Thermal study of a Large Ground Heat Exchanger in the Cold Weather Environment of Northern USA

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Loop Field Construction

Overview
What are we studying?
What are we measuring?
What have we found?
Our Goals?
EEEC  BUILDING Z in the UND campus

Grand forks, North Dakota

$6 million New building; Office space for 90 additional employees

47,000-square-foot addition
System Features

- 43 heat pumps with aggregate cooling capacity of 110 Tons and heating capacity of 100 tons.
- Total Kw = 90 kW (Fan and Compressors)
- GHX loop circulating pump = 15 HP
- Maxm flow rate = 628 GPM
- Fluid = 20% Propylene Glycol
GHX features

- 210 Boreholes each 150 ft deep
- Bore dia = 4.5 inch
- Borehole spacing = 12 ft
- U tube dia = 1 inch
- Backfill Material = Bentonite
Equivalent Full Load Cooling and Heating Hours
For some cold places in the USA

<table>
<thead>
<tr>
<th>Annual Hours</th>
<th>Office -8 AM to 5 PM Five days/ Wk (2200 hrs-2400 hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooling Hrs</td>
</tr>
<tr>
<td>Bismarck. ND</td>
<td>250-540</td>
</tr>
<tr>
<td>Great Falls MT</td>
<td>210-490</td>
</tr>
<tr>
<td>Minneapolis MN</td>
<td>320-610</td>
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</tbody>
</table>

Excerpts from ASRAE publication 1120-TRP, 2000
Borefield Modeling Approach

SQUARE CYLINDER GEOMETRY

ADIABATIC BOUNDARIES

Borehole and grout
Location of Monitoring Holes
Ground temperature measurement at FARGO, ND

<table>
<thead>
<tr>
<th>Measurement depth (cm)</th>
<th>Average mean-annual temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.44</td>
</tr>
<tr>
<td>5</td>
<td>8.69</td>
</tr>
<tr>
<td>10</td>
<td>8.8</td>
</tr>
<tr>
<td>20</td>
<td>8.47</td>
</tr>
<tr>
<td>30</td>
<td>8.58</td>
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<tr>
<td>50</td>
<td>8.4</td>
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<tr>
<td>60</td>
<td>8.09</td>
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<td>80</td>
<td>8.24</td>
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<td>125</td>
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<td>150</td>
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<td>770</td>
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<tr>
<td>970</td>
<td>7.21</td>
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<tr>
<td>1170</td>
<td>7.39</td>
</tr>
</tbody>
</table>

Ongoing ground temperature measurements at 19 depth levels from 1980.

Geology and weather quite similar to UND GHX location.

Both cases soils are clay, silt, fine sand, silty clay

Distance between two sites 70 miles.
Temperature History -1

Days from 12/2/0X

Ground temperature Degree C

- - Hole # 5 @731 cm (24 ft)
- - - - Hole # 7 @731 cm (24 ft)
Fargo @ 770 cm 2003/4
Fargo @ 770 cm 2002/3
Temperature History -2

Days from 12/2/0X

- Hole # 4 @ 487 cm (16 ft)
- Fargo @ 470 cm 2003/4
Ground Temperature History -3

Days from 12/2/2005

Temp. difference Hole # 4 and Hole # 5
Location of Monitoring Holes
Loop Field bypassed if the heat pump loop return fluid temperature is between $50^\circ$-$60^\circ$ F ($10^\circ$-$15.5^\circ$ C)

Building Night setback temperatures:

- $60^\circ$ F ($15.5^\circ$ C) in the winter
- $80^\circ$ F ($26.7^\circ$ C) in the summer
Heat Extracted from the GHX system on a typical December Day
Entering Water Temperature: Typical Daily Cycle in the winter
Long term Study Goals

- Monitor ground temperature over long period to observe the effect of imbalance in loads.
- Correlate actual observed temperature drifts with the actual load imbalance.
- Use numerical models with boundary conditions at the ground surface taken at the GST derived from control measurements.
- Design optimization study
- Study of Passive methods for preventing the temperature drift
THANK YOU FOR YOUR KIND ATTENTION
QUESTIONS???

&

COMMENTS!