Practical considerations of GSHP

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Introduction

- This talk will be given in 3 parts:
- An introduction to heat pumps, and the properties of the ground as a heat source.
- Decisions & choices that need to be made in specifying a GSHP system.
- Discussion and pictures of the Keyworth 2 building project.

What is a Heat Pump?

- A heat pump is a machine, similar to a house hold fridge.
- Transports heat between 2 spaces at different temperatures, by using electrical power.
- Natural bodies of air, water or ground are “infinite” reservoirs of heat due to their large mass and heat capacity, and can be used as heat source/sink.
- Effectiveness measure: COP. A fridge has a typical COP of 1.8. GSHP can achieve COP of 2.8-4.

History

- First proposed by Lord Kelvin in 1850s as a reversed refrigerator “Warming Machine”, later called “Heat Pump”.
- Haldane (1930) published an influential article on HP in UK, triggered US & Swiss developments.
- J. Sumner pioneered first UK installations in 1940s.
- 1970s oil crisis raised energy security as an issue in many countries, driving progress in Sweden, Germany, Austria and Switzerland.

GSHP today

- Sweden, Austria, Switzerland, US & Canada are reaping the reward of many years of investment in this technology and have large installation bases.
- UK uptake is still very small; possibly still in 3 digits.

Why use ground as energy source?

- Soil temp at depths below 7-8m is fixed all year round, immune from surface temp variations.
- The heat in the soil is almost entirely due to solar radiation.
- In Northern Europe typically 10-12C.
- In summer can be used as a heat sink.
- In winter can be used as a heat source.

Getting the heat out of the ground

- Borehole specification dictated by geology.
- U-tubes carrying coolant fluid need to be embedded in the boreholes to abstract and transport the ground heat to the surface.
- Major capital cost in GSHP is borehole excavation.
- To minimise this capital cost in new build projects, the boreholes excavated for building foundations can also be used as they have already been costed as part of the building.
- Energy piles as building foundations have been used for past 10 years. Saves installation costs by embedding ground heat exchanger in the foundation piles.

Adjust your expectations

- GSHP are designed to feed low temp (35-40C) heating systems e.g. under floor heating.
- GSHP are not suitable for high temp. (60-70C) heating systems.
- Need well insulated modern buildings. GSHP in old lossy buildings may be disappointing.

Sizing ground store/ plant/ load

- It is important to match the ground store to the plant and the building load.
- Oversizing is not an option. Each borehole costs the price of a new car. Careless sizing is costly and leads to long payback times.
- Undersizing is the preferred practice.
- Symmetrical abstraction of heat is recommended, to prevent degradation of reservoir.
- GSHP are best operated at peak capacity than partial, so may be better to split load across several units.

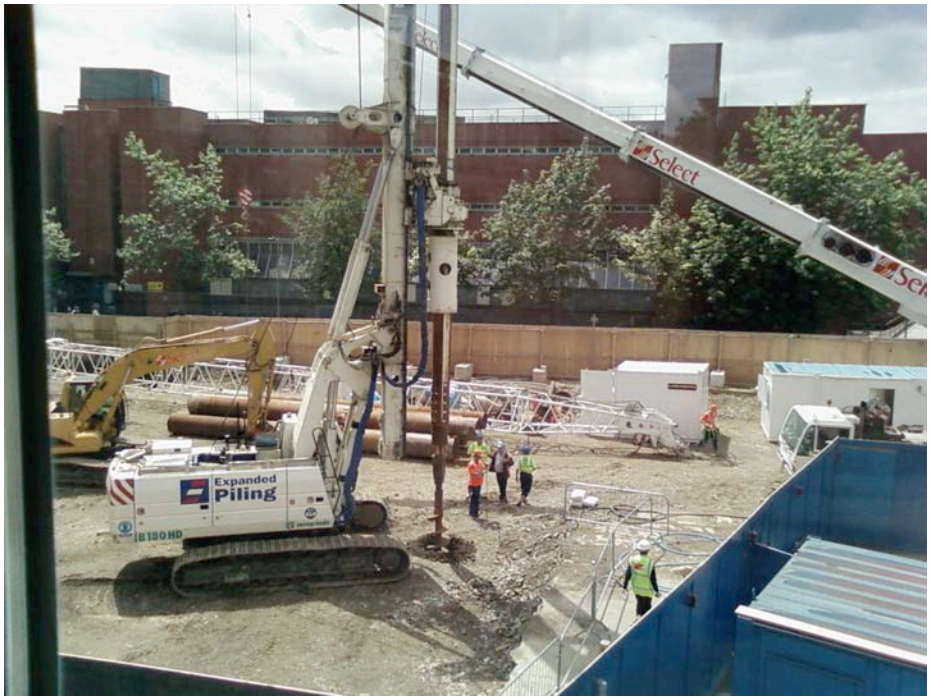
Designing the ground store

- Prior to 1980s, a variety of models and formulas; very hit or miss.
- Researchers at Lund University, Sweden, developed a set of models that form the basis of most current design software, giving everyone a standard estimation tool.
- Examples of software tools are EED by Hellstrom & Sanner, and geothermal module for TRNSYS by Pahud & Hellstrom.

LSBU Keyworth-2 building

- New addition to LSBU designed to include a sustainable energy centre, to open by 2010.
- Features 4 x 140kW GSHP; Total nearly 600kW.
- Ground circuit initially specified 140 energy piles, of 60-75cm diameter, 25m deep.
- Finally required about 170 energy piles as geology issues restricted depth to 20m.

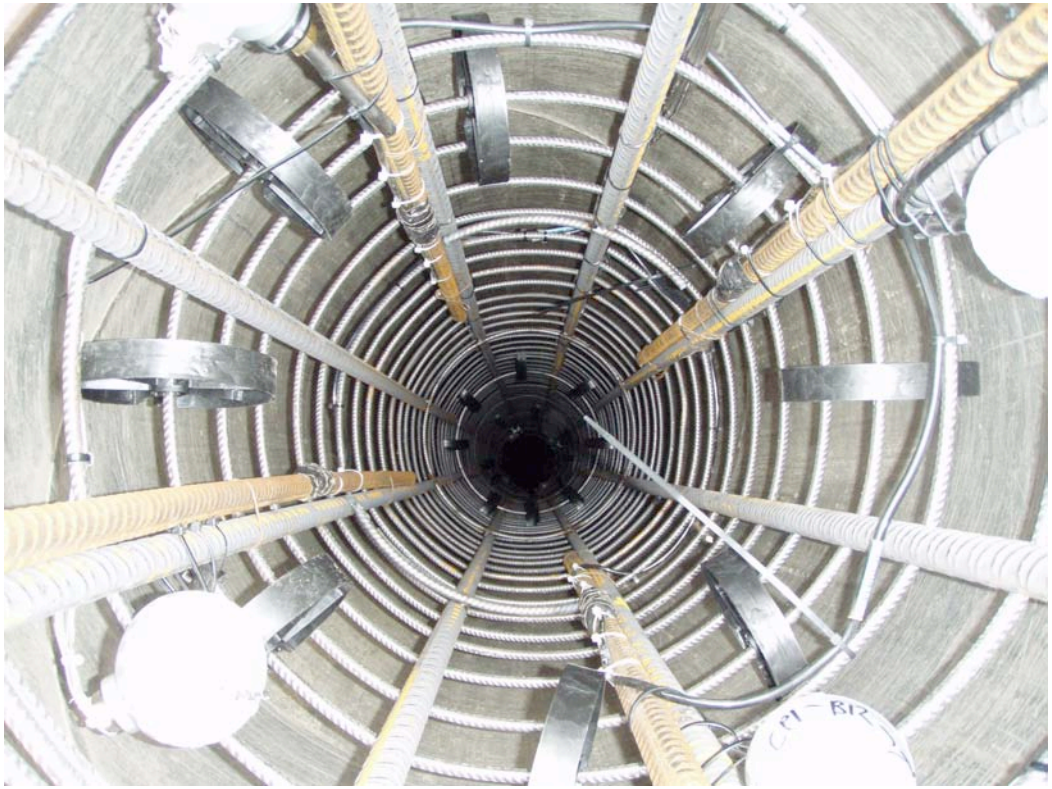
The first borehole of Keyworth-2



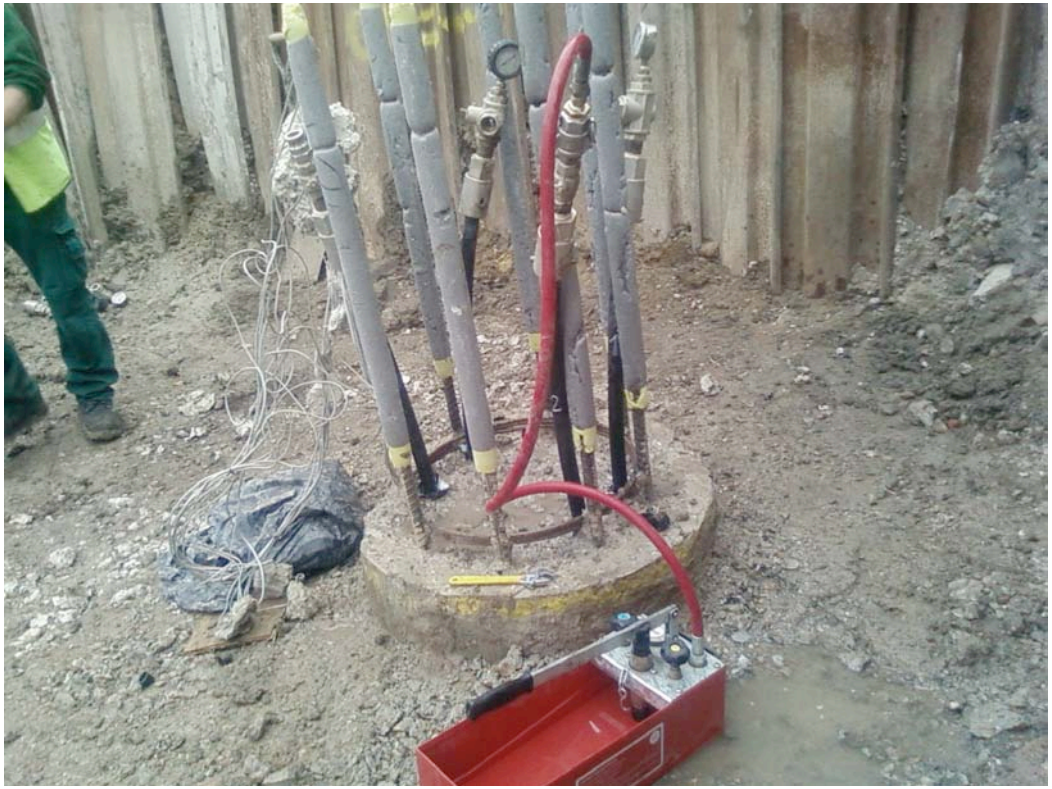
Pile cage showing coolant tubes

Lifting the cage and pipes into the borehole.

Borehole prior to concrete pouring.



Testing the pipes after concrete has set



Conclusions

- GSHP technology is a mature sustainable technology, effective in reducing the energy overheads of buildings.
- In the UK it is held back because expertise is limited to just a few firms, and limited knowledge and exposure among the rest of the building professionals.
- Hopefully this gathering is a positive step in reversing this shortcoming.