Discussion Session 6.1:
Geoenvironmental Issues

Kenichi Soga
Professor of Civil Engineering
Department of Engineering
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
\[ Q_{room} = 25^\circ C \]

\[ T_{in}^{sec} = 35^\circ C \]

\[ T_{out}^{sec} = 30^\circ C \]

\[ T_{out}^{prim} = 0^\circ C \]

\[ T_{out}^{prim} = 5^\circ C \]

\[ Q_{prim} \]

\[ Q_{sec} \]

\[ Q_{room} \]

\[ T_{room} = 25^\circ C \]

\[ Q_s \]

\[ q_s \]

\[ \Delta T_{prim} \]

\[ \Delta T_{sec} \]

\[ COP = 3 - 5 \]

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

Summer
- Air: 36 °C
- Soil: 29 °C
- Pipe: 28 °C
- Heat extraction: 31W

Winter
- Air: 17 °C
- Soil: 16 °C
- Pipe: 13 °C
- Heat extraction: 47W
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

Building Demand Model (TRNSYS)

- Heating / Cooling Demand kWh(t)

Distribution System Model (TRNSYS)

- Heating / Cooling kWh(t)
- Temperature, Wind, Solar Radiation

Heat Pump Model

- T(t), Flow(t)
- Auxiliary Heating / Cooling kWh(t)

Auxiliary Systems Model

- Ground Thermal Recharge T(t), Flow(t)

Ground Heat Exchanger Model

- Ground Temperature Change T(t), Flow(t)
- T(t), Flow(t)
How many new generation geothermal energy systems can be installed at “city” scale without losing control of ground thermal capacity?

London Heat Map

Source: Department of Energy and Climate Change
Energy pile/wall/tunnel design

- Reaction at fixed node
- Unit displacement at the node

Raft cap discretised into four-node elements, modelled by FE method

Individual pile response modelled by continuum solutions, allowing slip between soil and pile element if capacity is reached

Pile-to-pile and pile-raft interaction evaluated by elastic solutions
Mechanical Load Tests coupled with thermal loading

- Heat Sink Pile
- Heat Pump
- Main Pile
- 1200 kN
- May 2007
- July 2007
- 30m
- 24m
- 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
Permafrost

Methane hydrate

Lower soil layer

Sea (more than 500 metres)

Seabed

Methane Hydrate (few 100 m below seabed)

BHSZ

Lower soil layer
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.
1. Cantilever Walls:

- 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
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
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.
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