A framework for Energy Performance Assessment of a large BREEAM certified GEOTABS implemented in Kortrijk

Julio Vaillant Rebollar
Tom Prinzie
Caroline Van Marcke
Arnold Janssens
Subjects

- Context
- EDC Study Case Characterization
- Framework for further Investigation
- Closure Remark

Geothermal

- Heating with a Heat Pump
- Passive Cooling

Thermally Activated Building System (TABS)
Radiant heating and cooling systems with pipes embedded in the building structure (slabs, walls)
Context

VM_EDC

GEOTABS: Overview of some Existing Projects

17 Existing Projects

Source: www.hybridgeotabs.eu; www.geotabs.synavision.de
EDC Study Case Characterization

- European Distribution Center (EDC)
- Building area 90,000 m²
- State of the Art on Warehouse and Logistics: 80% of the orders are automatically processed
- Green Electricity: 13,000 PV Panels
- Very Good BREAM Certification

BREEAM

- Energy
- Transport
- Pollution
- Materials & Resources
- Water Efficiency
- Land Use & Ecology
- Health & Well Being
## EDC Study Case Characterization

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Specification Parameter</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Pump</td>
<td>Heating: 170 kW/39 kW, COP= 4.4 (850 kW)</td>
<td>5</td>
</tr>
<tr>
<td>Heat Exchanger</td>
<td>Passive Cooling 41 kW</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Passive Cooling 380 kW (454 kW)</td>
<td>1</td>
</tr>
<tr>
<td>Gas Boiler</td>
<td>107 kW (SH)</td>
<td>6</td>
</tr>
<tr>
<td>Air Handler Unit</td>
<td>1260 m³/h ... 18120 m³/h</td>
<td>9</td>
</tr>
<tr>
<td>Glycol/Water Circulating Pump</td>
<td>115 m³/h</td>
<td>3</td>
</tr>
<tr>
<td>Hot Water Circulating Pump</td>
<td>22 m³/h; 52 m³/h</td>
<td>6</td>
</tr>
<tr>
<td>Cooling Water Circulating Pump</td>
<td>11 m³/h; 25 m³/h</td>
<td>6</td>
</tr>
</tbody>
</table>

**Floor Plan Details**

- **Floor 0**
  - **Thermal Activated** with T_setpoint = 14°C
  - **Under Floor Heating** with T_setpoint = 21°C

- **Floor 1**
  - **Air Heating System** with T_setpoint = 21°C
  - **Ceiling Heating** with T_setpoint = 21°C

- **Floor 2**
  - **Not Heating**
EDC Study Case Characterization

- 4 MW PV Panels
- 516 Borehole
- Glycols Pumps
- Backup Boilers
- Passive Cooling
- Hot Water Pumps
- 850 kW Heat Pumps
- 9 CO2 Controlled AHUs
- Thermal Solar DHW
Framework for further Investigation

The formalization of a framework for the energy performance assessment

- Identify and define the share of the heating and cooling loads (base load and peak load)
- Performance characterization of main HVAC system components (Heat pump, Ground heat exchangers, TABS, Air Handle Units)
- Assessing the ground energy storage field performance to guarantee the long term thermal balance of the ground.
Framework for further Investigation

The formalization of a framework for the energy performance assessment

Operational Optimization as a Process
### Framework for further Investigation

#### Design of system and infrastructure

<table>
<thead>
<tr>
<th>Surface</th>
<th>Description</th>
<th>U-value [W/m².K]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution Center</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor on ground</td>
<td>30 cm heavy concrete</td>
<td>0.14 m² K/W</td>
</tr>
<tr>
<td>Facade</td>
<td>8 cm heavy concrete, 10 cm PIR, 6 cm heavy concrete</td>
<td>0.22</td>
</tr>
<tr>
<td>Roof</td>
<td>18 cm heavy concrete, 10 cm PIR, 0.1 cm asphalt</td>
<td>0.21</td>
</tr>
<tr>
<td>Internal wall</td>
<td>14 cm heavy concrete</td>
<td>0.08 m² K/W</td>
</tr>
<tr>
<td>Internal floor</td>
<td>32 cm hollow core concrete slabs, 14 cm light concrete</td>
<td>0.23 m² K/W</td>
</tr>
<tr>
<td>Door</td>
<td></td>
<td>U_{\text{value}} = 2.0 W/m² K</td>
</tr>
<tr>
<td>Office</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor on ground</td>
<td>1 cm tiles, 7 cm concrete, 10 cm PUR in situ, 15 cm heavy concrete</td>
<td>4.46 m² K/W</td>
</tr>
<tr>
<td>Facade</td>
<td>8 cm heavy concrete, 10 cm PIR, 6 cm heavy concrete</td>
<td>0.24</td>
</tr>
<tr>
<td>Roof</td>
<td>18 cm heavy concrete, 16 cm PIR, 0.1 cm asphalt</td>
<td>0.14</td>
</tr>
<tr>
<td>Internal wall</td>
<td>1 cm gypsum, 10 cm mineral wool, 1 cm gypsum</td>
<td>2.87 m² K/W</td>
</tr>
</tbody>
</table>

(Source: Building Design Master Plan)
Framework for further Investigation

Problems caused by Ground thermal imbalance

- Decrease of the outlet temperature of ground heat exchanger (GHE)
- Deterioration in the heating performance of the ground-coupled heat pumps
- Heating reliability will decline indoor air temperature falling below design range
Problems caused by Ground thermal imbalance

- Decrease of the outlet temperature of ground heat exchanger (GHE)
- Deterioration in the heating performance of the ground-coupled heat pumps
- Heating reliability will decline indoor air temperature falling below design range

GHE solutions for Ground thermal imbalance

- Borehole space
- Borehole length
- Borehole layout
- Improving thermal properties
Framework for further Investigation

*HVAC System-modified solutions for thermal imbalance of GCHPs*

- The solar collector can release heat to the soil for recharging GHE
- Identify the best combination of TABS and secondary emission system
- Utilization of the auxiliary condenser boiler (214 kW) to take on the peak heating load
- Increases the cooling demand by connecting TABS that were not foreseen to receive passive cooling
- Utilization of the industrial process waste heat as compensation by means of heat injection into the soil.
Framework for further Investigation

*Operation-modified solutions for thermal imbalance of GCHPs* (REHVA Guidebook no. 20)

- **Intermittent operation strategy**
  - Seasonal operation strategy
  - Rule Based Control strategies
  - *Model Predictive Control strategies*

- **Control strategies for TABS:**
  - Time based or zone temperature control
  - Weather dependent supply/average water temperature control
  - Intermittent pump operation control
  - TABS surface temperature is the controlled variable,
1. A framework for the energy performance assessment GEOTABS building defining the key element to approach the *Operational Optimization of the System as a Process* have been proposed

2. Potential *Problems caused by the Ground thermal imbalance* due to the significant difference of Cooling and heating demand have been highlighted

3. Ground Heat Exchanger - solutions to overcome the thermal imbalance like increasing borehole space/length/depth and the design of the borehole layout have to be closed follow up by mean of *Measurement of ground temperature behaviour*. 

4. Possible *Solutions and priorities* to carry out future in-depth studies have been presented
Closure Remark

Suggestions of further Investigation priorities

- **Integrating the gas boiler** to take on about 25% heating load can achieve better economy as well as lower energy consumption.

- **Integration of solar energy** to recharge the ground during summer or night time can avoid the thermal imbalance and improve the heating COP of the heat pumps.

- **Integration with waste heat** from the industrial process can improve the thermal imbalance, but is restricted by the amount and generating occasion of waste heat.

- **Seasonal operating strategy** can make full use of the advantages of the auxiliary energy at different periods in hybrid GCHP systems to eliminate the thermal imbalance.

- **Intermittent operation** can also be an interesting option to evaluate, a suitable intermittent strategy is 12 h operation and 8–12 h downtime.
A framework for Energy Performance Assessment of a large BREEAM certified GEOTABS implemented in Kortrijk

Thank you

Julio Vaillant Rebollar
Tom Prinzie
Caroline Van Marcke
Arnold Janssens