HGC

HYDRO-GEO-CONSULT GmbH

Report

„Thermal-Response-Test (TRT) for a test-BHE“

Project

„Brno, Botanická“

contractor:

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client:

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1 Introduction

1.1 Preface

For the site Brno, Botanická, it’s planned to use geothermal energy for cooling the building. The necessary foundation piles will be thermal activated in this way.

The base for a professional dimensioning of the pile-field is the determination of the site-specific thermal conductivity of the bedrock. In addition a drilling was realized on the construction-site and a borehole heat exchanger (BHE) was installed. At this BHE the Thermal-Response-Test was accomplished and the thermal conductivity determined.

1.2 Contractual relation

Client for the test: GE-TRA s.r.o. from Liberec.

1.3 Accomplished work

The Thermal-Response-Test was realized by the Co. Hydro-Geo-Consult GmbH from 08/08/2012 to 11/08/2012 over a period of 72 hours.

In the run-up to the TRT, the measurement of the undisturbed underground temperature occurred (into the pipe). This kind of measurement is much more sensitive than the simple circulation of the fluid for a couple of minutes.

2 General description

2.1 Location of the site

Botanická

Brno

2.2 Drilling conditions

The boundary conditions for the drilling are as follows:

- Final depth of borehole: 13 m (determined during the temp-log)
- Borehole diameter (0,0 – 4,5 m): 273 mm
- Borehole diameter (4,5 – 13,0 m): 220 mm (average: 238 mm)
- Type of BHE: PE 4 x 32 mm

2.3 Geological boundary conditions

There were no information to the layer specification of the drilling available. Thus, it was essential to use information from already existing boreholes. The concerning report (GEOtest, Brno, březen 2010) was handed over by the client.

Following layers were estimated for the test-borehole:

- 0,0 – 3,8 m: anthropogenic filling (gravel, clay, concrete)
- 3,8 – 6,0 m: loess
- 6,0 – 7,8 m: gravel and clay
- 7,8 – 8,1 m: gravel, sand
- 8,1 – 13,0 m: clay

The groundwater level was set with 6,2 m below surface.

3 Thermal-Response-Test

3.1 TRT- device

The test device consists of the following main components:

- 0-9 kW electric heater,
- circulating pump,
- data logger for temperature of inlet flow and return flow, volume flow, air temperature,
- control units,
- data modem for remote transmission and remote control.

3.2 Boundary conditions

Depth of tested BHE:	13 m
Type of BHE:	PE-HD-Double-U, 4 x 32 x 2.9 mm
Period of measurement:	08/08/2012 to 11/08/2012
Heating capacity:	830 W
Max. inlet flow temperature:	34,8 °C
Max. return flow temperature:	33,9 °C
Test phase:	4340 min, used data: 3140 min

3.3 Result of measurements

The logged temperatures (by TRT) of inlet (red graph) and return (green graph) are pictured in figure 1. The flow of fluid shows the blue graph. Before started the heating period, the undisturbed ground temperature was measured (16,3°C) – appendix 1.

The whole TRT ran without any breaks. All logged date a sufficient stable. The temperature-curves show a constant increase.

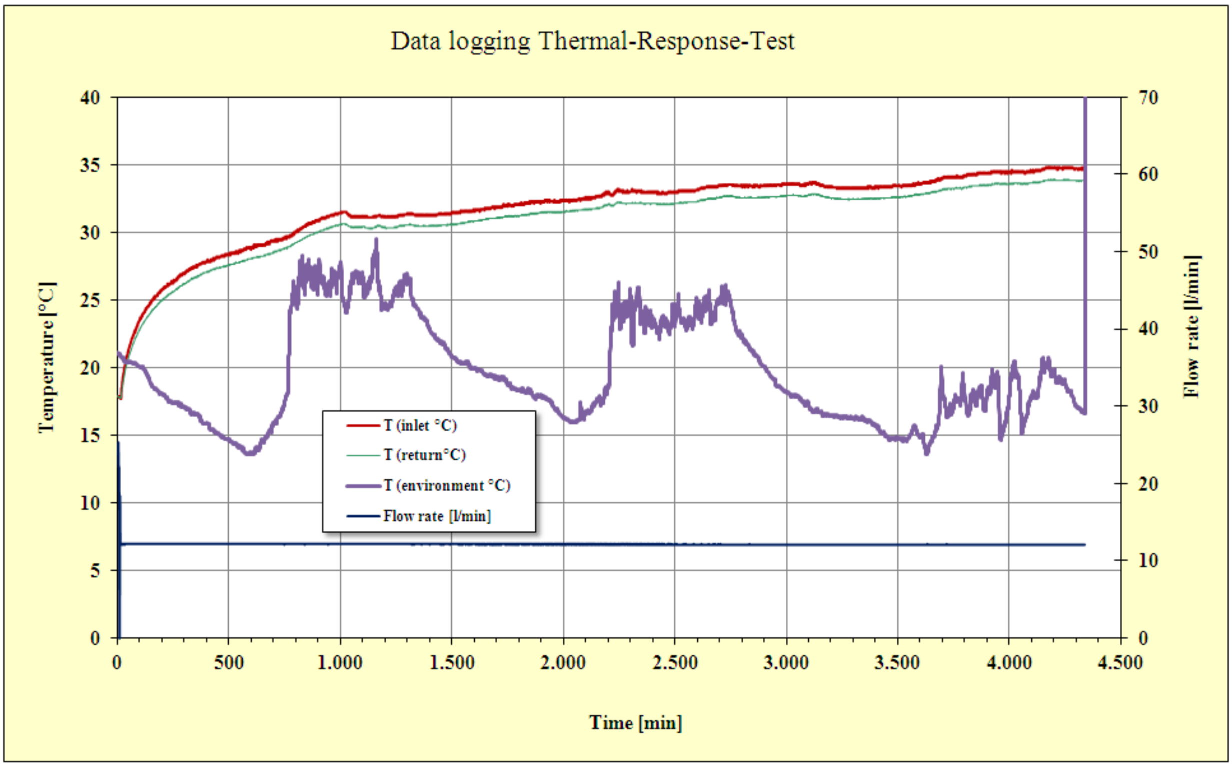

Figure 3-1: Logged temperatures and volume flow rates

In a first step of evaluation of the logged values the minimum time validity criterion has to be examined.

In order to accomplish a representative computation, the registered data are used starting from 1200 minutes.

In figure 3-2 are diagrammed the supplied heat emission (here: amount of heat) and the mean fluid temperature. Both parameters are needed directly for the test analysis. The thermal output is computed thereby over flow rate and temperature spread. The selected evaluation time window is likewise represented.

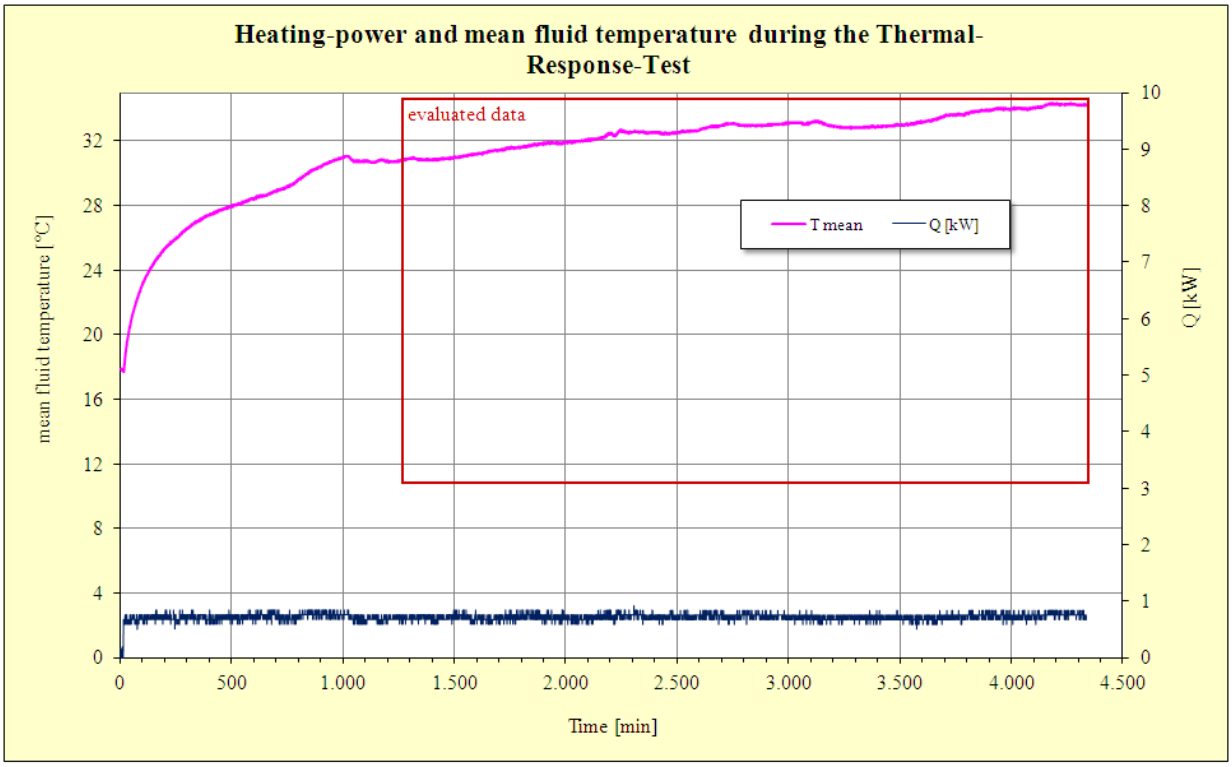

Figure 3-2: Mean fluid temperature and heat emission in the ground

3.4 Analysis

The evaluation is effected according to Kelvin's line source theory.

In figure 3-3 the mean temperature of the heat carrier fluid is laid on a logarithmic time axis.

From the upward gradient of the regression line the effective or apparent heat conductivity λ^* results in:

$$\lambda^* = \frac{Q}{4\pi \cdot H \cdot k}$$

The following figure results for the selected time window between 1200 … 4340 min.

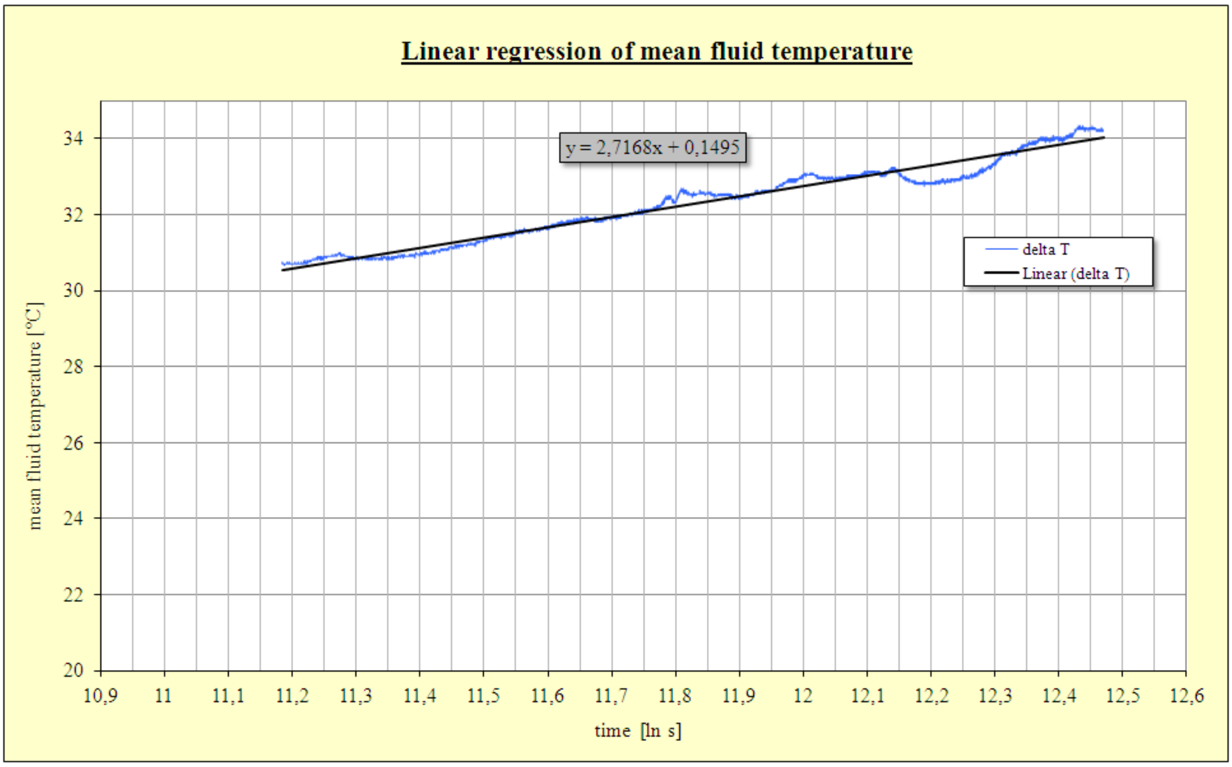

Figure 3-3: Mean fluid temperature of the heat carrier fluid and regression line

An effective heat conductivity of **1,63 W/(m K)** is determined.

4 Summary of the results

The results of the test are summarized in the following table 4-1:

Table 4-1: Results of the Thermal-Response-Tests

Time window [h]	H [m]	r_b [m]	t_{min} [h]	Q [W]	k	T_0 [°C]	R_b [K/(W/m)]	λ^* [W/m·K]
20,0…72,3	13	0,119	20	727	2,7168	16,3	(0,15)	**1,63**

Due to the use of thermal activated piles, the calculated borehole thermal resistance is minor.

Because of the only estimated geological profile for the test pile, the results contain an unpreventable haziness.

The effective thermal conductivity for the geothermal use of the underground amounts at the location and under the realized conditions **1,63 W/(m K)**. Because of the more or less dry underground and the significant anthropogenic filling, the calculated value can be marked as “mean to bad”.

Additional it should be mentioned, that the measured undisturbed underground temperature is unexpected high.

5 Literature

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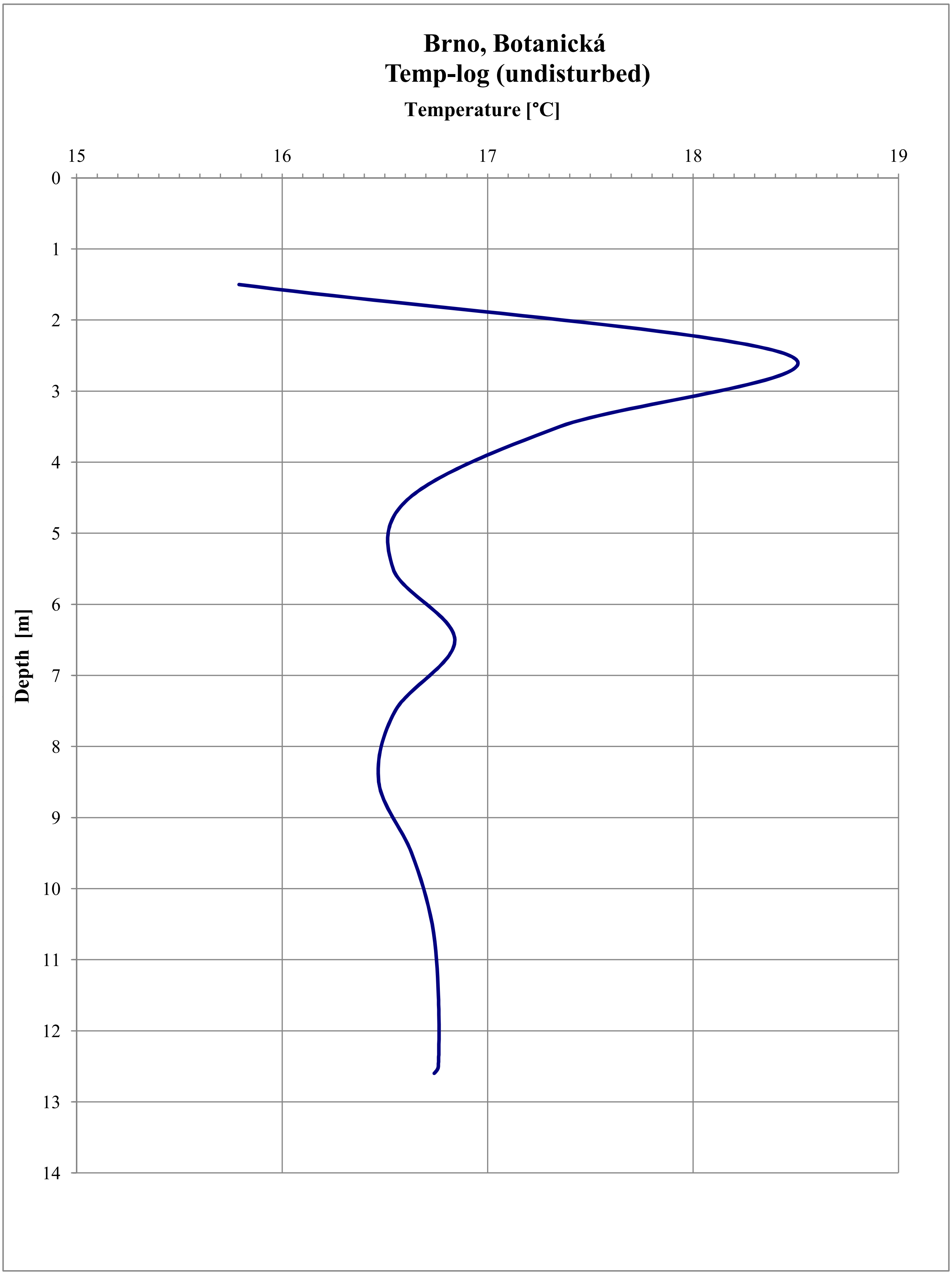
Appendix

Appendix 1

Temperature log



Brno, Botanická
Temp-log (undisturbed)
Temperature [°C]
15
16
17
18
19
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Depth [m]

Appendix 2

Photo documentation

Figure 1: running TRT

Figure 2: closed pipes after TRT