This module has been delivered with support from the CITB Growth Fund, which aims to ensure that the construction industry has the right people, with the right skills, in the right place, at the right time and is equipped to meet the future skills demands of the industry.

MODULE 9 GEOTHERMAL DRILLING

Two Days

THE FOLLOWING SUB MODULES SHALL BE DELIVERED WITH ACCESS TO ALL THE EQUIPMENT MENTIONED, AND SPECIALISTS IN GEOTHERMAL DRILLING PRESENT

DAY ONE

9.1 INTRODUCTION

9.1.1 Climate Change Act 2008 – Carbon budgets
9.1.2 Electrical Heating – energy independence, growth targets for heat pumps
9.1.3 Geothermal Drilling growth potential to 2050 – drivers for growth
9.1.4 What is Geothermal Energy?
- Shallow Geothermal and Deep Geothermal
- Solar influence to 15 metres (summer & winter temperature influence)
- Earth's Core – radioactive decay, UK heat map, heat flux
- Correlation between soil temperatures and heat flux

9.1.5 Ground Source Heat Pump – how does it work?
- Heat Source
- Compressor
- Heat Distribution – heat emitters
- Expansion Valve
- Coefficient of Performance (compared to boilers)

9.1.6 Anchor Materials – functions & practical examination
9.1.7 Ground Heat Exchangers
- Open Loop – waterwell boreholes (injection, abstraction, thermal breakthrough, horizontal separation, cone of depression, injection mound), lakes, rivers, marine
- Closed Loop Horizontal – straight pipe, slinkies etc.
- Closed Loop Boreholes – main elements (borehole, loop pipe, u-bend, loop weights, grout, thermal transfer fluid, geology, water levels), single and double Loops

Practical	Knowledge
Will be able to identify closed loop borehole elements	Where geothermal energy comes from, components of a heat pump, how a ground source system works

9.2 CLOSED LOOP SYSTEM DESIGN

9.2.1 Importance of correct design
9.2.2 Who designs closed loop systems – what is their role? What do they use for designing?
9.2.3 Peak Cooling Loads, Annual Cooling Energy, Peak Heating Load, Annual Heating Energy, Base Load
9.2.4 Annual Temperature variation

9.2.5 Heat Pump Selection
9.2.6 Geology – thermal conductivity and strata differences, averaging a borehole thermal conductivity
9.2.7 DECC look up tables
9.2.8 Thermal Response Testing – what is it and how does the test take place

9.3 LEAD DRILLER INSTRUCTIONS AND SPECIFICATIONS

9.3.1 Design Detail – Design & geology report, borehole location (and plan), diameter, depth, single or double loop, loop depth, grout type etc.
9.3.2 Drilling Instruction – method, diameter, depth, flushing requirements, casing, site access, specific requirements e.g. resident needs
9.3.3 Completion Instruction – Loop details, weights required, grout type, loop testing (flow and pressure), loop tails completion and protection
9.3.4 Layout Drawings and buried services information
9.3.5 Applicable Standards and Guidance
- BDA Safety Guidance
- GSHPA Vertical Borehole Standard
- EA Environmental Good Practice Guide for Ground Source Heating & Cooling
- MCS 3005 Requirements for Contractors …

9.3.6 Source Protection Zones
9.3.7 Coal Authority Requirements
9.3.8 What can go wrong to impact on design?
- Incorrect borehole spacing
- Incorrect loop fitted e.g. single instead of double
- Incorrect grout
- Boreholes in wrong positions
- Incorrect flow and pressure testing
- Changing number and depths of holes/loops

9.3.9 Only the Designer can change the design!

9.4 DRILLING AND LOOP INSTALLATION

9.4.1 Get organised – Efficient equipment, tidy site, plan equipment movement, step up productivity, safe working, sensitive environments
9.4.2 **Appropriate Drilling Rigs and Techniques**
- Geothermal drilling goes to depths and strata not generally experienced by other drilling disciplines e.g. ground investigation etc.
- Awareness of rig capacity and equipment limitations
- Cable percussion, rotary, sonic etc. – Advantages and disadvantages
- Ability to adapt – casing availability, sealing bentonite on site, selection of bits on site etc.
- Ability to cope with waste water, dust etc.
- Air flush drilling – pros and cons e.g. will heat ground so is it appropriate for a thermal response test? Weight of loop will be a problem in a dry hole. Other examples.
- Mud drilling – pros and cons. Need for good settlement and cleaning system.
- Mud drilling – need to use mud balance, marsh funnel and

9.4.3 **Loop Weight Calculations**

- To overcome buoyancy
- Calculation – weight fluid displaced, weight water in loop, weight of loop
- Custom weights

9.4.4 **Drilling Problems**

- Little geological information as not previously drilled
- Poor verticality – holes intercepting, 'stealing' heat from adjacent properties, loop install can be hindered etc.
- Geological anomalies e.g. anhydrite strata heaving (Staufen, Germany)
- Mine workings – coal, salt, gypsum, limestone etc.
- Saline water – degrades muds, affects grouts
- Artesian ground water
- Borehole depth – deeper you go the problems multiply!

9.4.5 **Loop Installation Issues**

- Loop damage – cuts, scratches, crushing etc. Store and inspect loops
- Advantages of loop reel and well head roller
- Loop 'shavings' – Casing top protector required
- Loop tail protection – to prevent debris entry – heat/fuse, fusion, bungs, tape, what is preferable?
- Other site workers – excavator drivers, dumper drivers etc. driving over loop tails

Practical	Knowledge
Will be able to understand design, carry out loop weight calculations, examine drilling and loop installation problems	Contribution of high quality drilling and loop installation in conforming to design and success of ground heat exchanger

9.5 GROUTING AND BACKFILLING

9.5.1 Grout and Backfill definitions
9.5.2 Types of grout, Advantages & Disadvantages – cement/water, cement/bentonite/water, bentonite/water, bentonite/silica-sand/water, bentonite/cement/sand/water
9.5.3 What is a geothermal grout? GSHPA borehole standard defines
9.5.4 Colloidal and paddle mixing. What should be used?
9.5.5 Positive displacement pumps types
9.5.6 Bentonite mixing and pumping requirements
9.5.7 Tremmie pipe description and importance
9.5.8 Silica sand – its purpose and percentage of silica dioxide for thermally enhanced grouts
9.5.9 Securing loop tails during grouting to prevent loop rising
9.5.10 Correct grouting tremmie operation
9.5.11 Granular backfill – disadvantages. Angular material provides point load on pipe – slow crack propagation
9.5.12 Granular backfill - tremmie operation only

Practical	Knowledge
Will be able to select tremmie operation for grouting and backfill operations	Range and features of different grout types and those most suitable for closed loop installations

9.6 FLOW AND PRESSURE TESTING

9.6.1 The Money Tests – important to get right and obtain client acceptance
9.6.2 Importance of testing flow first
9.6.3 Flow test measurements – flow AND pressure in the loop
9.6.4 Flow test requirements – gauges near loop tails, smooth pump, flow restricting valve, water meter/known container volume, stop watch, no restrictions
9.6.5 Flow test – 3 flow rates and corresponding pressures
9.6.6 Pressure test to BS EN 805 simple test
9.6.7 Weather effects on pressure test – how to overcome
9.6.8 Pressure test components – hand pump, gauge, pump connector, bleed/isolation valves, stop watch
9.6.9 Correct pressure test operation (water only not air)
9.6.10 Test pressure calculation (to overcome grout hole pressure if grout present)
9.6.11 Recording of tests and client approval

Practical	Knowledge
Will be able to carry out flow and pressure testing	Most important elements of flow and pressure testing

9.7 INSTALLATION RECORDING

9.7.1 Importance – all details should be recorded for future use (50 years plus)
9.7.2 BDA template reports
- Borehole drill log & completion record for loop installation
- Summary record of installation details
- Summary report flow and pressure test

9.7.3 Borehole layout drawing

DAY TWO

9.8 GEOTHERMAL DRILLING

9.8.1 Plan Route on Site

Practical	Knowledge
Will be able to negotiate agreed route from site entrance to hole location	Restricted routes Terrain Ground conditions
Will be able to liaise with client, especially domestic, regarding what is planned	Diplomatic conversation

9.8.2 Loading and Unloading

Practical	Knowledge
Will be able to load and unload the rig and equipment in a safe and organised manner	Manual handling regulations Stowage for transport Company policy

9.8.3 Site Welfare

Practical	Knowledge
Will be able to identify and locate welfare facilities on site or near site: - - toilets - washing facilities - first aid - eating - overnight accommodation	Transient worker welfare requirements Company policy Importance of cleanliness

9.8.4 Storage and Security

Practical	Knowledge
Will be able to arrange safe, secure and appropriate storage for rig, equipment and goods while on site	Company policy COSHH regulations Security devices and procedures Hazards to personnel and public
Will be able to protect items from theft	Unauthorised visitors Public and visitors

9.8.5 Determine Contract drilling requirements

Practical	Knowledge
Will be able to liase with client / engineer as required	How to interpret drilling specifications, plans and instructions.

Will be able to read, understand and interpret drilling requirements	Measuring Method statements
Will be able to locate position for drilling	Risk assessment

9.8.6 **Check for hazards**

Practical	Knowledge
Will be able to carry out risk assessment and locate hazards in vicinity of hole	Ground stability factors Underground / Overhead services Other hazards e.g. contamination, traffic Confined space working
Will be able to select appropriate action to minimise hazard	Reporting to supervisor. Rig relocation / working platform
Will be able to select appropriate PPE	PPE

9.8.7 **Rig start up and positioning**

Practical	Knowledge
Will be able to carry out pre operational checks e.g. oil and fluid levels	Rig Manual instructions. Company procedures.
Will be able to start and position rig accurately: - - Start Up - Manoeuvring - Levelling & Stabilising Rig - Setting Orientation (inclination, direction, height etc) - Accuracy & Tolerances	Rig Manual instructions. Company procedures. Hole entry point.

9.8.8 **Drilling to depth**

Practical	Knowledge
Will be able to carry out all pre-drilling checks: - - Safety Checks, (Personnel PPE, Danger Zone clearance) - Start Up - Check Emergency Stops, Guarding Mechanisms - Establish Datum Point for hole depth recording - Measure length of drill rods / casings - Check bit size	Rig Manual instructions. Company procedures. Safety guidance. Risk assessment. Measuring techniques and measuring tools
Will be able to complete a drill run in efficient and productive manner: - - Commence Drilling - Monitor Gauges - Adjust Rig Functions as necessary	Rig Manual instructions. In-the-hole equipment instructions. Company procedures. Drilling specification. Geological appreciation.

- Complete Run according to drilling specification	Varying ground conditions.
Will be able to measure and record all information from drill run: - - Record Hole depth (stick up as part of calculation) - Record all required information - Record formation changes and depth - Record any particular events e.g. water strike - Record depth of casing	Company procedures. Measuring. Method of recording e.g. notebook to be submitted to supervisor Geological appreciation. Varying ground conditions.
Will be able to measure length of, and load, next drill rod or casing in safe and productive manner working with driller support	Rig Manual instructions. Company procedures. Measuring techniques and measuring tools Manual handling. Rod and thread characteristics. Rod handling procedures
Will be able to carry out several drill runs to reach designed hole depth (overdrill by 500mm)	Drilling specification. Company procedures.
Will be able to thoroughly clean hole to clear out debris	Drilling specification Flushing technique
Will be able to recover, break and store in-the-hole equipment, and shut down rig: - Withdraw, unload and clean in-the-hole equipment - Withdraw Casing (if specified) - Lower, Shut down and derig the Rig	Company procedures. Rig Manual instructions. Storage procedures.
Will be able to proceed to loop installation immediately to avoid any ground relaxation	Company procedures. Anchoring specification & practice

9.9 LOOP INSTALLATION

9.9.1 **Loop inspection, loading and preparation**

Practical	Knowledge
Will be able to inspect loop (s) for damage	Cuts, scratches and other physical damage limits, and rejection procedures
Will be able to determine that's it's the correct loop (s)	Checking procedures Loop installation specification
Will be able to load loop (s) on loop reel (s) safely and without causing damage	Loop reel loading procedure
Will be able to note details of loop into log book e.g. manufacturer's label information etc.	Need to document everything

Will be able to carry out loop pressure test at this point (if required by instructions)	Loop pressure testing procedure
Will be able to remove loop wrapping (if fitted) and dispose of	Removal of waste
Will be able to either calculate what size loop weights to be fitted or read specification as to which weights	Correct loop weight importance
Will be able to fit loop weights	Manufacturer's instructions

9.9.2 **Rig, casing and tremmie preparation**

Practical	Knowledge
Will be able to install a well head roller	Best locations
Will be able to place and secure a loop casing protector	Function of loop casing protector
Will be able to inspect tremmie for damage and any blockage	Cuts, scratches and other physical damage limits, and rejection procedures
Will be able to load tremmie on tremmie reel safely and without causing damage	Tremmie reel loading procedure

9.9.3 **Loop insertion**

Practical	Knowledge
Will be able to feed loop into borehole to required depth	Manual handling
Will be able to fit loop spacers (if specified)	Manufacturer's instructions Installation instructions
Will be able to check that loop is at design depth	Loop metre markings Installation instructions
Will be able to carry out flow and loop pressure tests once loop inserted (if required by instructions)	Loop flow testing procedure Loop pressure testing procedure
Will be able to cut loop pipes to appropriate tail length	Safe cutting procedure Desirable tail lengths
Will be able to seal or plug loop tails	Simple heat/fusion technique Electro fusing Installation instructions

9.10 GROUT MIXING AND GROUTING OPERATION

9.10.1 **Grout materials**

Practical	Knowledge
Will be able to check grout materials e.g. bentonite, sand etc. meet grouting	Manufacturer's labelling Grouting instructions

specification	

9.10.2 **Grout mixing**

Practical	Knowledge
Will be able to load grout materials and water, in correct order and quantity into a suitable paddle mixer	Measuring Manual handling COSHH regulations PPE regulations e.g. dust mask Grout mix instructions
Will be able to commence and complete mixing operation	Grout mix instructions Paddle mixer operation

9.10.3 **Tremmie insertion**

Practical	Knowledge
Will be able to feed tremmie into borehole to required depth	Manual handling
Will be able to check that tremmie is at design depth for commencement of grouting operation	Measuring Installation instructions

9.10.4 **Grout pumping**

Practical	Knowledge
Will be able to prepare the pump and make all connections to mixer and tremmie	Pump manufacturer's instructions Whip lash restraints
Will be able to secure loop tails to avoid loop rising from hole	Pipe buoyancy under grouting
Will be able to commence and complete the grouting of hole, raising tremmie in stages, until hole overflowing with clean grout	Grout mixing & pumping Tremmie raising procedures

9.11 FLOW AND PRESSURE TESTING

9.11.1 **Flow test**

Practical	Knowledge
Will be able to prepare the flow test equipment, connect its elements together and make connections to loop tails	Flow test equipment Manufacturer's instructions
Will be able to carry out flow test and repeat	Flow test according to BS EN 805 simple test

Will be able to record all results	Recording procedures

9.11.2 **Pressure test**

Practical	Knowledge
Will be able to prepare the pressure test equipment, connect its elements together and make connections to loop tails	Pressure test equipment Manufacturer's instructions
Will be able to carry out pressure test	Pressure test instructions
Will be able to record all results	Recording procedures

9.12 INSTALLATION RECORDING

9.12.1 **Lead Driller recording**

Practical	Knowledge
Will be able to record all aspects of the drilling, loop installation, grouting operation, and flow and pressure testing	Recording procedures
Will be able hand over all records in legible form to immediate superior	Company procedures