School of Civil Engineering
FACULTY OF ENGINEERING

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Geothermal Technology for Economic Cooling and Heating

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GSHPA Technical Seminar 2018

Outline

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- Geothermal heating and cooling research at Leeds
  - People
  - Investments in new facilities
- The GEOTeCH project
  - The concept
  - Technologies being developed: drill rig, heat pump, heat exchangers.
  - Demonstration systems and buildings
  - Energy pile modelling and validation

Geothermal systems and Energy Geotechnics research: People at Leeds

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Barry Clarke
Professor of Geotechnical Engineering

Raul Fuentes
Associate Professor in Infrastructure Engineering

Amir Khan
Lecturer

Fleur Loveridge
University Academic Fellow

Eric Peterson
Research Fellow

Simon Rees
Professor of Building Energy Systems

Ida Shafagh
Research Fellow

https://engineering.leeds.ac.uk/civil

Investment: UKCRIC

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http://www.ukcric.com

- UKCRIC: *UK Collaboratorium for Research in Infrastructure & Citie*
- A national research council investment of £125m initiated 2017
- Vision: understanding making national infrastructure systems that a resilient, adaptable and affordable.
- A consortium of 14 Universities (coordination at UCL)
- Funding many new laboratory facilities
- Leeds will develop a Centre for Infrastructure Materials facility
- Initial research project: PLEXUS (Infrastructure energy resources; Cambridge, Cranfield, Leeds, Imperial, Newcastle, Sheffield)

UNIVERSITY OF BIRMINGHAM · University of BRISTOL · UNIVERSITY OF CAMBRIDGE · CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD · Cranfield UNIVERSITY · UNIVERSITY OF LEEDS · Imperial College London

UCL · Loughborough University · MANCHESTER 1824 The University of Manchester · Newcastle University · UNIVERSITY OF OXFORD · The University Of Sheffield. · UNIVERSITY OF Southampton

UKCRIC Investments

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UKCRIC Facilities:

- National Buried Infrastructure Test Facility – Birmingham
- National Infrastructure Laboratory – Southampton
- Smart Grid Industry Laboratory – Sheffield
- Advanced Infrastructure Materials Laboratory – Imperial
- Centre for Infrastructure Materials (exposure/aging) – Leeds
- Fire and Impact Laboratory for Resilient Infrastructure Materials - Manchester
- Blast Research Laboratory – Sheffield
- Dynamic Foundation-Structure Interaction – Bristol (with Cambridge &Oxford)
- Large Scale Wave Testing Facility – Bristol
- National Research Facility for Infrastructure Sensing – Cambridge
- Urban Water Test Facilities – Cranfield, Sheffield, and Newcastle
- Human – Infrastructure Interactions Facility - UCL

UKCRIC Urban Infrastructure Observatories:

- Bristol
- Cardiff
- Cranfield
- Newcastle
- London (UCL)

Facilities: Leeds Engineering and Technology Campus (LETeC)

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- A new investment (up to 20 acres of land) for research and innovation facilities
- located in Leeds next to M1
- Initial projects:
  - Institute for High Speed Rail and System Integration
  - Centre for Infrastructure Materials
  - Infrastructure Robotics field test facilities

https://engineering.leeds.ac.uk/news/article/351/university_appoints_new_chair_in_high_speed_rail_engineering

https://www.leeds.ac.uk/news/article/4103/national_research_centre_to_make_infrastructure_more_efficient

https://engineering.leeds.ac.uk/news/article/20132/school-of-computing/275/success-at-the-field-robotics-challenge-

Facilities: Centre for Infrastructure Materials at LETeC

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- The National Centre for Infrastructure Materials – a UKCRIC collaboration between Leeds, Manchester and Imperial College
- Leeds will make a £10m investment at LETeC to provide a facility for study of aging of infrastructure materials and geo-energy infrastructure.
  - Environmental test chambers and external exposure test facilities
  - High quality meteorological measurement station
  - Large shaking table
  - *Geo-energy lab and field testing facility*

Geo-energy laboratory and field testing facilities

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Geo-energy facilities:

- Lab with thermal properties testing facilities
- ‘Programable’ heating and cooling source (TRT and variable frequency cycles)
- Distributed Temperature Sensing equipment
- Full-scale energy pile
- Test field adjacent
- High quality meteorological measurements

Aims:

- Fundamental research on soil/structure interaction and ground heat exchange
- Site investigation methods
- Testing/monitoring of prototype heat exchangers
- Open to UKCRIC partners and other Universities
- Open for Industrial development and testing

On-line in early 2020

The GEOTeCH Project

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Title: **Geothermal Technology for Economic Cooling and Heating (GEOTeCH)**

Funded by the EU Horizon 2020 Secure Clean Energy programme. Project value: €7.15m

Overall aim: demonstrate geothermal heating and cooling technologies that can improve uptake of renewables and reduce EU carbon emissions economically

Challenges being addressed

- Complexity of construction
- Robust design and operation
- Capital cost

Project Concepts

- For smaller buildings: Develop a marketable package of technologies and designs to increase deployment of renewable energy
- For larger buildings: improved foundation heat exchanger technology and energy management systems

GEOTeCH is co-funded by the European Community **Horizon 2020 Program** for European Research and Technological Development (2014-2020) and has received research funding from the **European Union**

The Consortium

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Geothermal Technology for Economic Cooling and Heating (GEOTeCH)

GEOTeCH

Project partners:

- Industry SMEs: 4
- Large companies: 2
- Universities and Industry Research Organisations: 8
- Specialist management organisations: 2

Member states:

- UK: 2
- Netherlands: 3
- Belgium: 1
- Spain: 5
- Italy: 4
- Germany: 1

Solintel · Groenholland · Geothex · ARC BCN Engineers Consultors · Stüwa · HiRef · D'Appolonia · COMSA · tecnalia · CONRAD · University of Leeds · KU Leuven · COMSA Industrial · De Montfort University Leicester · Università degli Studi di Padova · Universidad Politecnica de Valencia

The technologies: Drilling

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- Features:
  - An auger technique for shallow clay/sedimentary formations (10-60m)
  - Avoids water usage and mud disposal
  - Low emissions, low noise engine systems
  - Highly automated – cassette loading and remote control.

The technologies: Hybrid heat pump

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Aim: a robust design that will work in a wide range of climates and variations in load:

Features:

- Hybrid ground/air operation
- Fully reversible heating/cooling
- R32 refrigerant (low volume)
- Variable speed compressor
- Low noise variable speed fans
- Separate DHW heat exchanger
- Added building control and remote monitoring systems

The technologies: Coaxial borehole heat exchanger

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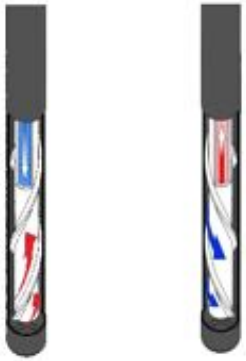
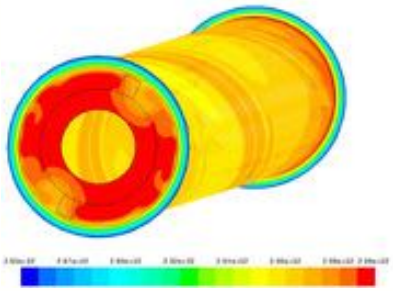
Aim: achieve lower thermal resistance and shorter designs for a range of load conditions. Optimize the design for acceptable pressure drops



The GeoTheX concept
(GeoTheX b.v.)



Numerical modelling of flow and heat transfer inside the heat exchanger (Univ. of Leeds).

Validation testing of prototypes
(Groenholland Geo Energy Systems)

The technologies: Coaxial borehole heat exchanger

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Prototype installation

Spiral vanes on the inner tube

On-site prototype assembly

The technologies: Diaphragm wall heat exchangers

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Aim: optimize wall and pile heat exchanger design and installation for larger non-domestic buildings. Develop improved modelling and design tools.

Work at Leeds:

- New modelling methods – application of the ‘Dynamic Thermal Network’ approach.
- Validation using data from two sites in Barcelona with wall heat exchangers and one in Belgium with an energy pile.

Demonstration Projects

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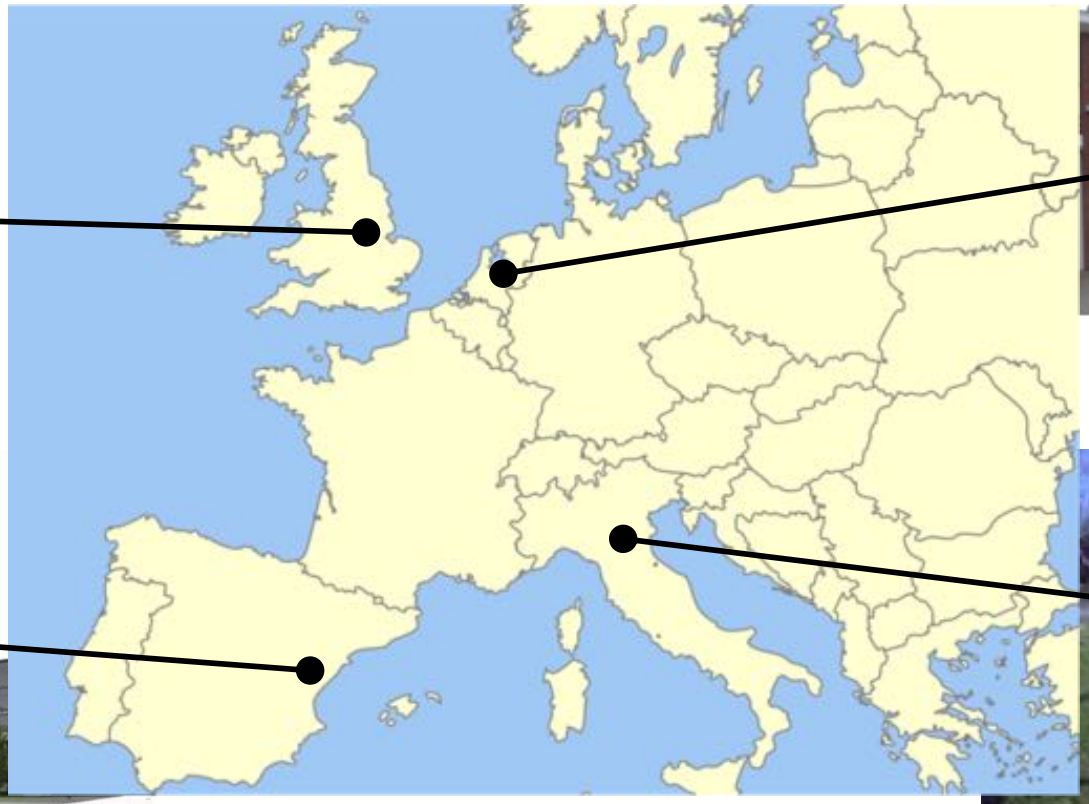
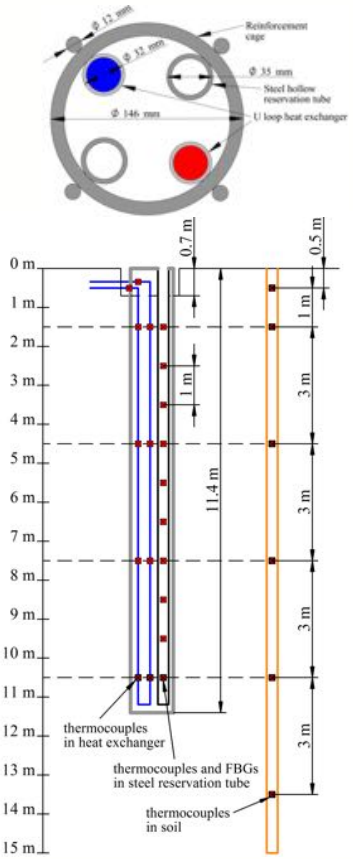
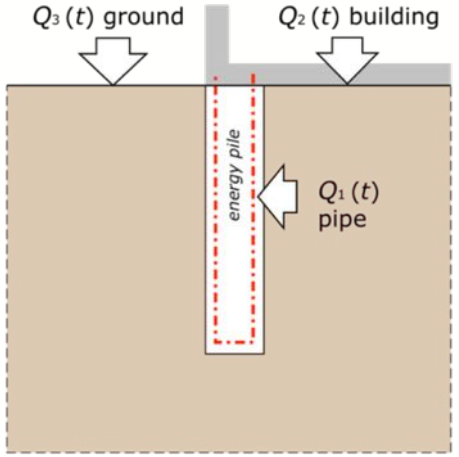


Energy pile modelling and validation

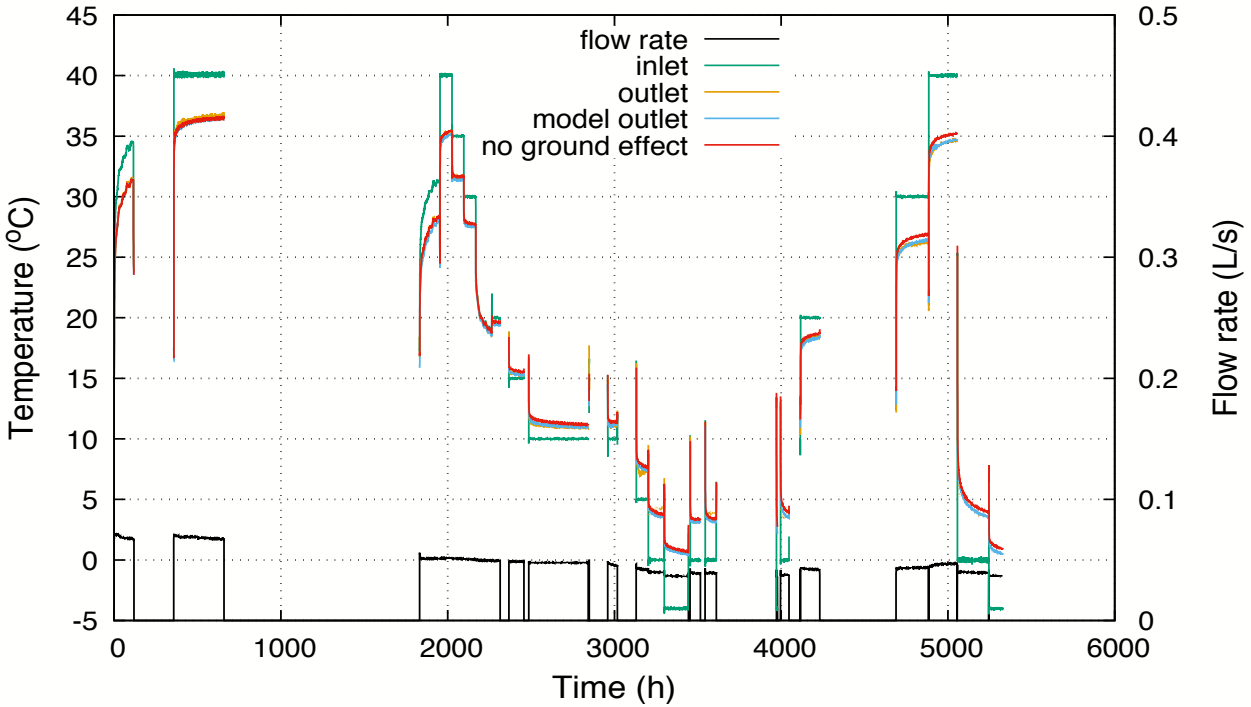


- 5 piles tested in Ostend with both heating and cooling over 9 months.
- Piles are relatively short Displacement Screw piles with a single U-tube
- The Dynamic Thermal Network model allows the effect of ground and building thermal conditions to be modelled.



Allani, M., G. Van Lysebetten, and N. Huybrechts. 2017. "Experimental and Numerical Study of the Thermo-Mechanical Behaviour of Energy Piles for Belgian Practice." Pp. 405–12 in *Advances in Laboratory Testing and Modelling of Soils and Shales (ATMSS)*, edited by A. Ferrari and L. Laloui. Cham: Springer International Publishing.

Energy pile model validation



Errors in energy exchange	Heat rejected	Heat extracted
No ground effect	10.5%	9.9%
Ground effect included	-1.3 %	-0.5%

Conclusions:

- the model performs well for this case
- The effect of ground surface heat transfer is important to capture

Summary

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- New investments are being made in geo-energy research facilities
- Open for business in early 2020
- GEOTeCH
  - Next steps – implementation at demonstration sites
  - Monitoring and evaluation data will be available at the end of the project: April 2019.
  - More information at: http://www.geotech-project.eu

Thanks for Listening

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