

# Geothermal Energy Pile

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### **Presentation overview**



- Why
- What
- How
- Geothermal Energy Pile: Thermo-Mechanical study
- Outcome

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### Why

- 73% energy is being used for heating/cooling and hot water
- Every house is responsible for 20,000 kg (20 tonnes) of greenhouse gas emissions (GHG) per year
- Conventional heating/cooling system efficiency 50% to 80%
- Carbon tax, energy is getting more expensive
- Reduce energy use and GHG emission save the world



### What is ground energy

- Ancient concept: caves, underground houses, wine cellar
- Ground has stable temperature throughout the year and it is equal to the average annual temperature
- Ground is warmer than air in winter and cooler than air in summer













### **Confusion with terminology**

- Types of geothermal energy
  - Deep
  - Shallow

#### Deep geothermal energy

- available at few kms
- comes from hot rock due to radioactivity
- used for electricity generation

#### Shallow geothermal energy

- under our feet
- solar radiation
- heating/cooling the buildings

### How does it work?

- What do we need?
  - Ground
  - Heat exchanging loop
  - Heat Pump
- What is heat exchanging loop?
  - Plastic pipe (HDPE)
  - Fluid (water or water + glycol)

#### Horizontal loop

- Lot of space available
- Trenches
- Horizontal bore holes
- Vertical loop
  - Limited space
- Vertical Bore hole







### How does it work?



- Open loop
  - Pond, lake, river
  - Water table is high and stable
  - Low installation cost





Monday, 09 April 2018



### Heat pump



Image source: Geoexchange



### Heat pump



Image source: Geoexchange

## What is a Geothermal Energy Pile?

- What is a Pile?
- Deep foundation
- Soft ground
- High-rise buildings





• Skin friction and end bearing

## What is a Geothermal Energy Pile?

- Vertical loop
- Cost effective
- Land



### **Challenges**



- What will happen if heat is transferred in and out of the pile foundation:
  - Pile load capacity (friction)
  - Surrounding soil bearing capacity
  - Heat transfer and storage in pile and surrounding soils
  - Pile expansion, contraction, stress and strain
  - Soil deformation, consolidation
  - Does the concrete crack?

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### **Project at Monash**

- Laboratory study
  - Thermal conductivity
  - Specific heat capacity
  - Thermo-mechanical properties
    - > Thermo-consolidation
    - > Thermo-triaxial shear strength
    - > Thermo-elastoplastic theory
  - Lab-scale model pile test
- Field study
  - Thermo-Mechanical testing of a fully instrumented Geothermal Energy Pile
- Cost-benefit analysis
- Numerical study Thermo-hydro-mechanical (THM) study Monday, 09 April 2018

For selected Victorian soils and concrete



### How to do pile mechanical testing?

#### **Pile static load testing**



### Pile static load testing







### **Pile dynamic load testing**



### **Field testing at Monash**



- Static load test using Osterberg cell
- Thermal loading via heat pump
- Fully instrumented bore pile
  - Vibrating wire strain gages
    - > Vertical and radial strain
    - > Temperature
  - LVDT
    - > Pile displacement
  - Thermocouples
    - > Temperature in soil



### Site for field test



Monash University, Clayton





### **Pile installation**







# **Pile installation**







### **Schematic of field pile**



### **Thermo-Mechanical testing**



- Short term thermal loading
  - Heated (2.4 KW) for 9 days
  - Cooled for 45 days
- Long term thermal loading
  - Heated (2.4 KW) for 52 days
  - Cooled for 78 days
- Pile tested using O-cells before and after each heating and cooling cycle to investigate the effect of heating/cooling on pile load capacity.







- Pile load capacity does not get affected by heating/cooling of energy pile
- Instead pile load capacity increased after heating

### **Case studies**



- Geoscience Australia Building in Canberra •
  - First building in Australia
  - 352 vertical bores, 100 m deep
  - Saving of £80,000 a year
- Kingsmill Hospital, Mansfield, UK ٠
  - Open loop lake system —
  - 10.5 MW system, largest in Europe which required peak heating and cooling capacity of 5000 kW each
  - Save 9600 MWh of gas and electricity a year
  - Prevent 1,700 tonnes of CO2 entering into atmosphere which is equivalent to removing 600 cars off the road
  - Saving of £120,000 a year
- Lambeth College, London, UK •
  - 141 Energy piles
  - 426 kW cooling and 268 kW heating, 4 reversible heat pumps
  - Prevent 253 tonnes of CO2 entering into atmosphere annually which is equivalent to removing 80 cars off the road
- Saving of £35,000 a year

### **Summary**



- It is the most energy efficient, environmental friendly and cost effective way of heating or cooling a building (International Energy Agency)
- It is renewable, sustainable and reduces green house gas (GHG) emission
- 300% to 600% efficient
- One system for both heating and cooling and hot water supply
- Swimming pool can be heated as well.
- No maintenance, small space required for heat pump
- No noise
- Ground source systems are saving the equivalent of 13 million barrels of oil a year
- An average home fitted with ground source system reduces CO<sub>2</sub> emissions by the same amount as planting an acre of trees



# Obrigado Thanks for listening

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