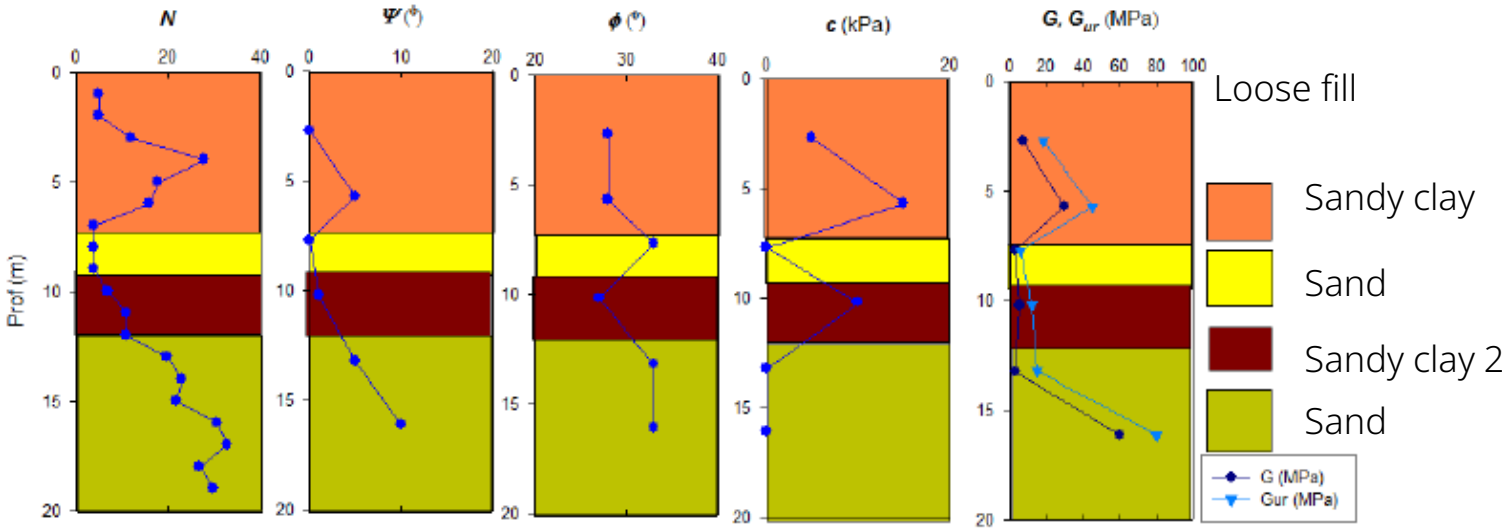


PMT program

Carter et al 1986

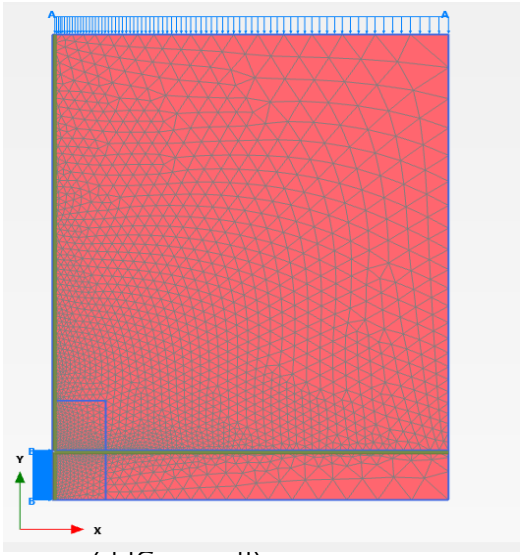


PMT results

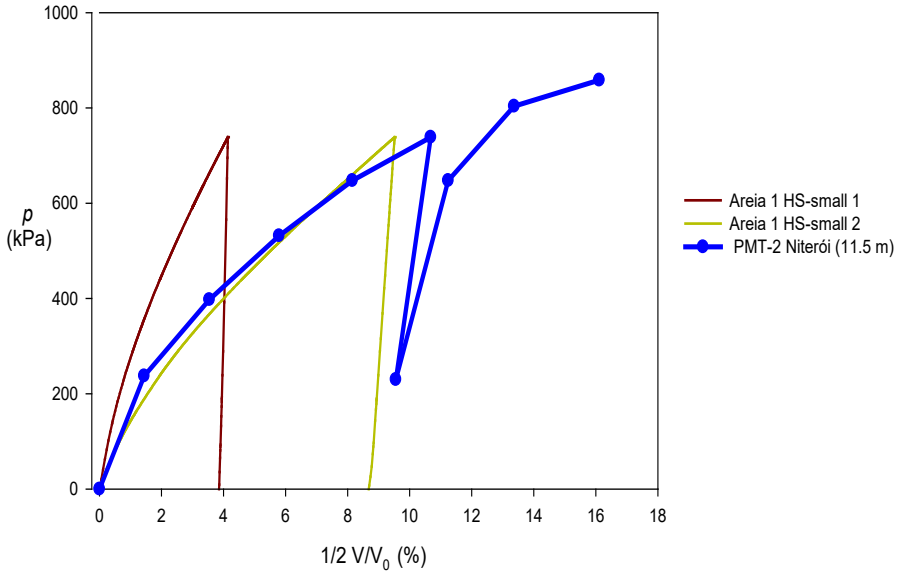

N
Ψ(°)
ϕ (°)
c (kPa)
G, Gur (MPa)
Prof (m)
Loose fill
Sandy clay
Sand
Sandy clay 2
Sand
G (MPa)
Gur (MPa)

PMT Numerical calibration

Plaxis 2D

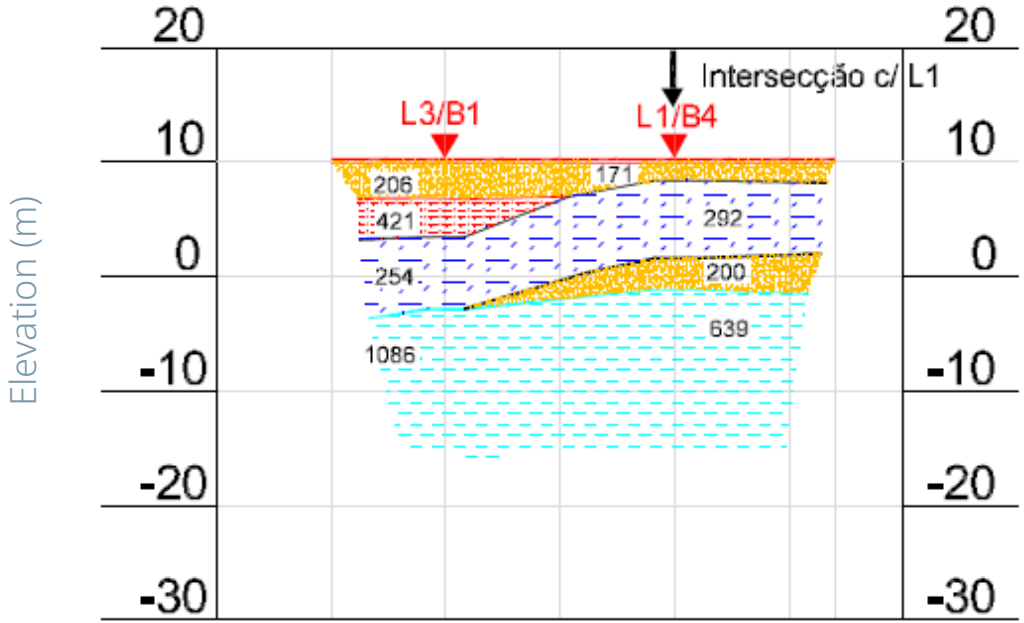


(HS-small)

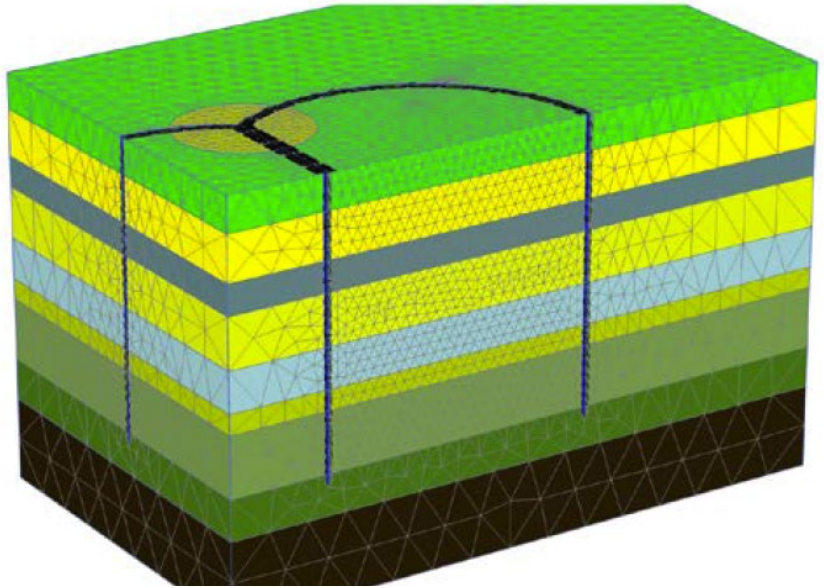


MASW Geophysics

Shear wave velocity V_s (m/s)



Soil model



Loose fill

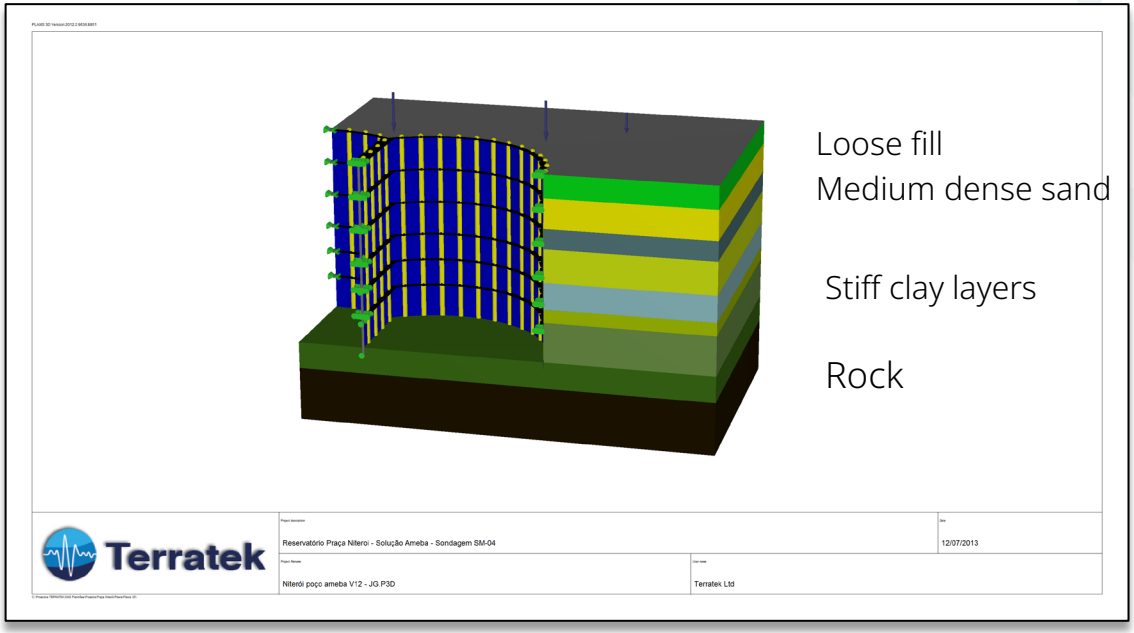
Stiff clay

Dense sand

Sandy clay

Granite

Plaxis 3D model

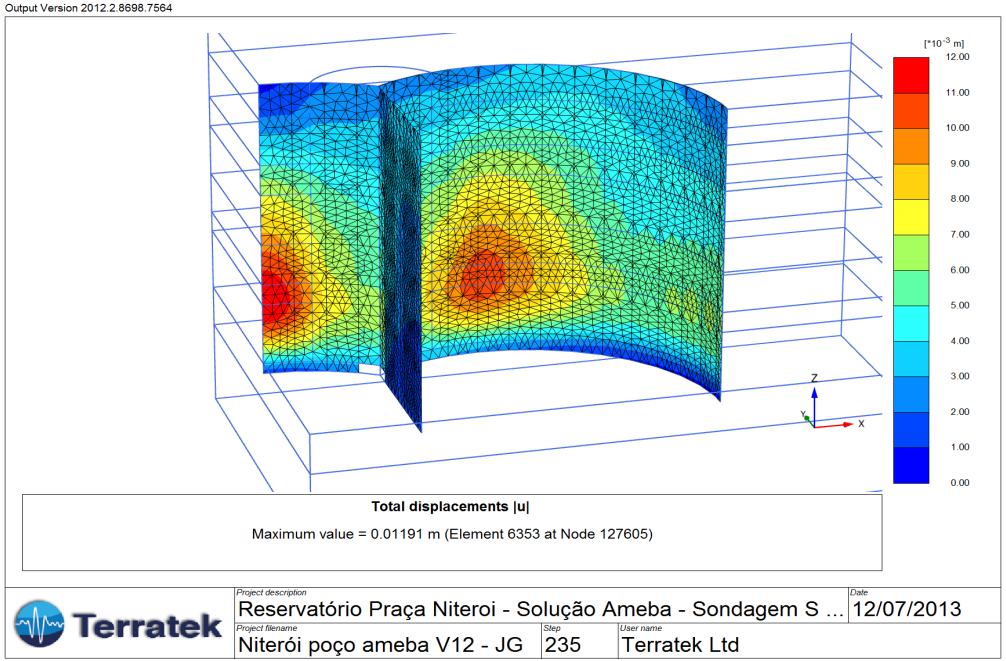


Loose fill
Medium dense sand

Stiff clay layers

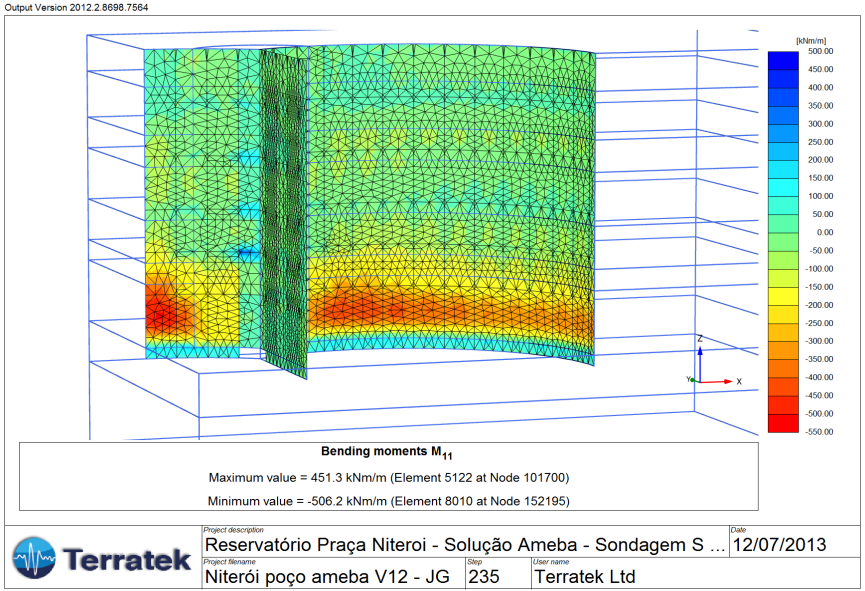
Rock

Diaphragm wall displacements



Max 12 mm

Transverse moments

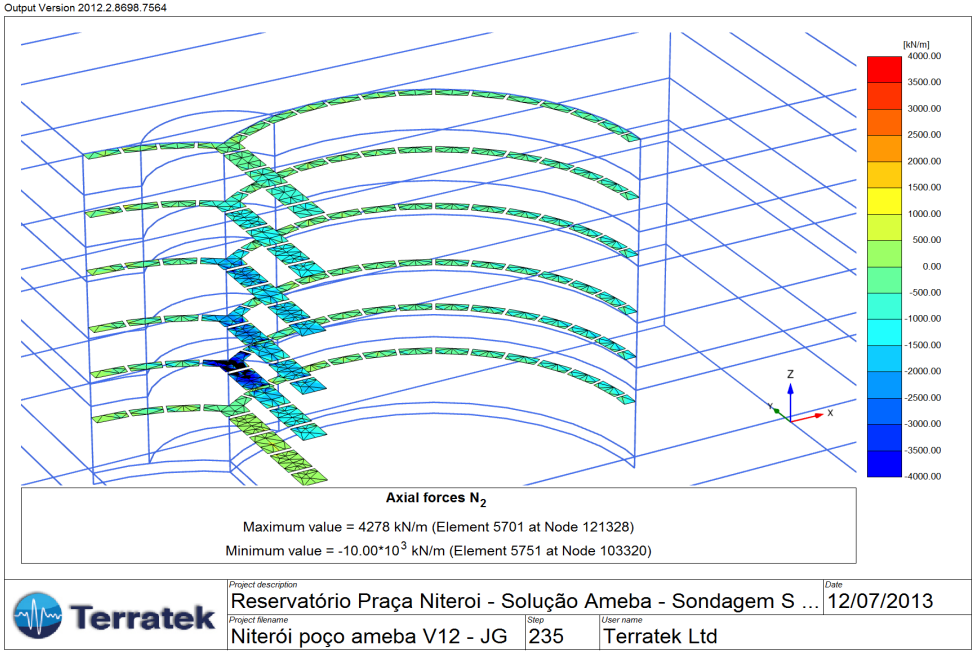


400 kNm /m

50 kNm /m

Transverse moments M11

Ring axial compression loads

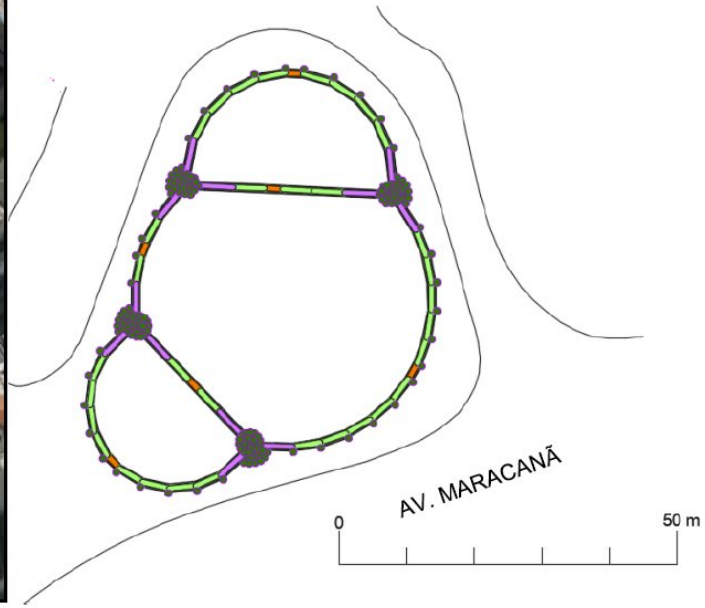


-500 kN/m

Axial load N2

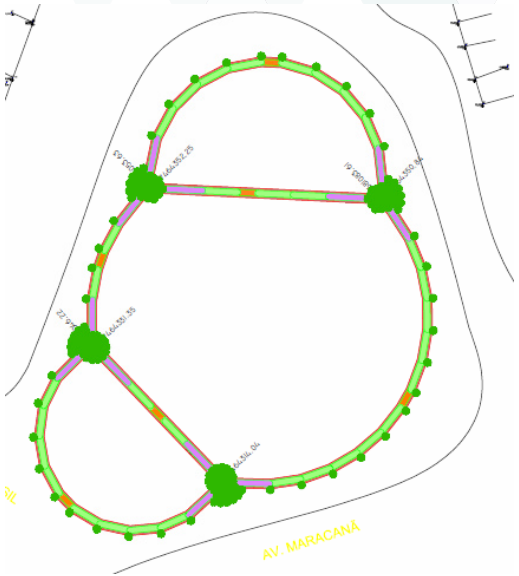
Niteroi Square

Varnhagen Square

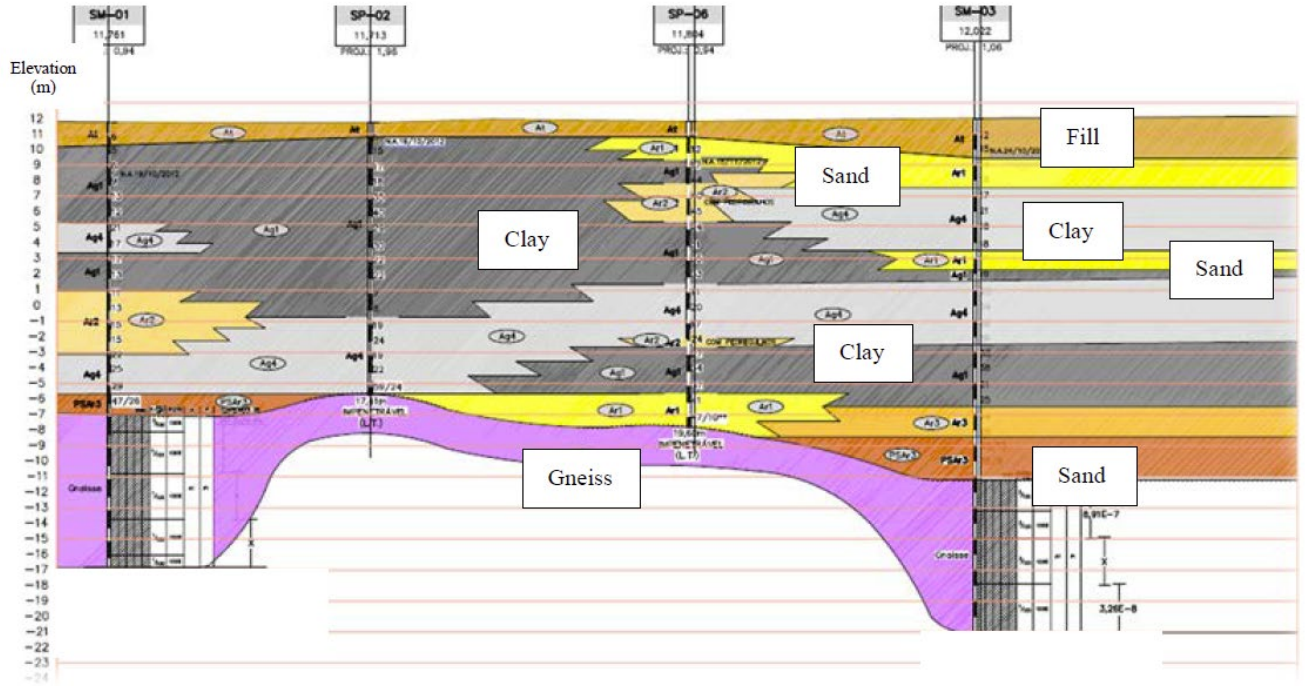


Varnhagen Square

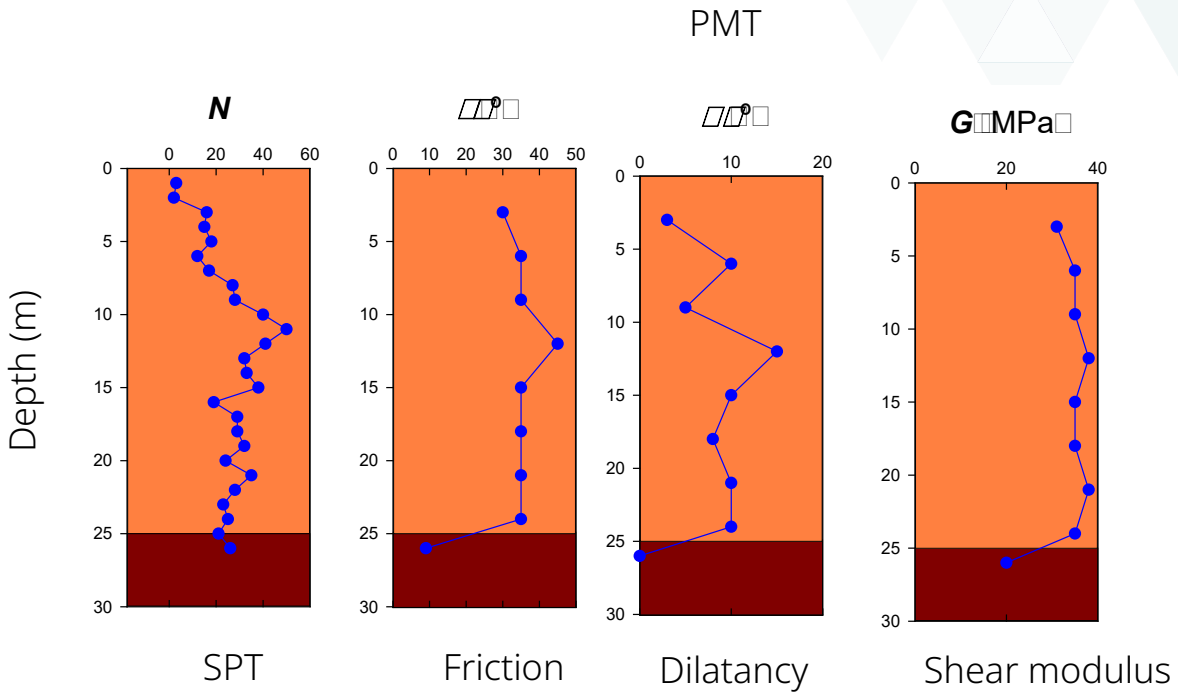
- Depth 23 m
- Central shaft radius 22 m
- Side shafts 15 m radius
- Volume 45 000 m^3
- 80 cm thick diaphragm wall
- Four levels of concrete rings



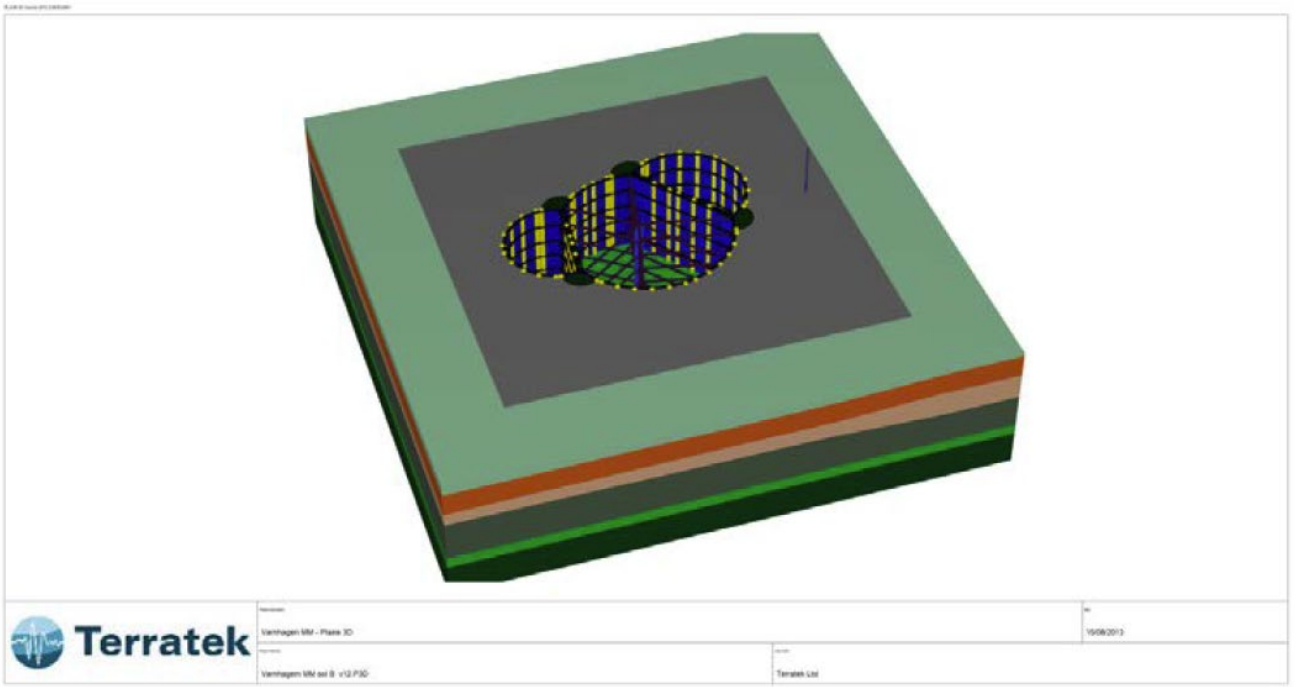
Soil profile



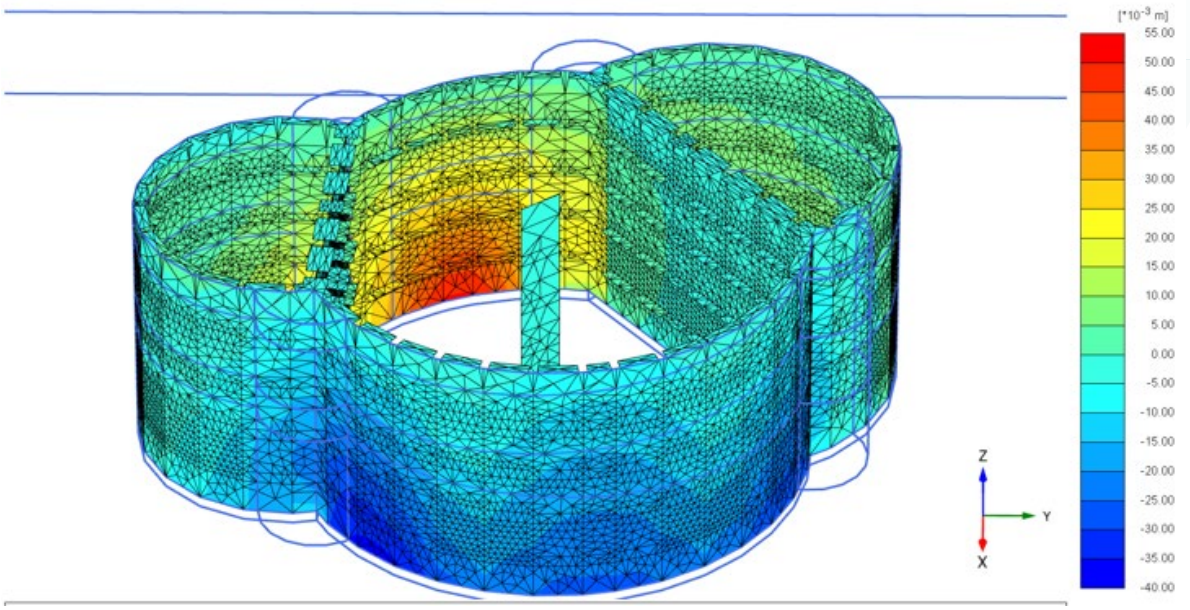
Soil properties



Plaxis 3D model



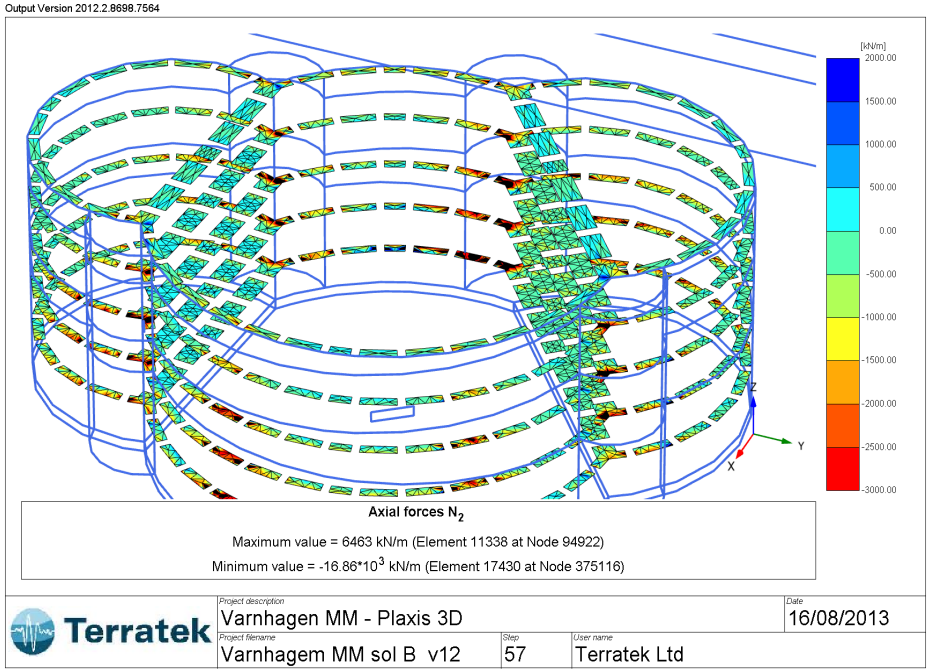
Horizontal displacements



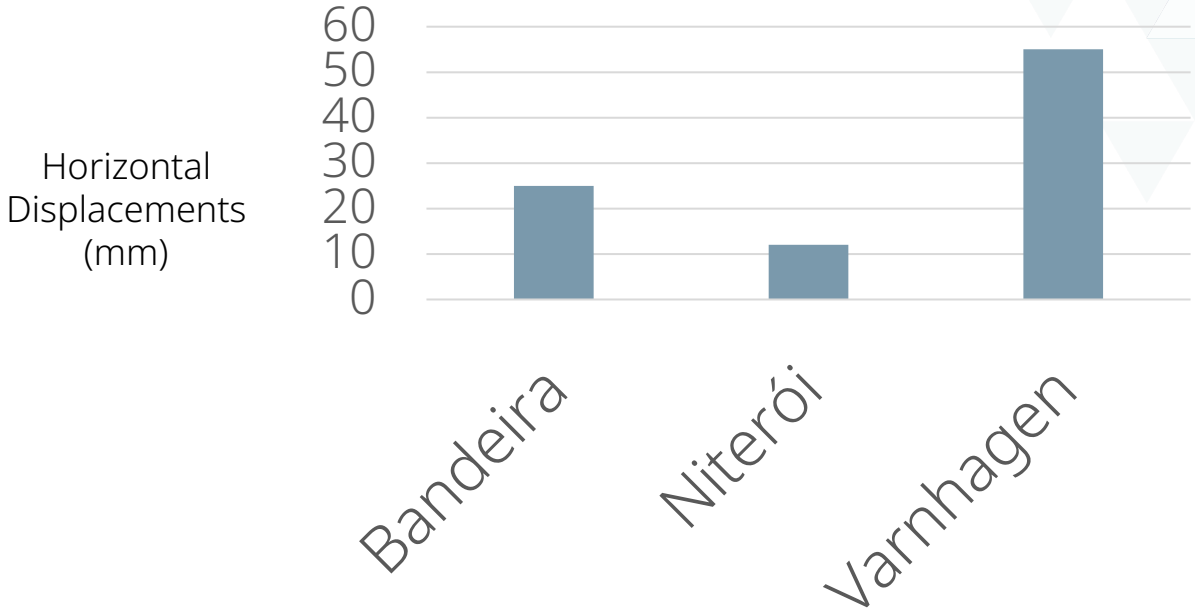
55 mm

Max values 50 mm

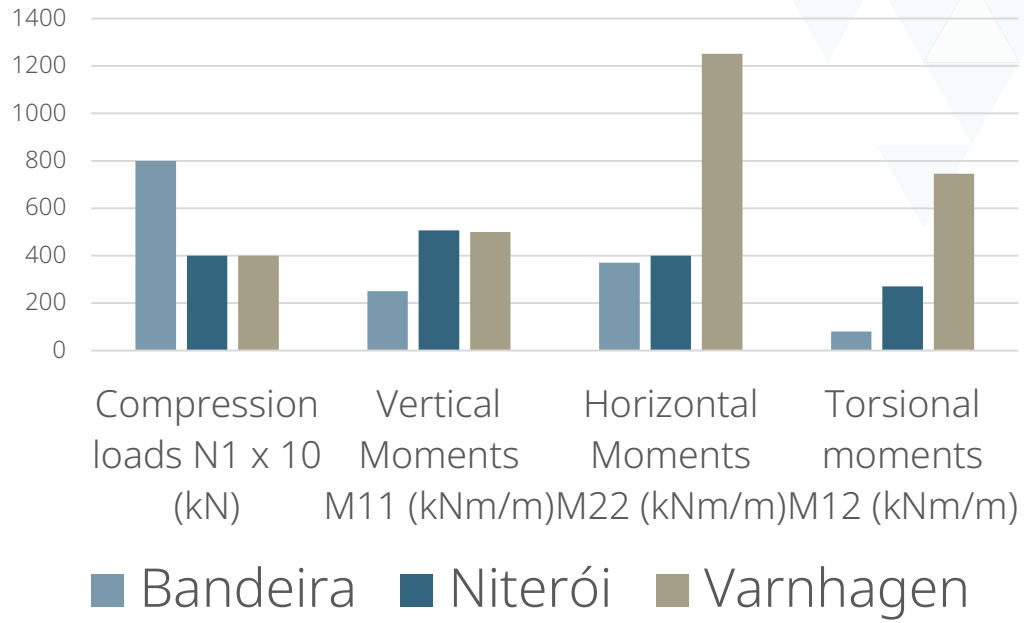
Loading on compression rings



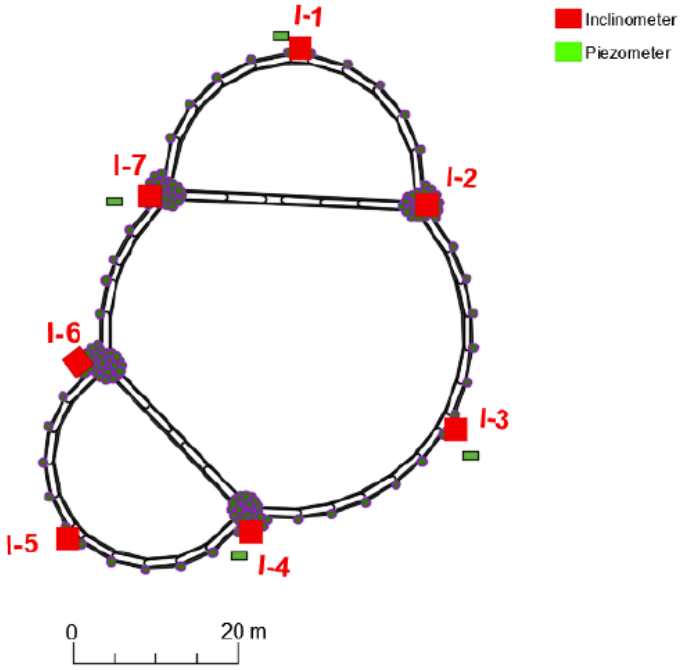
Predicted horizontal displacements



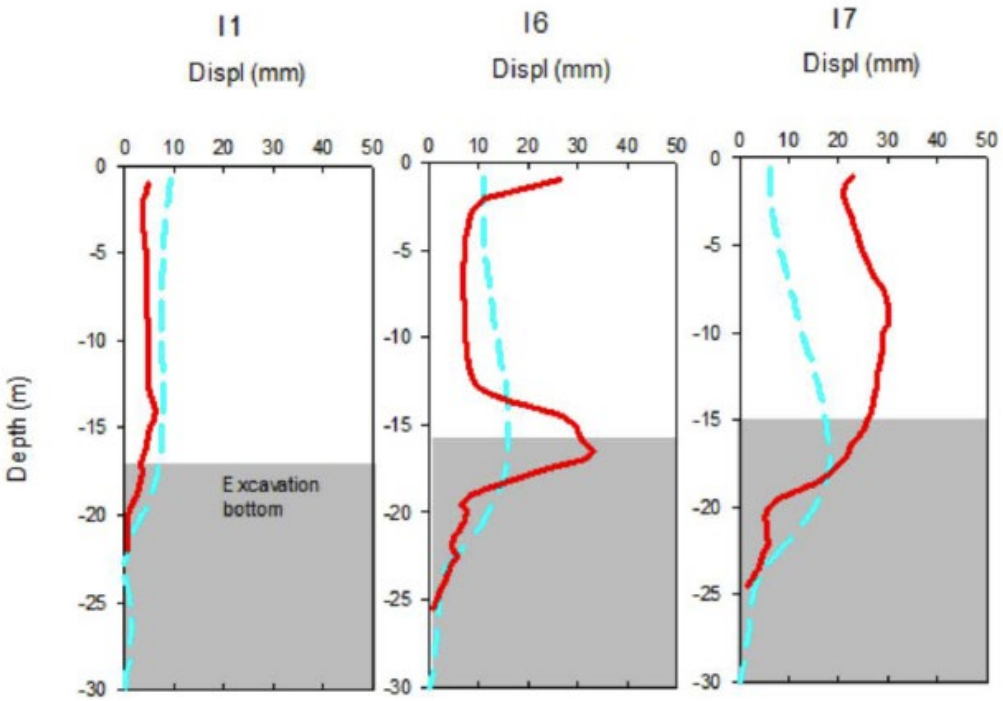
Predicted diaphragm wall loading



Instrumentation plan



Instrumentation results



Varnhagen Square

Conclusions

- Comprehensive site investigation
- 3D numerical modelling
- Design
  - 80 cm thick diaphragm wall
  - Internal rings
  - JG for joint sealings
  - JG improved Y-joints
  - Deep bottom slab avoided
- No damage to surrounding buildings
- Fast construction rates

Questions ?

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