XV EUROPEAN CONFERENCE ON
SOIL MECHANICS & GEOTECHNICAL ENGINEERING

Discussion Session 6.1: Geoenvironmental Issues

Kenichi Soga
Professor of Civil Engineering
Department of Engineering

UNIVERSITY OF CAMBRIDGE

ISSMGE: The Future by Dr. Joost Breedevelt

- Climate Change
- Urbanisation
- Sustainability
- Resources scarcity
- Energy
- Global population growth

Future for Geoevironmental engineers

Do you know any new industry or

Can you create new industry

to provide the professional practice that brings financial returns,

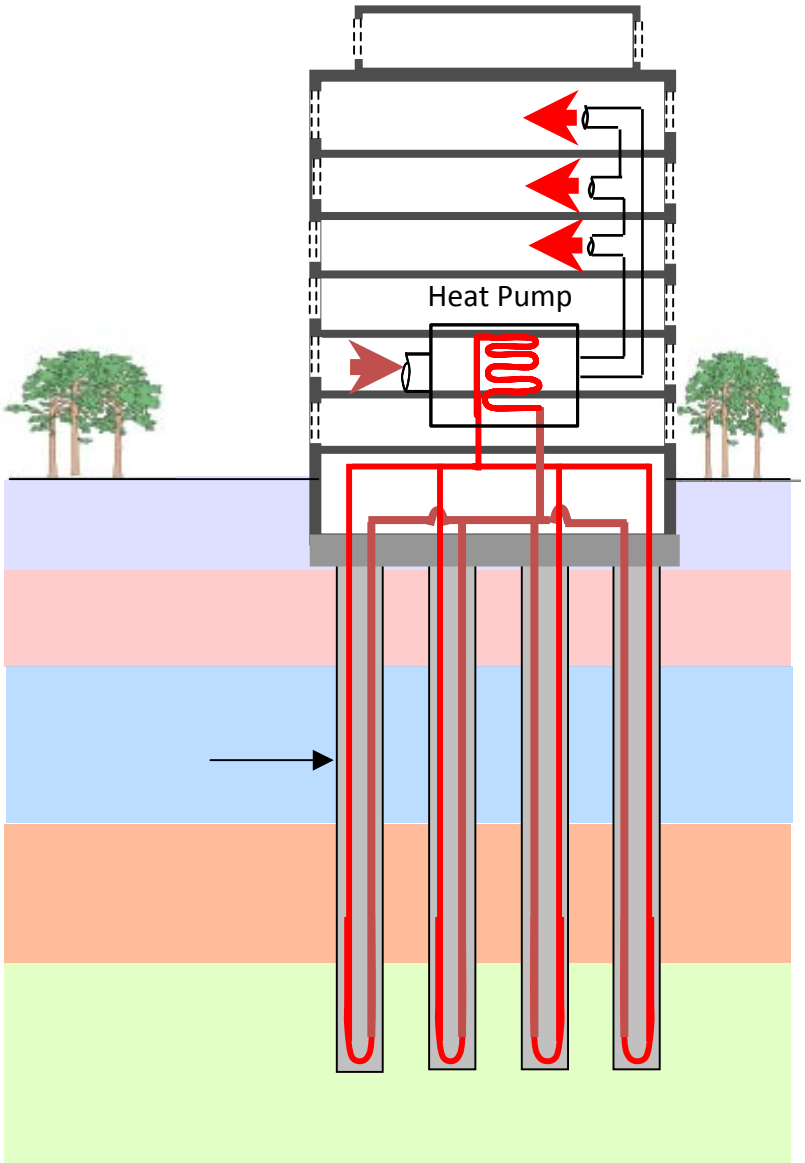
like we did in landfills and contaminated lands?

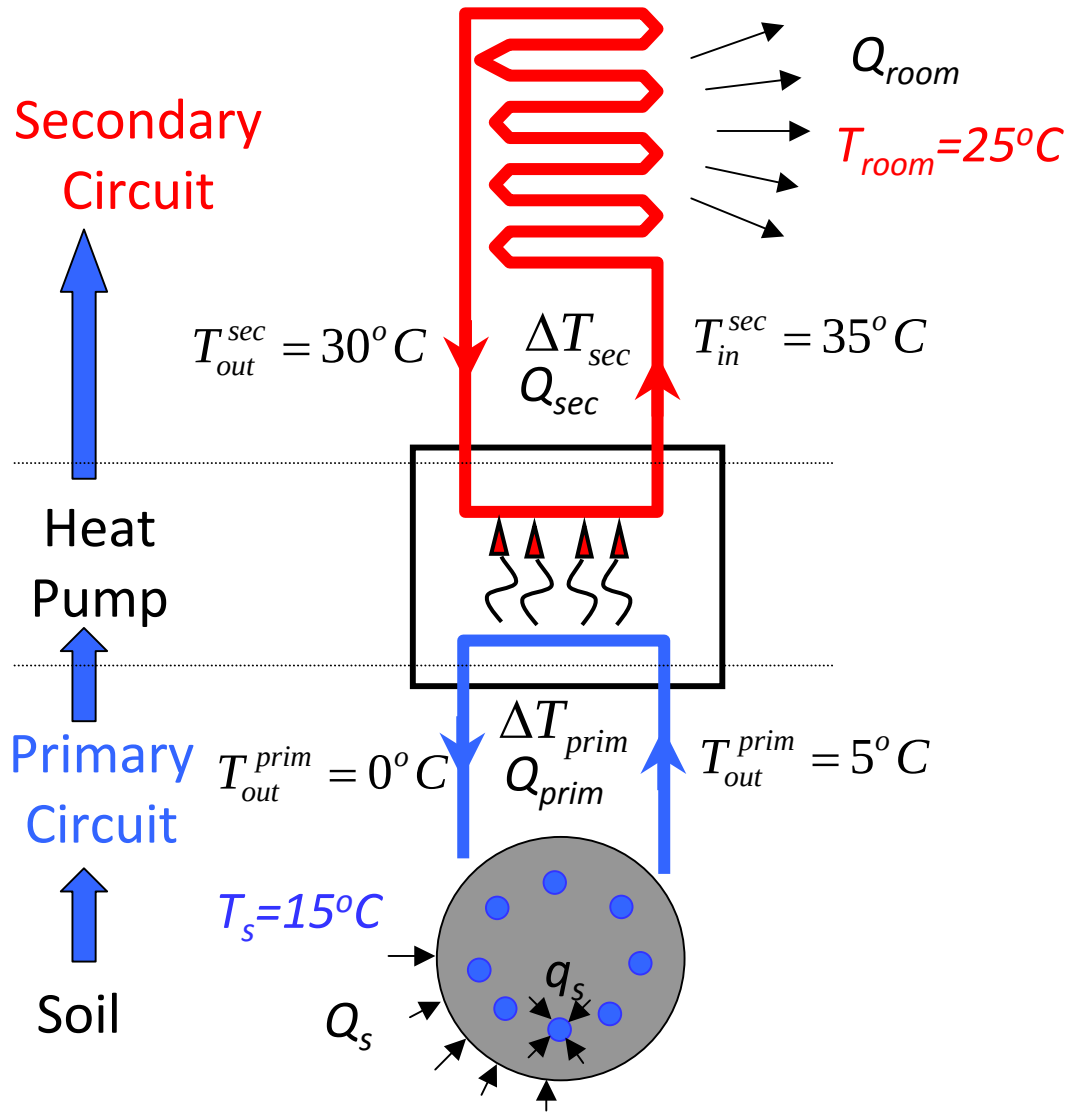
Where is geo-environment going?

Are we reactive (receivers) rather than proactive (producers)?

- Geothermal energy (shallow GSHPs)
- Radioactive waste from solid waste experience
- Carbon-based energy (shale gas, methane hydrates, etc)
- Low energy/intensity geotechnics (zero waste, low embodied energy, waste utilisation)
- Ground vibration
- Bio-engineering (see agricultural industry)

Geothermal energy


Heat Pump


Secondary Circuit
Heat Pump
Primary Circuit
Soil
Q_{room}
$T_{room}=25^oC$
$T_{out}^{sec} = 30^o C$
ΔT_{sec}
Q_{sec}
$T_{in}^{sec} = 35^o C$
ΔT_{prim}
Q_{prim}
$T_{out}^{prim} = 0^o C$
$T_{out}^{prim} = 5^o C$
$T_s=15^oC$
q_s
Q_s

COP = 3 - 5

Enhanced Geothermal Energy Systems: Energy Supply and Storage for Sustainable Development, Katzenbach, Clauss, Waberseck&Wagner

Figure 4. Main Tower, Frankfurt am Main, Germany, pile heads and connector pipes.

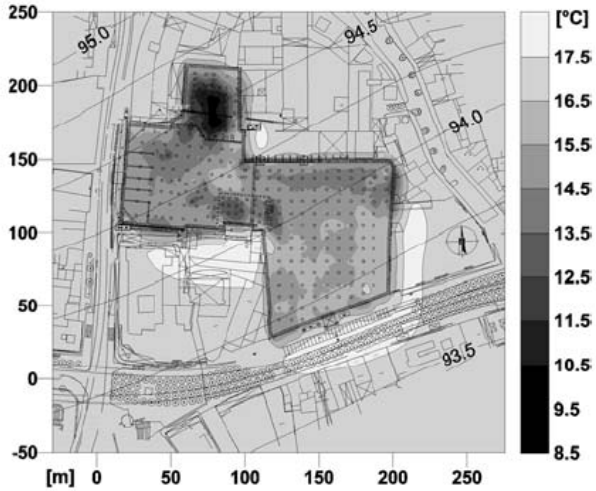
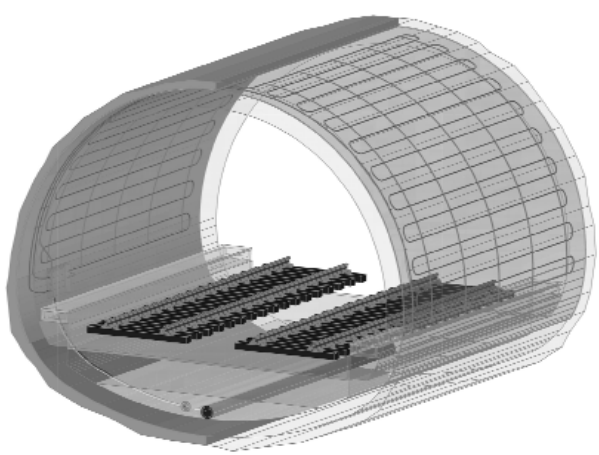
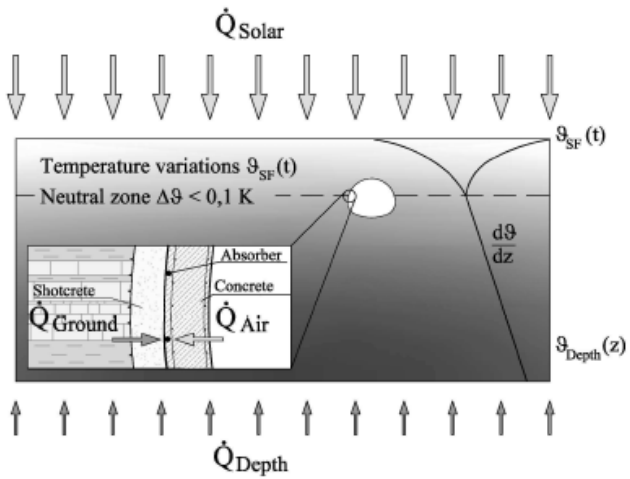


Figure 6. Numerical simulation of heat transport in subsoil after winter operation of the energy piles [11].

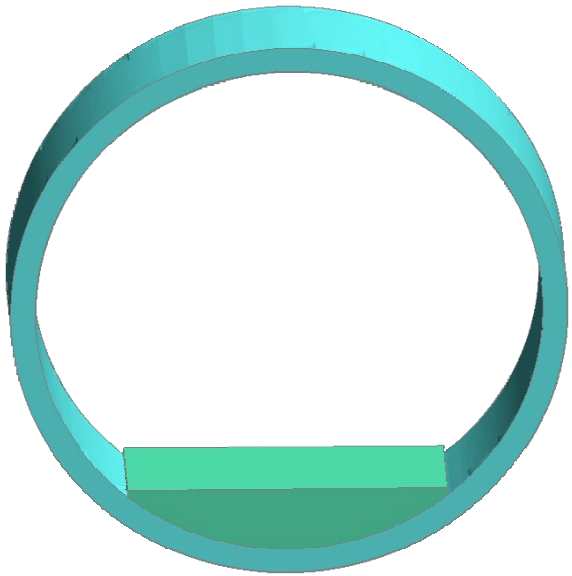
Tunneling as a contribution to sustainable energy
M. Schneider, Vermeer & Moormann

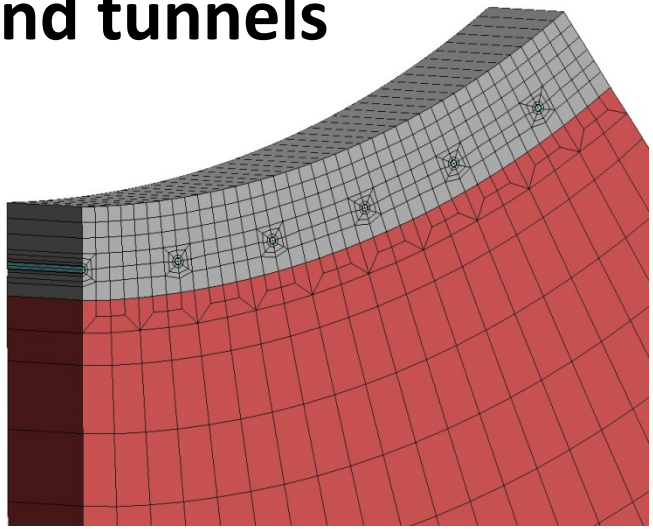


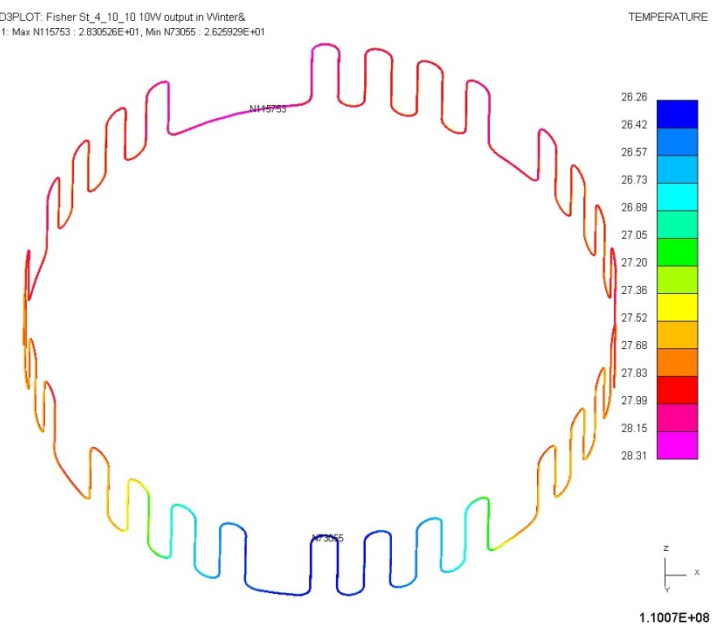


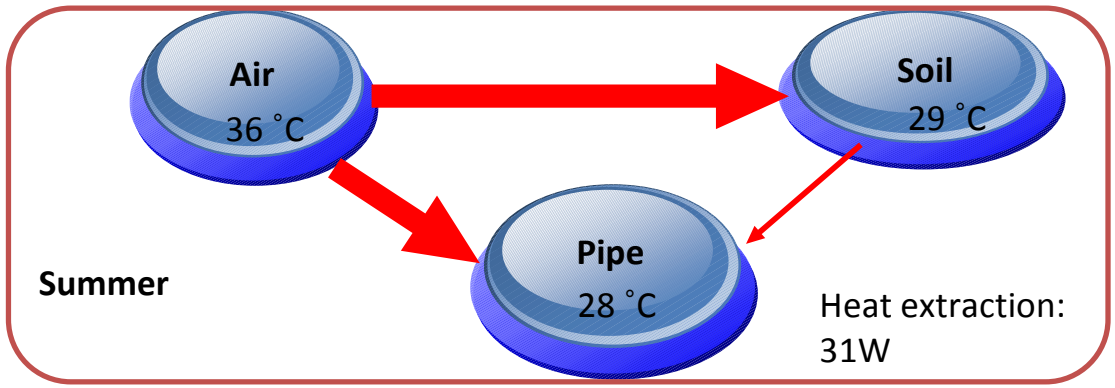
Shotcrete tunnel section of a city railway project

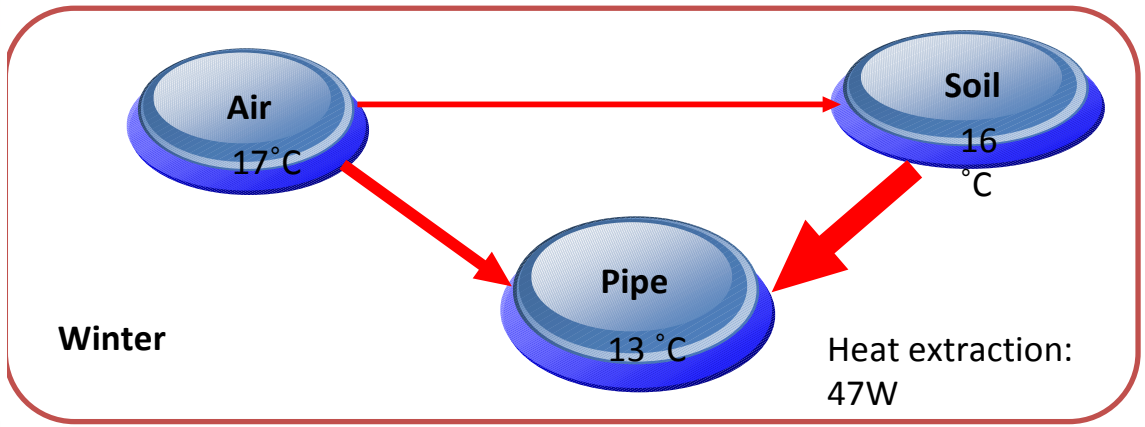
Heating from London Underground tunnels



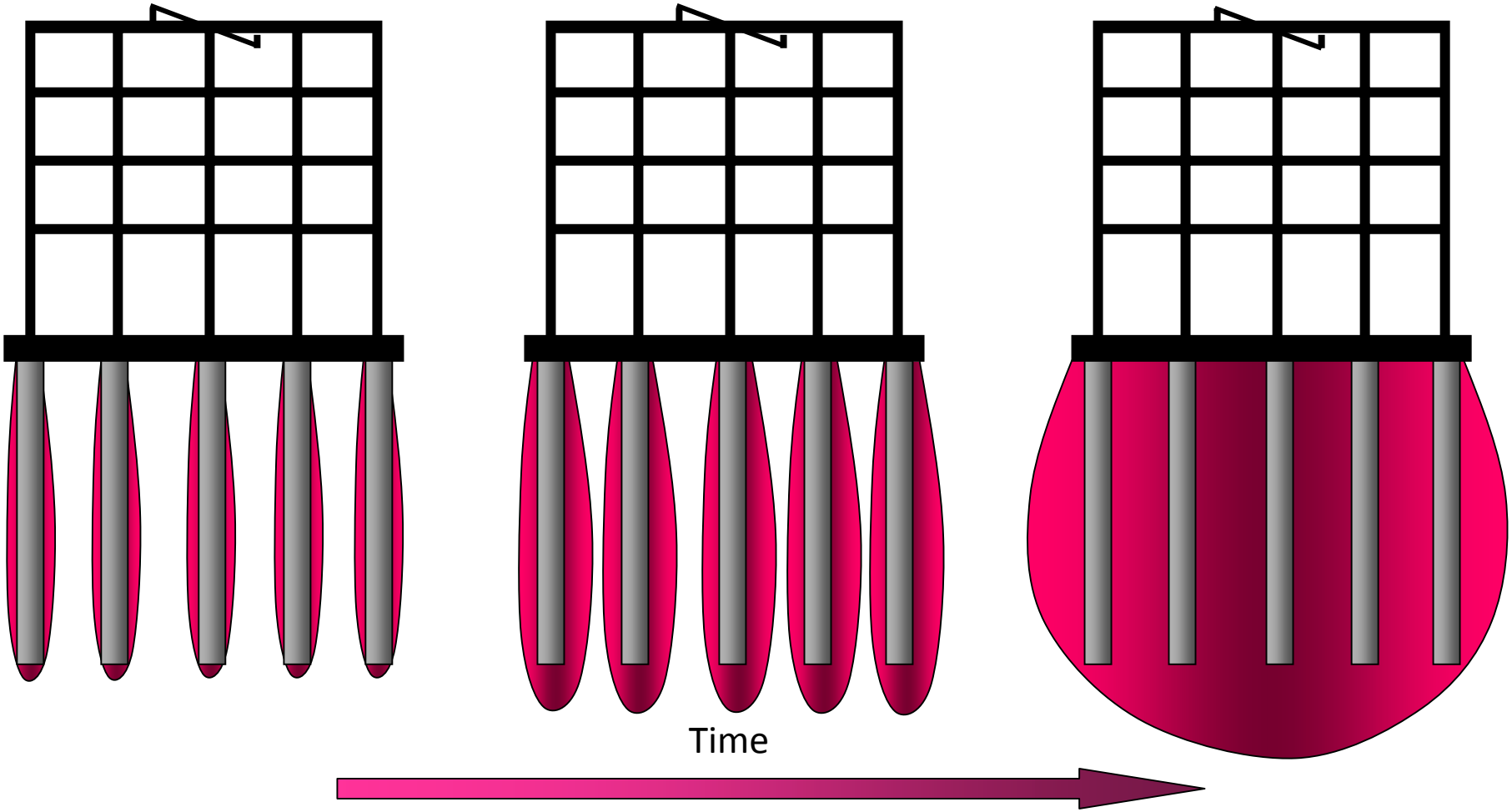








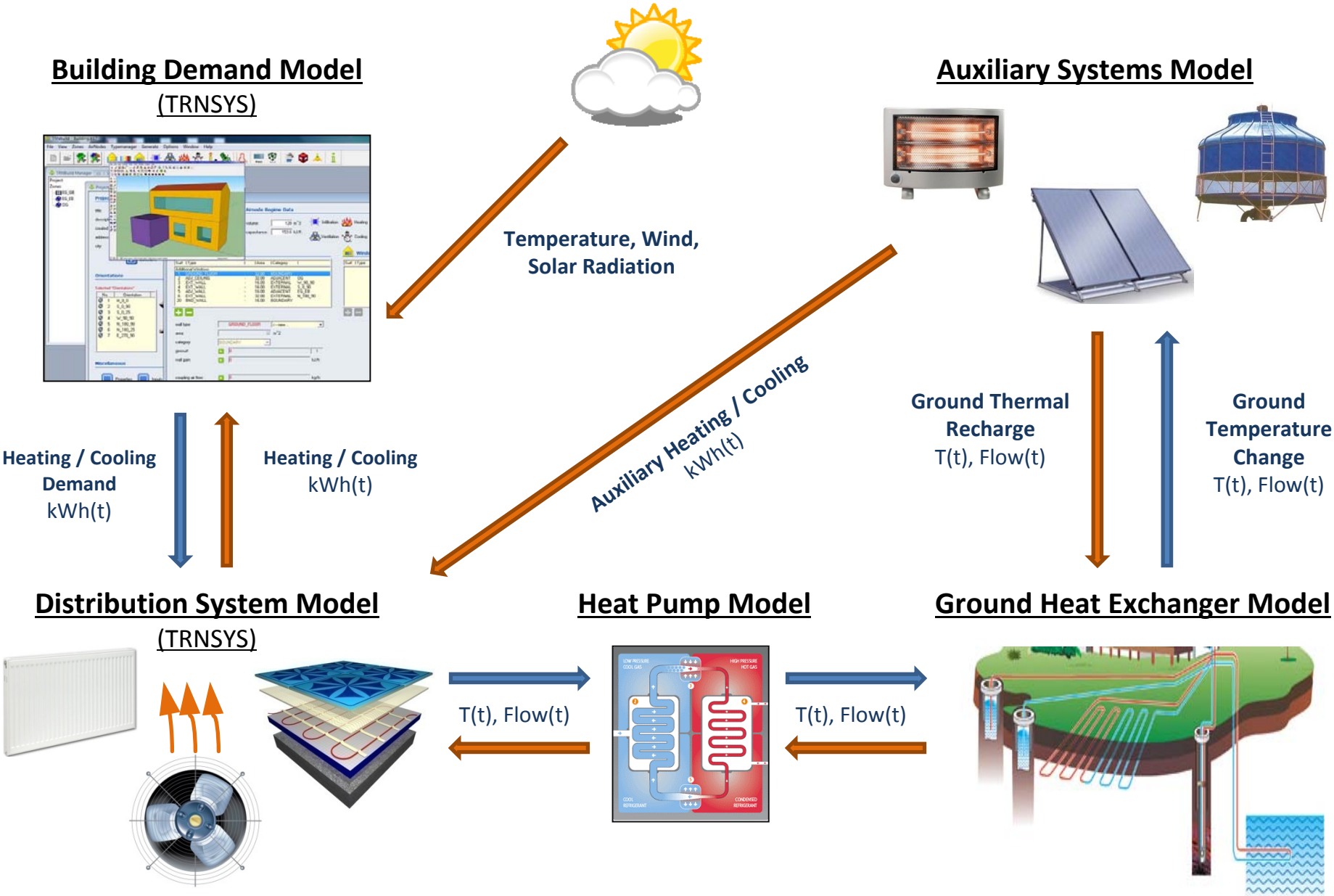
Long term heat imbalance



Developing heat plume with imbalance in energy demand

What risks could be involved in geothermal systems during their life cycles – particularly for the operational requirements of the buildings?

The Relationship between the Model Components



How many new generation geothermal energy systems can be installed at “city” scale without losing control of ground thermal capacity?

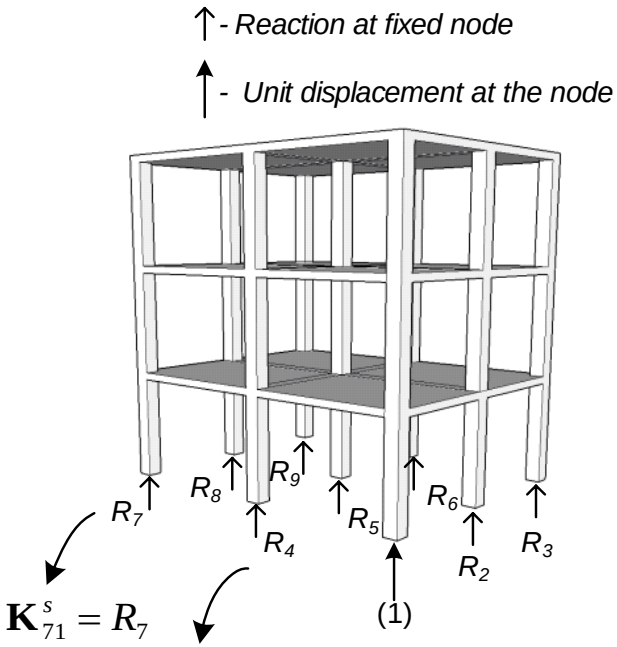
London Heat Map

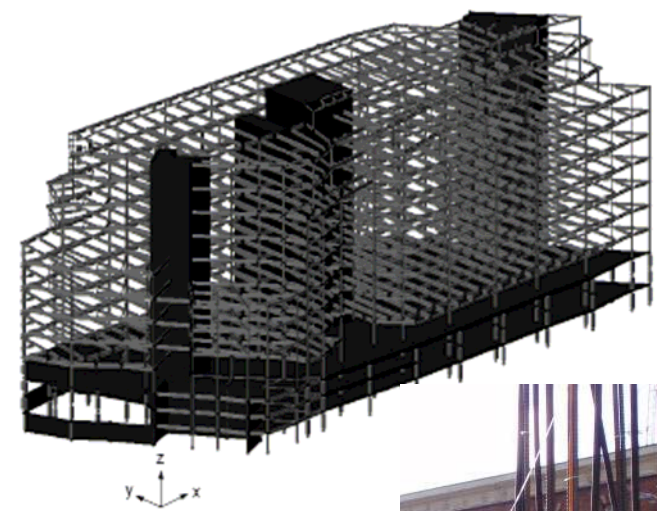
Total Heat Load (kW)

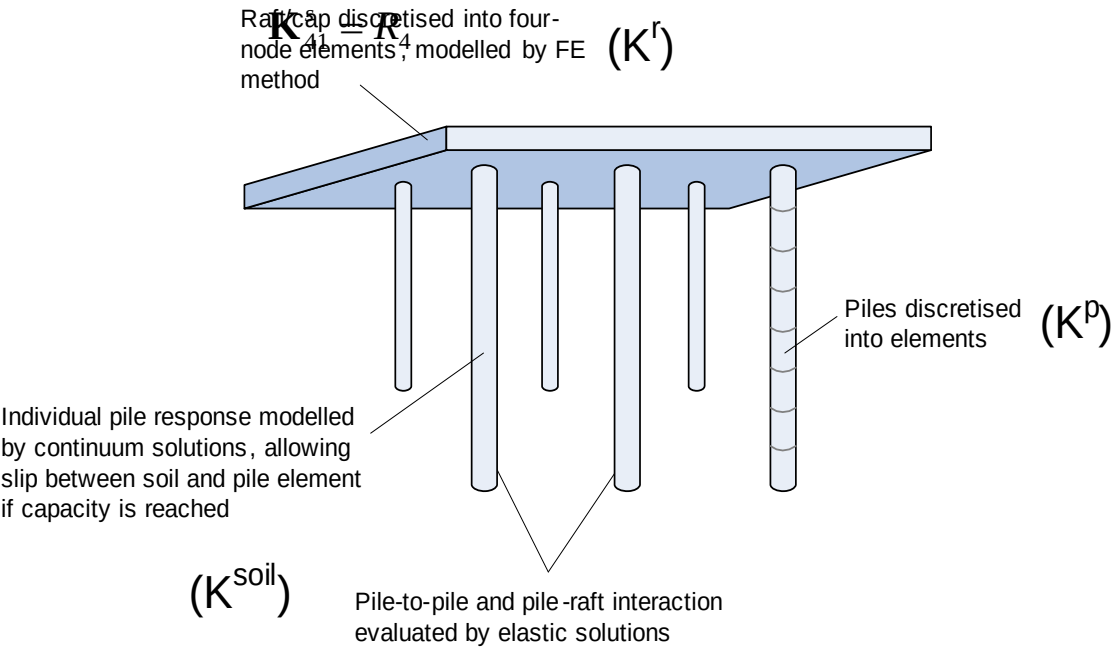
- 500 - 1,000 KW
- 1,000 - 5,000 KW
- 5,000 - 10,000 KW
- 10,000 - 50,000 KW
- 50,000 - 100,000 KW
- > 100,000 KW

Source: Department of Energy and Climate Change

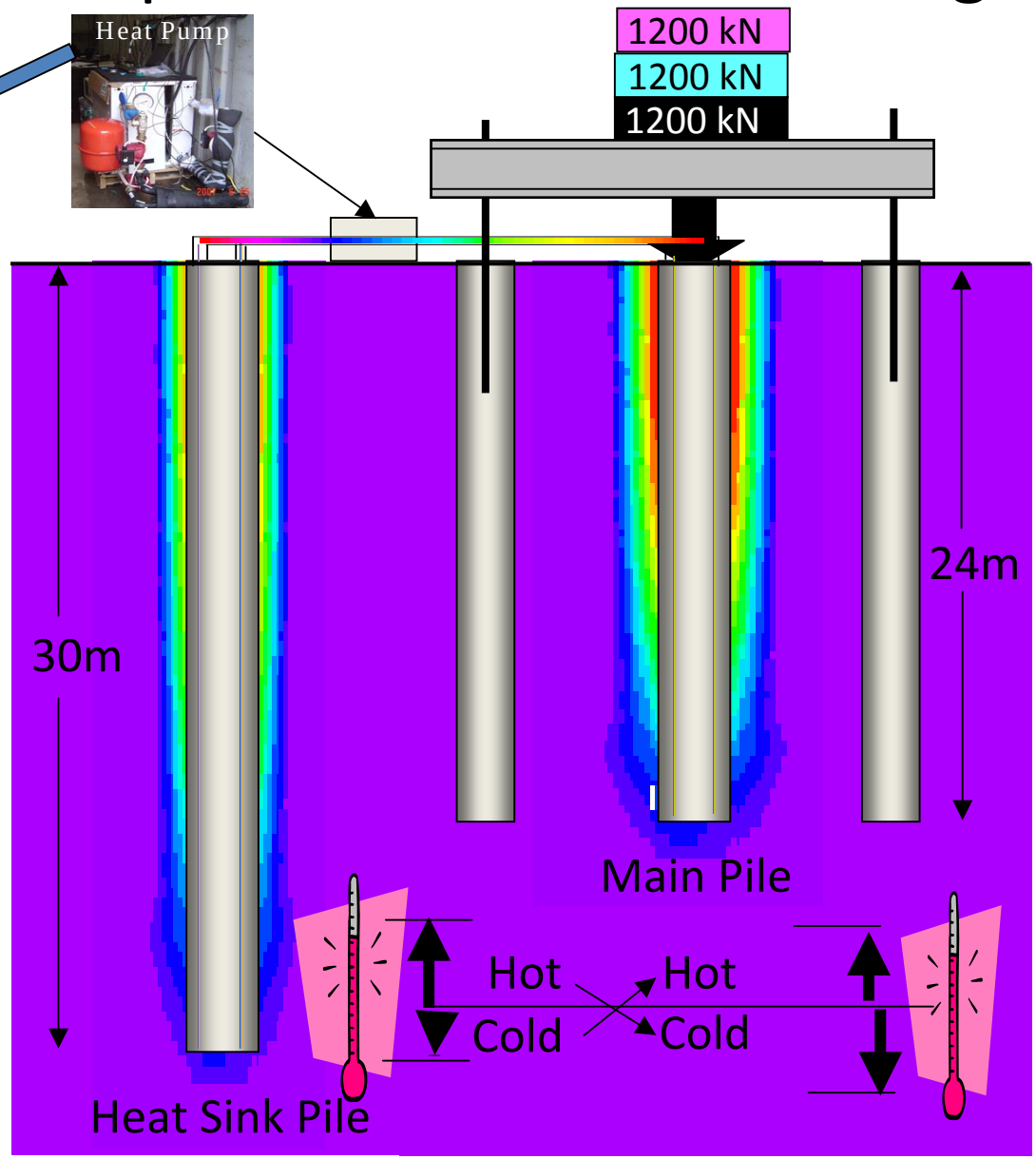
Energy pile/wall/tunnel design







Mechanical Load Tests coupled with thermal loading



Radioactive waste from solid waste experience

Some Geotechnical Aspects of UK Low Level Radioactive Waste Disposal
Tonks, Gallagher, Shaw
Post-closure hydromechanical behaviour of backfilled cavities
Dufour, Wong&Deleruyelle
Deposition tunnel backfill development: ¼-scale tests in Riihimäki
Korkiala-Tanttu, Nemlander, Keski-Kuha, Keto&Koho
Impact of sulfates on the mechanical and hydraulic behavior of a cement-clay mix
Di Emidio& Flores

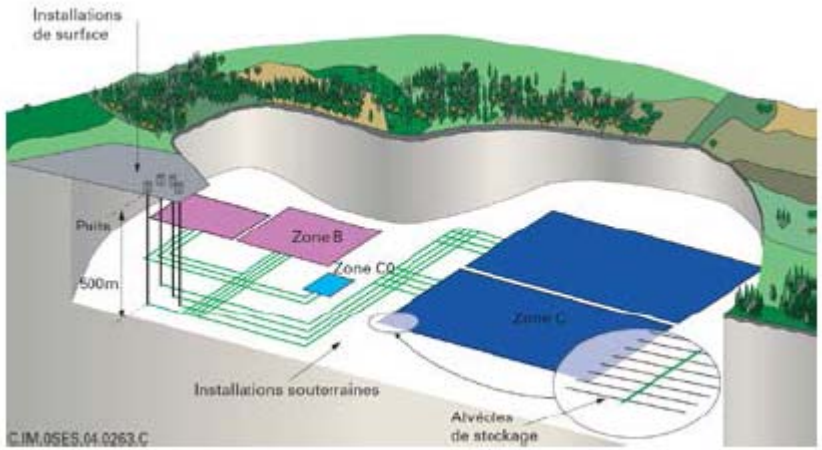


Figure 1. Aerial view of the UK LLWR from the north west

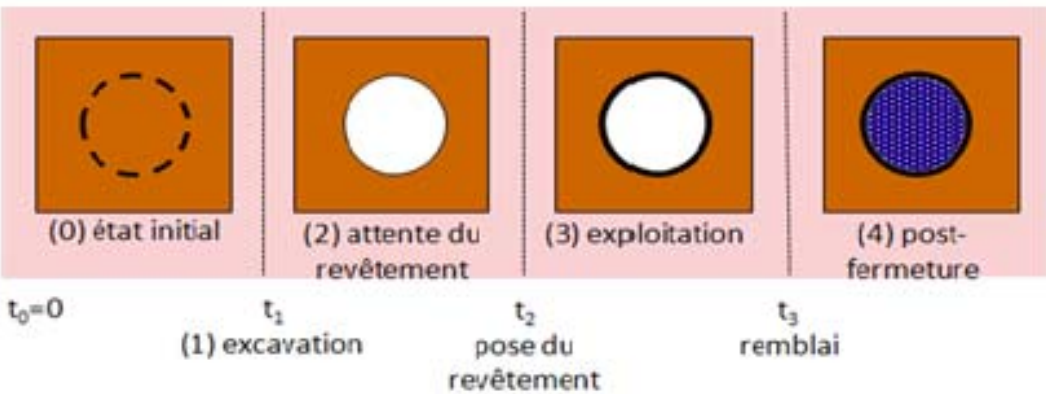
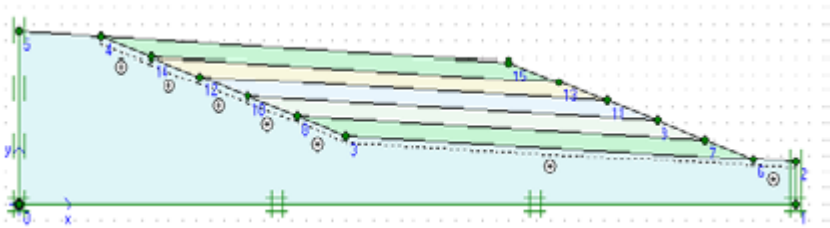
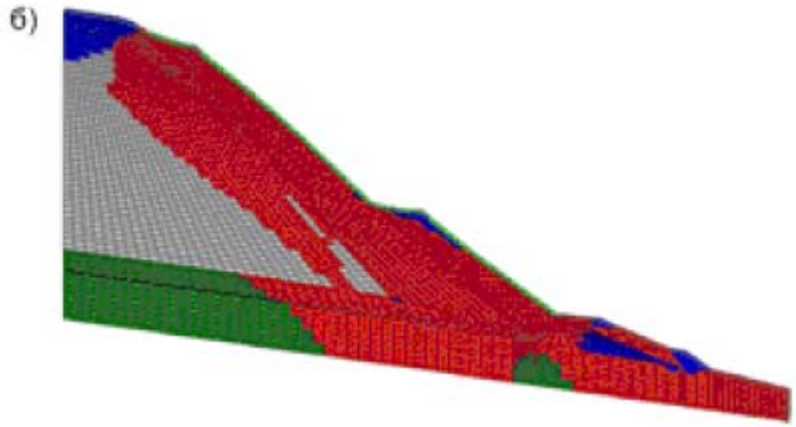


Figure 3. A steel grid covering the tunnel opening during a flow-through-test [2,5].

Stability analysis of bioreactor landfill
Varga
Reclamation of a slope of the solid waste landfill that rests its foot in the Ussury Bay, the Japanese Sea, Kudryavtsev, Valtseva, Fedorenko, Goncharova, Berestyanyy, Mikhaylin, Berestyanaya
Impact of seismic hazards on waste landfills
Zania, Tsompanakis&Psarropoulos





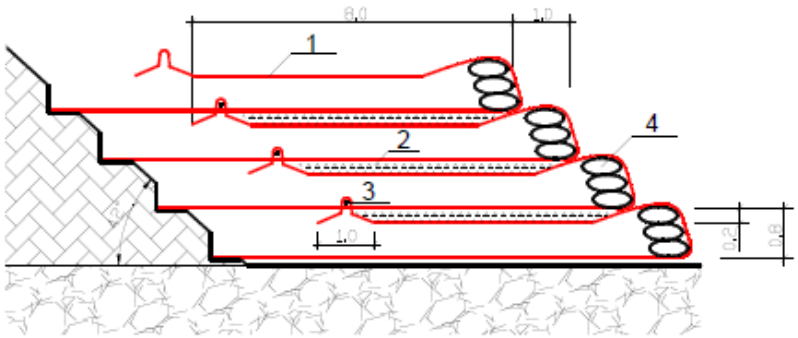
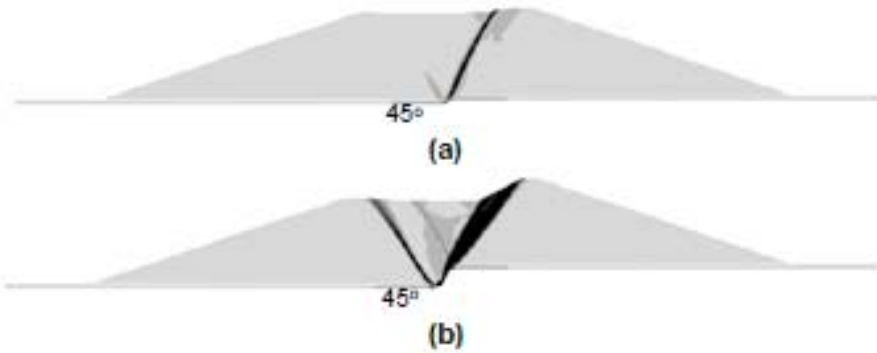
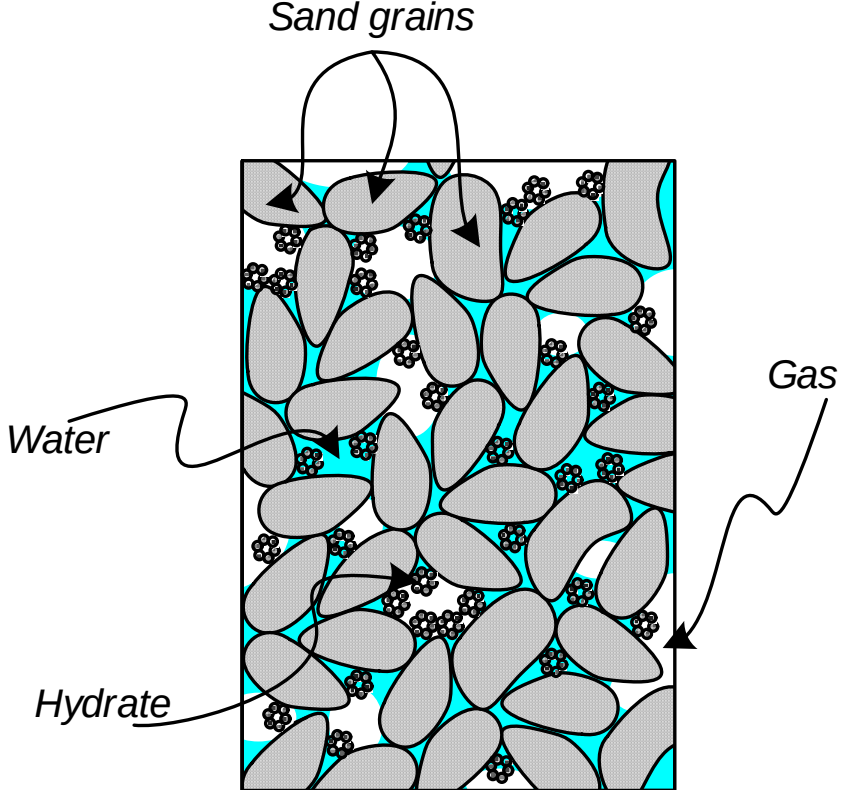
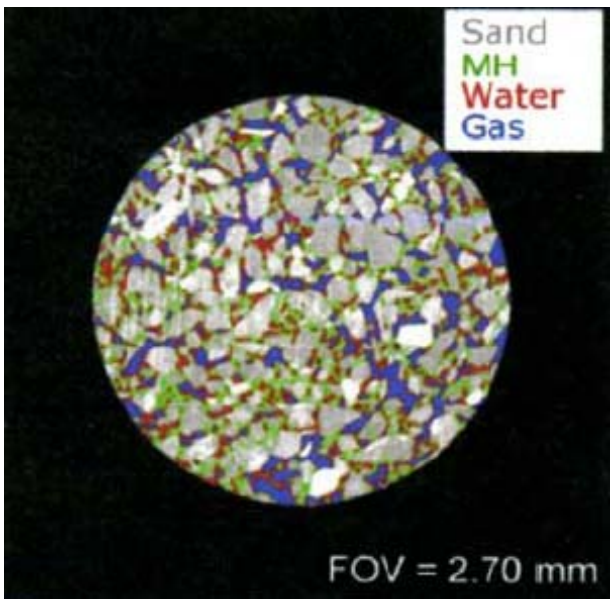


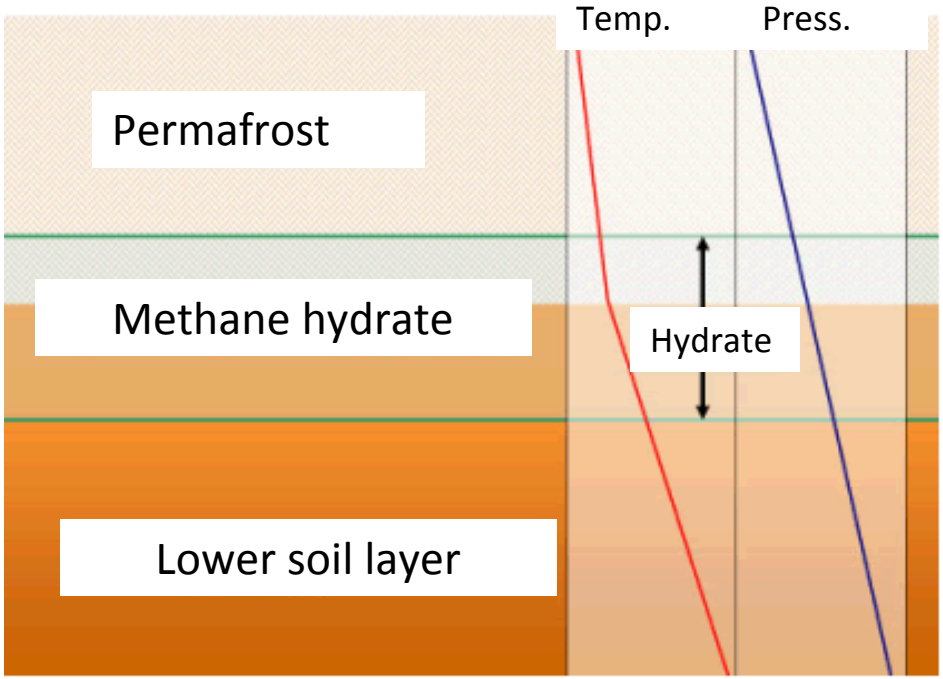
Figure 6. Scheme of laying geogrids in fixtures: 1- integral one-axis geogrid with strength of 170 kN/m; 2 - crushed stone of up to 4 mm in size; 3 - plastic connector for one-axis grid 4- sacks with local vegetation soil

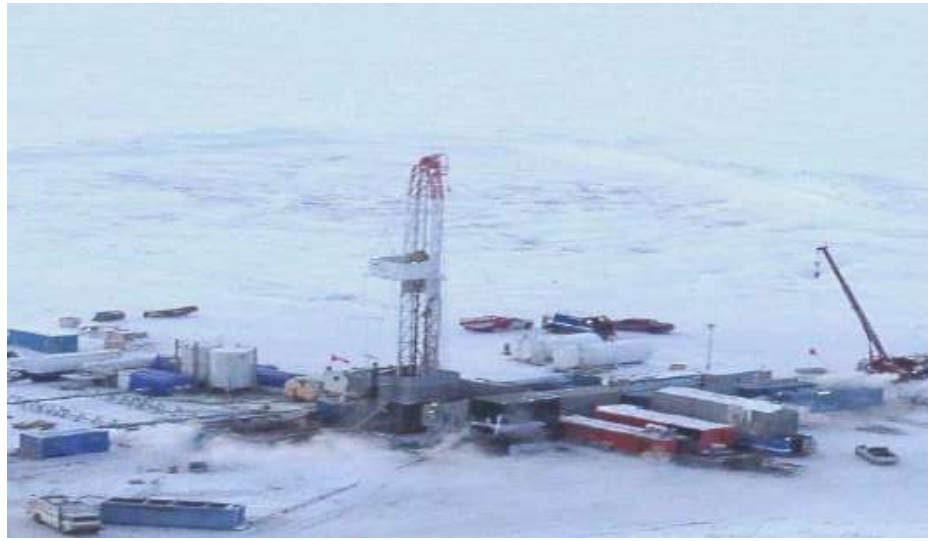


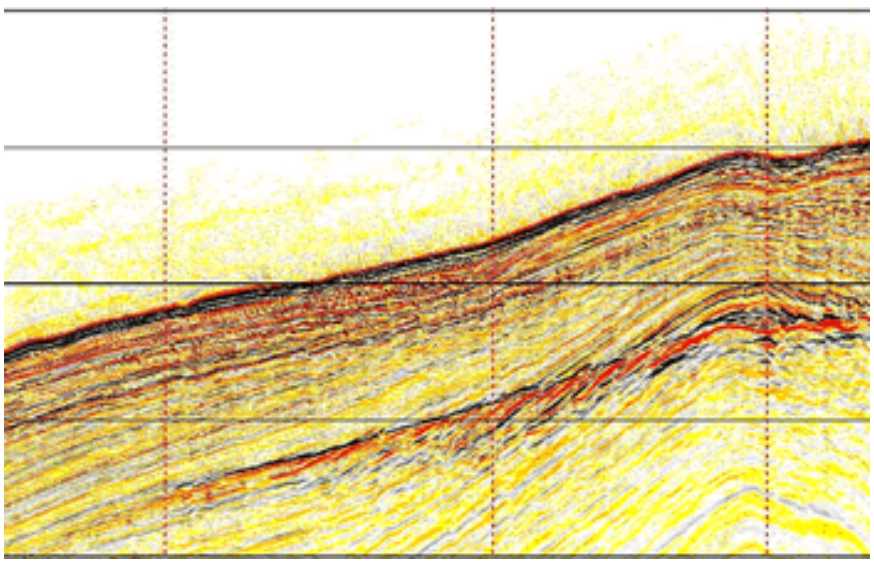
Carbon-based energy (shale gas, methane hydrates, etc)

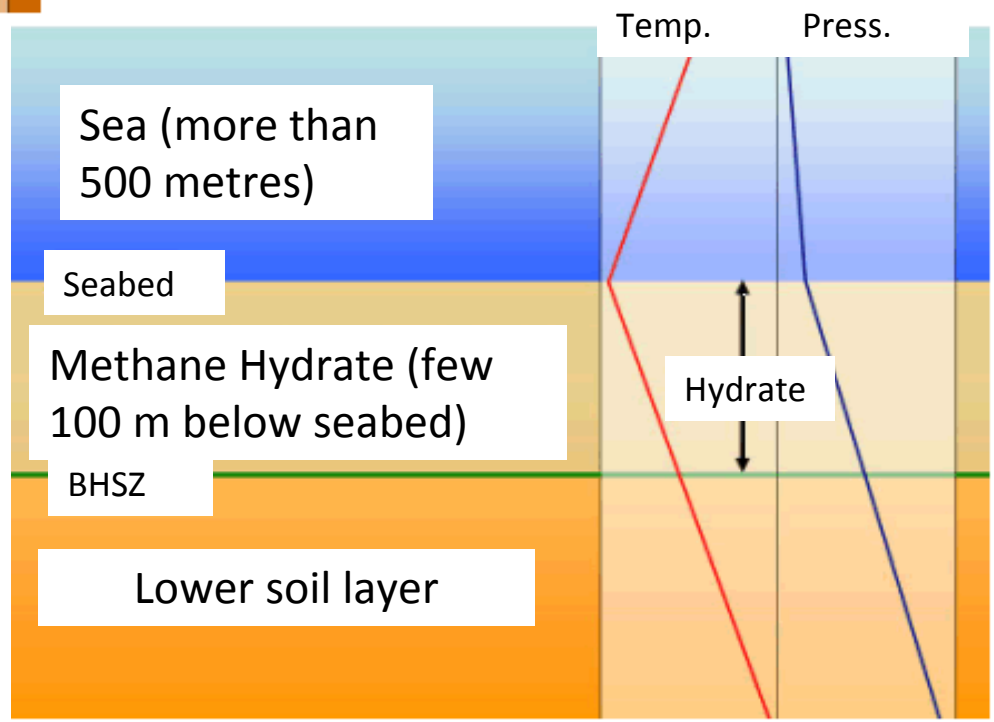

Sand grains
Water
Gas
Hydrate

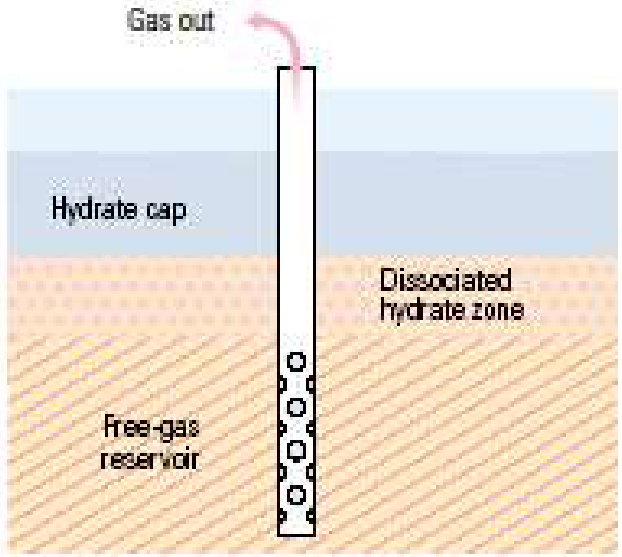

Sand
MH
Water
Gas
FOV = 2.70 mm


Temp.
Press.
Permafrost
Methane hydrate
Hydrate
Lower soil layer

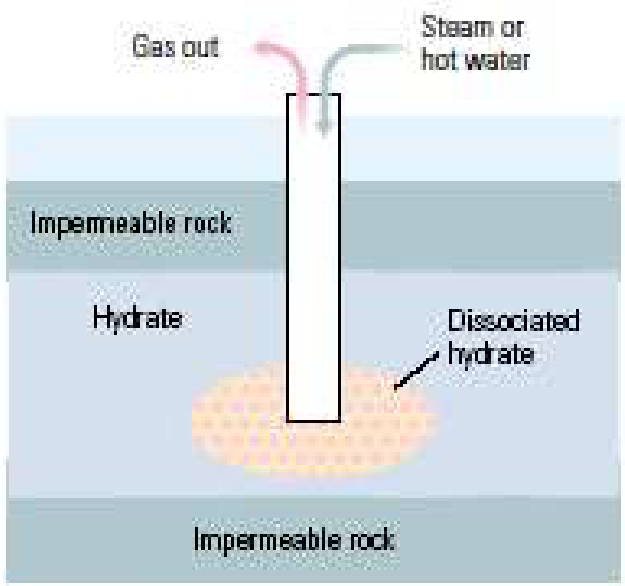




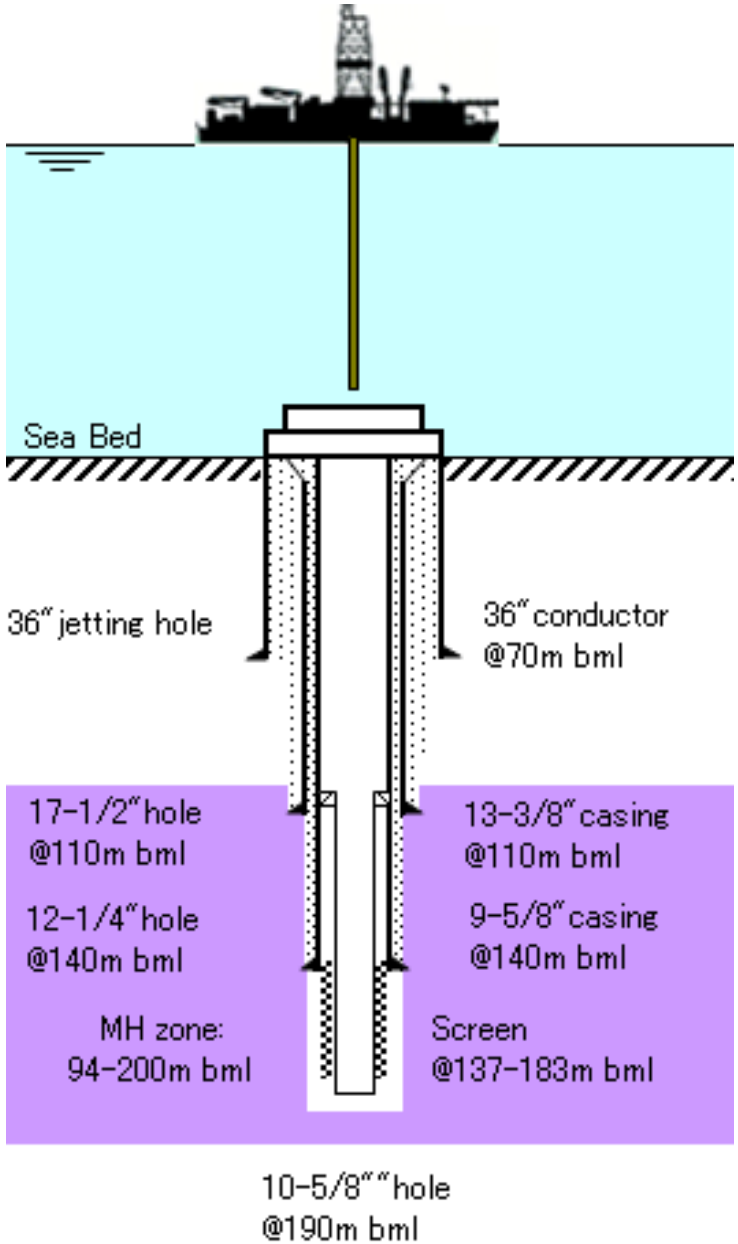

Temp.
Press.
Sea (more than 500 metres)
Seabed
Methane Hydrate (few 100 m below seabed)
BHSZ
Hydrate
Lower soil layer



Depressurization



Thermal Injection

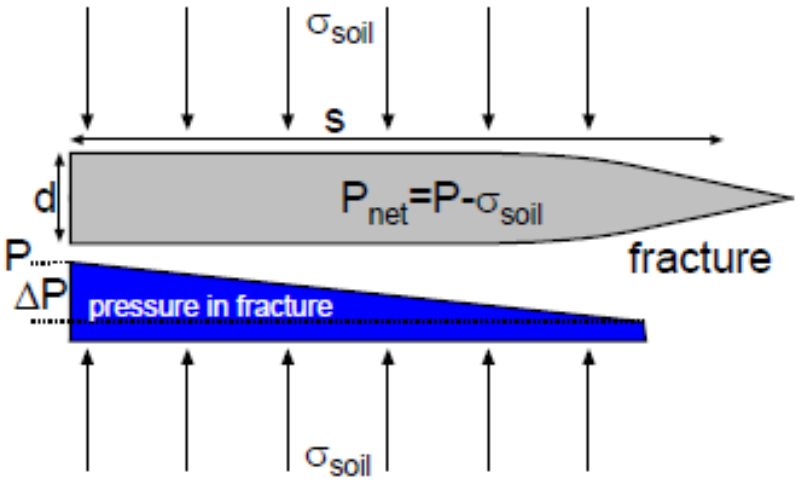


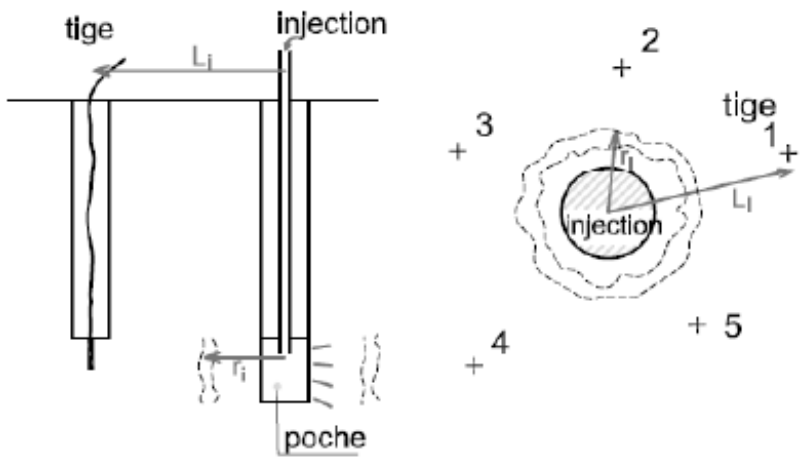
Mechanisms of hydraulic fracturing in clay, sand and rock

Bezuijen&van Tol

Global Measurements for low permeability tests

Massonnet





Low energy/intensity geotechnics (zero waste, low embodied energy, waste utilisation)

Mechanical properties of MSWI bottom ash in Denmark
Larsen
The Environmental Aspects of Utilizing Phosphogypsum in Embankment
Dapena, Pujol, Pardo de Santayana, Cuéllar&Rodríguez
Chemical Stabilisation of Closed Landfill Sites Using Chemical Agents
Khabbaz, Fatahi,

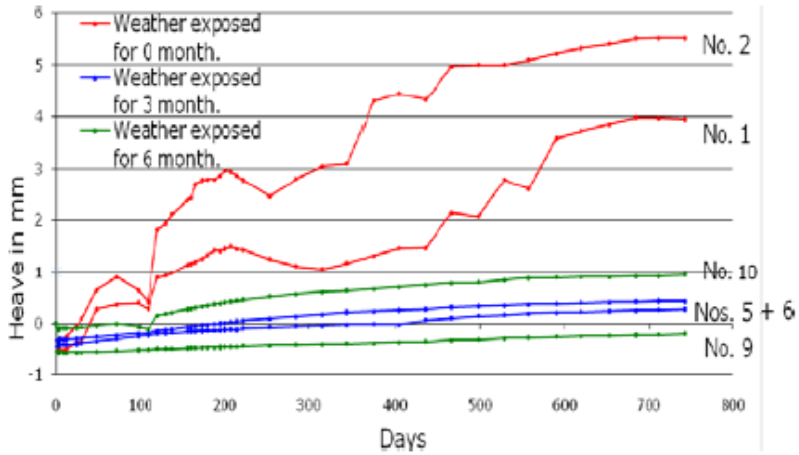


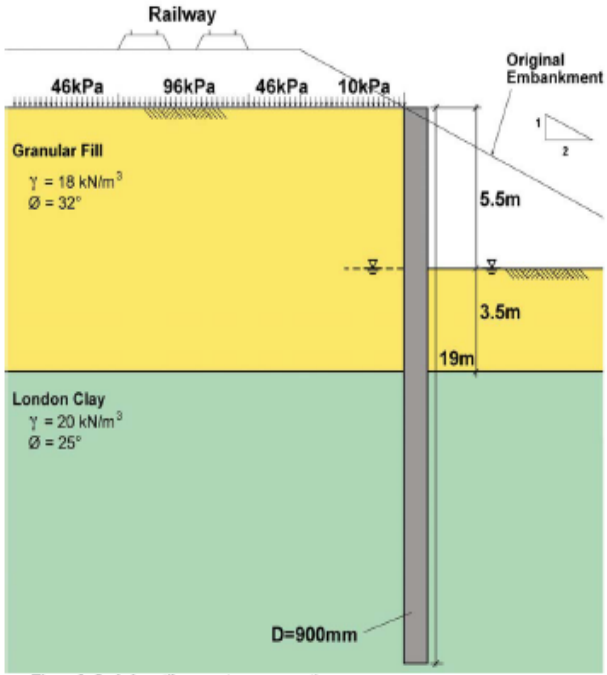
Figure 2. Heave development for drained bottom ash samples during test period

Figure 2. mixing process of fly ash-lime with MSW samples.

Figure 7. A sample of MSW for unconfined compressive tests mixed with fly ash-lime.

PP 2

1. Cantilever Walls



Design 1: Steel Cantilever System

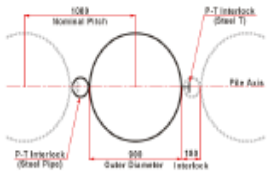


Figure 2: *Pressed-in Tubular Pile* cross section

- Diameter = 900mm
- t = 10mm
- Nominal Pitch = 1080mm
- Deflection = 84mm

Design 2: Concrete Cantilever System

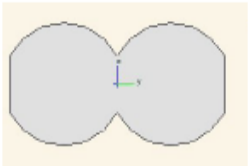


Figure 3: *Secant Pile* cross section

- C40 Concrete
- Diameter = 800mm
- Nominal Pitch = 750mm
- 16 x 460T40mm
- Deflection = 73mm

2. Propped cantilever using tension piles

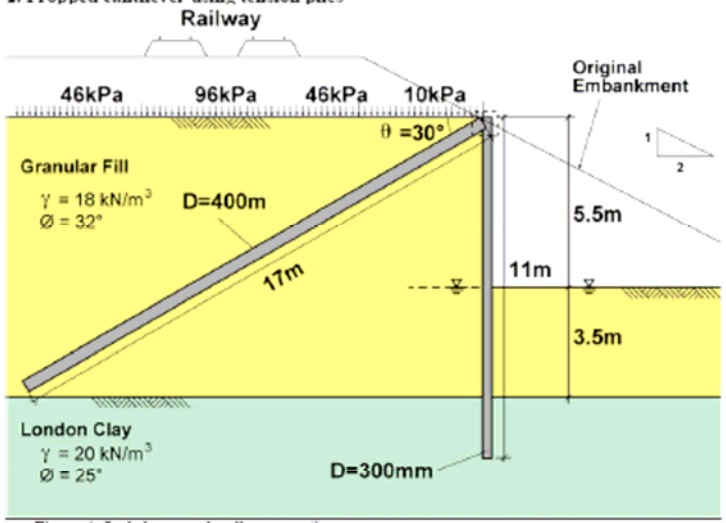


Figure 4: Scaled propped wall cross section

Design 3: Steel propped system

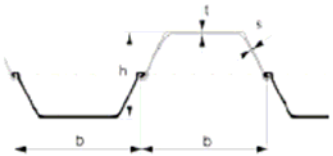


Figure 5: Sheetpile cross section

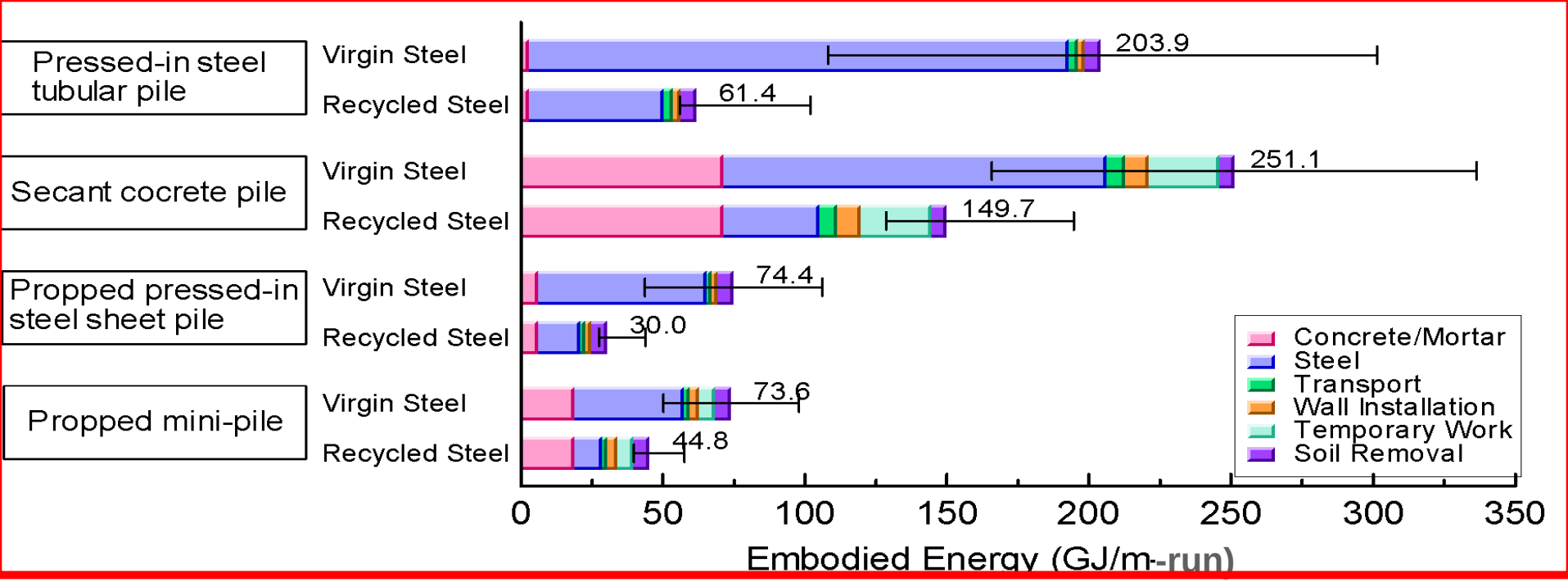
- PU12 S270
- b = 600mm h = 360mm t = 9.8mm
- I = 21600 cm⁴/m
- Deflection = 32mm

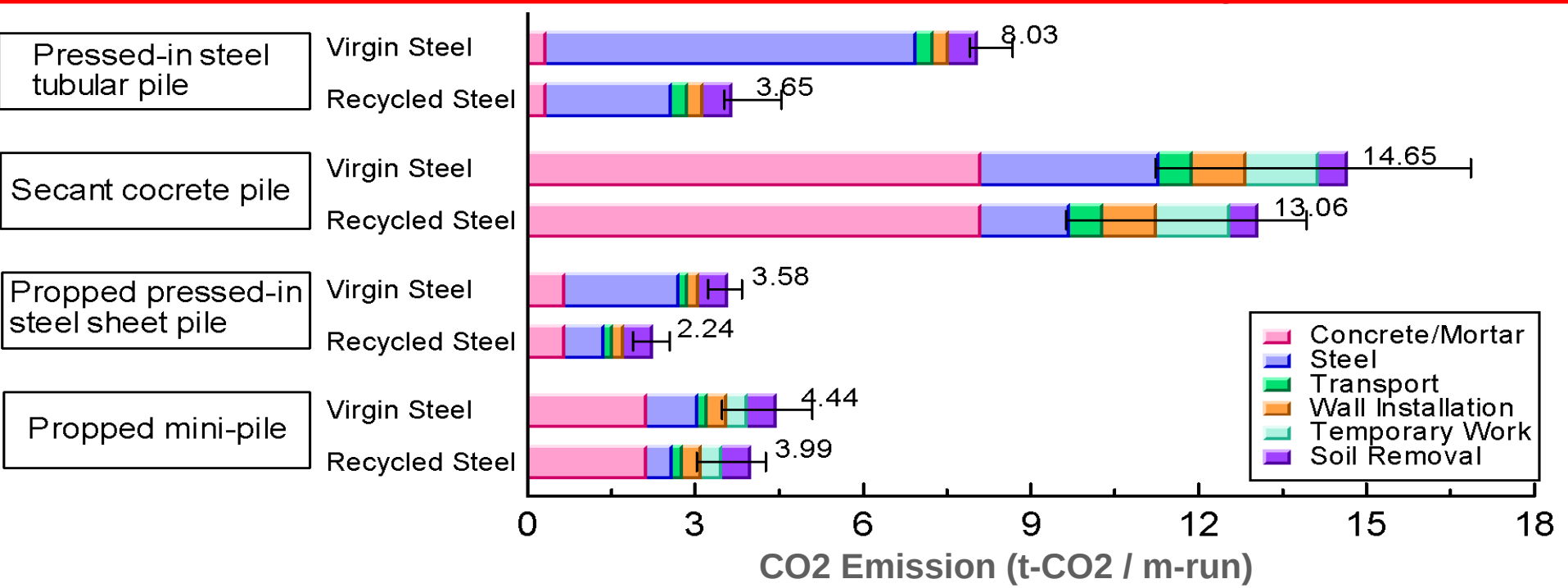
Design 4: Concrete Propped System

Figure 6: Minipile cross section

- C40 Concrete
- Diameter = 300mm
- 8 x 460T20mm
- Deflection = 34mm

- ~~Wall designs according to~~ BS8002:1994
- 100m wall length of 5m excavation
- Design Life of 120 years [Wall not removed]
- Deflection < 100mm
- Surcharge
- Distance of material transports from various sites
- Standard geotechnical profile and water condition in London


Pressed-in steel tubular pile
Secant cocrete pile
Propped pressed-in steel sheet pile
Propped mini-pile
Virgin Steel
Recycled Steel
203.9
61.4
251.1
149.7
74.4
30.0
73.6
44.8
Concrete/Mortar
Steel
Transport
Wall Installation
Temporary Work
Soil Removal
0
50
100
150
200
250
300
350
Embodied Energy (GJ/m-run)

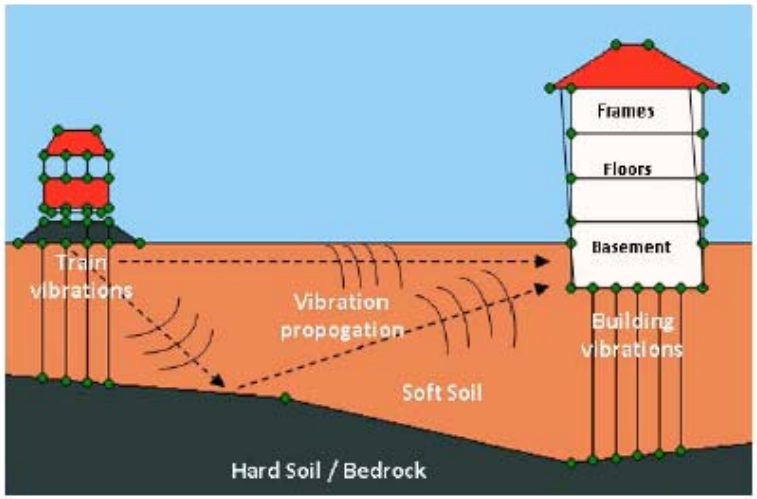

Pressed-in steel tubular pile
Secant cocrete pile
Propped pressed-in steel sheet pile
Propped mini-pile
Virgin Steel
Recycled Steel
8.03
3.65
14.65
13.06
3.58
2.24
4.44
3.99
Concrete/Mortar
Steel
Transport
Wall Installation
Temporary Work
Soil Removal
0
3
6
9
12
15
18
CO2 Emission (t-CO2 / m-run)

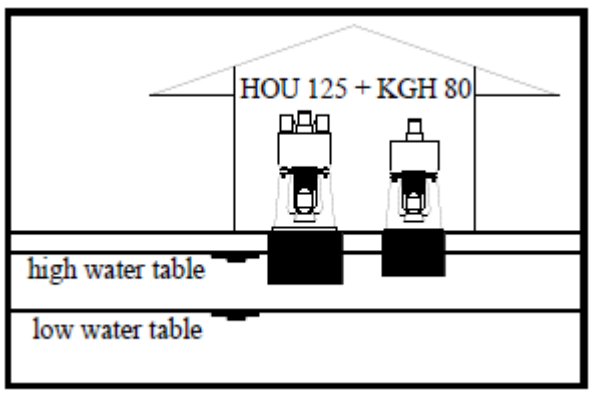
Ground vibration

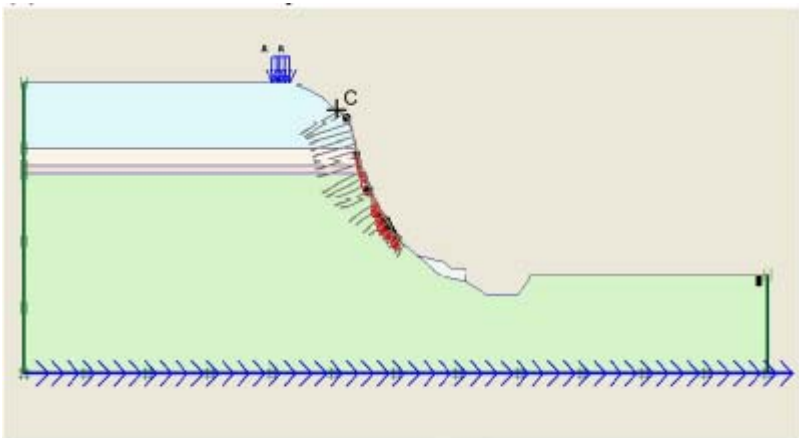
Case history: Influence of ground water level on vibrations induced by heavy forging hammers, Quinteros&Schneider

Dynamic behavior of a softer layer overlying hard soil / bedrock and vibration reduction Kellezi

Dynamic analysis of San Pedro Cliff at La Alhambra
Justo, Morales-Esteban, Durand, Vazquez & Justo







Tension cut-off points
Plastic points

(b) Dynamic analysis

Diversification of Environmental Geotechnics

- Research (Prof Manassero, Italy)
- Industry (Prof Van Impe, Belgium)
- Teaching (Prof Pantazidou, Greece)

- Diversification means
  - more proactive (i.e. create own ideas/business),
  - or more reactive toward problems given to us.

Where is geo-environment going?

Are we reactive (receivers) rather than proactive (producers)?

- Geothermal energy (shallow GSHPs)
- Radioactive waste from solid waste experience
- Carbon-based energy (shale gas, methane hydrates, etc)
- Low energy/intensity geotechnics (zero waste, low embodied energy, waste utilisation)
- Ground vibration
- Bio-engineering (see agricultural industry)