State of art and typology for the wireless transmission system in real use.
The estimation and judgment for the triggered value in EBS against the reference design value

Kei SUZUKI, RWMC
Presentation

1. What we learned from MoDeRn project
2. Typology of Transmitters
3. Sampling time and battery life
4. Make sensors more small
5. Estimation and judgment for the triggered value in EBS reference design
6. Conclusion
1. What we learned from MoDeRn Project

- From MoDeRn Case study in WP4, the idealistic arrangement of wireless transmission systems are proposed. This make us possible to consider the typology of wireless transmission system, and make us to develop new system.

Arrangement of wireless transmission system in real seized repository experiment

1. Small size, or the same size as an canister
2. Any direction,
3. Relay system
4. Relay system for transmitting 200m from URL to surface

Source: Köhte et al., 2007

Ref: M. Jobmann, DB-TEC
## 2. Typology of the transmitter

<table>
<thead>
<tr>
<th>Type</th>
<th>Short-range</th>
<th>Mid-range 1</th>
<th>Mid-range 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td>Φ : 50mm</td>
<td>Φ : 216mm</td>
<td>Φ : 700mm</td>
</tr>
<tr>
<td></td>
<td>L : 130mm</td>
<td>L : 310mm</td>
<td>L : 70mm</td>
</tr>
<tr>
<td><strong>Transmit. Test in CMHM URL</strong></td>
<td>L=25m Callovo-Oxfordian layer Noise:10mV</td>
<td>L=40m Callovo-Oxfordian layer Noise:2.0mV</td>
<td>L=50m Callovo-Oxfordian layer Noise:2.0mV</td>
</tr>
<tr>
<td><strong>Transmit. Test on the surface</strong></td>
<td>L=38m Noise:2.0mV</td>
<td>L=100m Noise:1.5mV</td>
<td>L=240m Noise:1.5mV</td>
</tr>
</tbody>
</table>
Long-range

- The long range antenna was developed in 2012, it will be tested over 110m in Horonobe URL in 2013. The result will be shown in WS of monitoring in Paris, May 2014.
3. Sampling time and battery life

<table>
<thead>
<tr>
<th>Operation period (Battery life time)</th>
<th>Short</th>
<th>Middle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of transmitter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmission distance</td>
<td>Maximum 25m in rock</td>
<td>Maximum 40m in rock</td>
</tr>
<tr>
<td>Note 1: Transmission distance depends on the noise level where the receiver is placed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Available channel</td>
<td>Thermometer and one channel (1 sensor)</td>
<td>4 channels (4 sensors)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transmission period (under the condition that the temperature is around 20-30°C)</th>
<th>Case1</th>
<th>Case2</th>
<th>Case3</th>
<th>Case4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement 24 times/day</td>
<td>1 sensor: 3-4 years</td>
<td>1 sensor: 7 years</td>
<td>1 sensor: 10 years</td>
<td>1 sensor: 10 years</td>
</tr>
<tr>
<td>Transmission 1 time/day</td>
<td>1 sensor: 3 years</td>
<td>1 sensor: 6 years</td>
<td>1 sensor: 10 years</td>
<td>1 sensor: 10 years</td>
</tr>
<tr>
<td>Case2</td>
<td>Measurement 4 times/day</td>
<td>1 sensor: 7 years</td>
<td>1 sensor: 10 years</td>
<td>1 sensor: 10 years</td>
</tr>
<tr>
<td>Transmission 1 time/week</td>
<td>1 sensor: 3 years</td>
<td>1 sensor: 6 years</td>
<td>1 sensor: 10 years</td>
<td>1 sensor: 10 years</td>
</tr>
<tr>
<td>Case3</td>
<td>Measurement 1 time/day</td>
<td>1 sensor: 10 years</td>
<td>1 sensor: 10 years</td>
<td>1 sensor: 10 years</td>
</tr>
<tr>
<td>Transmission 1 time/day</td>
<td>1 sensor: 10 years</td>
<td>1 sensor: 10 years</td>
<td>1 sensor: 10 years</td>
<td>1 sensor: 10 years</td>
</tr>
<tr>
<td>Case4</td>
<td>Measurement 1 time/week</td>
<td>1 sensor: 10 years</td>
<td>1 sensor: 10 years</td>
<td>1 sensor: 10 years</td>
</tr>
<tr>
<td>Transmission 1 time/month</td>
<td>1 sensor: 10 years</td>
<td>1 sensor: 10 years</td>
<td>1 sensor: 10 years</td>
<td>1 sensor: 10 years</td>
</tr>
</tbody>
</table>

Note 2: Transmission periods (battery’s durability) depend on the frequency and transmission.
Note 3: Transmission periods becomes shorter, if the temperature around the transmitter is high.

We need more longer battery life.
4. Make sensors more small

<table>
<thead>
<tr>
<th>Sensor Type</th>
<th>Manufacturer</th>
<th>Material</th>
<th>Pressure</th>
<th>temperature</th>
<th>Sensor Cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total pressure</td>
<td>Geokon 4800</td>
<td>SS316</td>
<td>20MPa</td>
<td>50°C</td>
<td>PVC</td>
</tr>
<tr>
<td>Pore pressure</td>
<td>Geokon4500HT</td>
<td>SS316</td>
<td>10MPa</td>
<td>50°C</td>
<td>PVC</td>
</tr>
<tr>
<td>RH humidity</td>
<td>Aitemin</td>
<td>Stainless steel</td>
<td>5MPa</td>
<td>50°C</td>
<td>Twisted shielded, Teflon jacketed</td>
</tr>
</tbody>
</table>

- For RH humidity with 10MPa sensor is able to offer.

![Model 4500HT High Temperature Piezometer](image1)

- Pore pressure 4500HT Cell 133mmX19.1mm

![Model 4800, 4815 Earth Pressure Cells](image2)

- Total pressure 4800 Cell 230mmX6mm
- Total pressure 4820 150mmX12mm
- Relative humidity SHT75-V3
RWMC examined the total pressure sensor of Geokon 4800 in a bentonite block of 470X550X330 for backfill, we need more smaller sensor.

Arrangement of sensor in a backfill block
New types of small sensors are developed day after day. Try to use them without restriction which requires more than 5 years of real usage.

Sensor arrangement

New type of Geokon 4800,
Total pressure
(not Hydraulic type)

Material: SS316

We have to collaborate with specialist of sensors, if problems would occur.
5. Estimation and judgment for the triggered value in EBS reference design

- There are some parameters which could not be detected by the sensors during re-saturation, such as inflow rate, piping and erosion phenomena.

**Bentonite block (Dry density: 1.6Mg/m³)**

**Saline water (NaCl 0.5M)/Inflow rate: (0.1 l/min)**

- **Initial state**
- **Start of the test**
- **After 1hr**
- **After 2hr**
- **After 3hr**
- **After 6hr**
- **After 9hr**
- **After 12hr**

- **Piping procedure**
  - 1hr: More sedimentation is observed.
  - $P_w=60\text{kPa}$: constant

- **3hr: Gap is filled by sedimentation. Water channels emerge in the sedimentation.**

- **6hr: Erosion goes on. No sealing can be seen. Accumulation of Sand.**
  - $P_w=60\text{kPa}$: constant
  - $V_{erosin}=0.39\%/\text{hr}$

- **Demolition**

- **In case of saline water, accumulation of sand occurs.**
- **In case of 0.1 l/min, no sealing occurs.**
The behavior of buffer during re-saturation stage should be carefully estimated, because it has strong relationship between water management and geo-hydrological condition, and also to the long term safety of EBS.

Countermeasure against piping and erosion

If the hydro-geological condition is not good (hy < 1.0X10^-6 m/s), we have to consider the site measurement of inflow rate, result of laboratory test and the result of water management, such as Post- and Pre-grouting.
6. Conclusion

- MoDeRn project made us opportunity to consider the typology of wireless transmission system.

- The future work is revealed, such as to postpone the battery life and distance, to study influence of temperature and radiation to wireless system.

- The sensors are developed day by day, we have to welcome this technical development and to collaborate with specialist of sensors.

- The behavior of buffer during re-saturation stage should be carefully estimated considering the result of laboratory test, site-measurement and water management, and geo-hydrological condition of rock.

- I hope to collaborate with members of IGD-TP as MoDeRn project did.

Than you very much!