Prague Metro – Site plan

Faculty of CE

Holesovice

Vltavska

Florenc
Micro-communication test area, Line A

Instrumentations in section: km 18,725 Line C, Track No. 2

Tunnel lining host rock:
Ordovician period, degree beroun
Dark grey wacke, wacke-shale with sandstone and/or quartzite, facies of claystone
Preliminary design of instruments placement in selected section

Convergence meas.  Tilt plates

Test area?
View – direction Vltavska station
Placement of instrumentation

Section in km 18,725
Selected tubing for the test area

Line C, Track No. 2
Section in km18,725
Placement of tilt plates and convergence bolts

- Symmetric
- TP + CB to be close as much as possible
- In relation to the test area

Angles of inclination of tilt plates after installation

Test area

- 25.4°
- 51.7°
- 47.6°
- 09.8°
- 47.6°
- 51.7°
- 25.4°
- 09.8°
- C 04.4°
- L 00.6°

Diagram showing the placement and angles of the tilt plates and convergence bolts in relation to the test area.
Tilt plate 2.01 and convergence bolt
Convergence bolt and tilt plate
Convergence bolt 2.04
Results of tilt measurement in mm/m

10/01/07  0,12
12/04/07  -0,18
10/01/07  -0,28
12/04/07  -0,52
10/01/07  0,24
12/04/07  0,68
10/01/07  -0,72
12/04/07  -0,74
10/01/07  0,32
12/04/07  0,32
Idea of crackmeter placement
Geokon crackmeter: range 12,5 mm

320 ± 10 mm

30 mm

Spacing mark

320 ± 10 mm
Location of crackmeter pattern
And what about the helmet?
Summary and recommendations for on coming (1/2)

- **Tilt monitoring** – to do:
  - Air moisture and temperature records
  - Temperature of tunnel lining records
  - 3 times repeated measurement records

- **Convergence measurement** – to do:
  - Interfels – retail part / or manufacture in our workshop
  - Tests of repeatability and temp.records
Summary and recommendations for on coming (2/2)

• Crackmeter:
  – Steel pattern application for core boring
  – Manual readings of four crackmeters
  – Connection to system / at the min. 2 data-loggers application

• Input for digital imaging:
  – Repeated digital snaps sequences in the section km 18,725
    • Resolution shall be increased (now 3,2 MP)
Meeting at Prague 24/10/2006

Anticipation / optimistic / contemplating / …
Acknowledgements

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RESEARCH ON UNDERGROUND STRUCTURES AGEING WITH EXPLOITATION OF MONITORING AND MICROMEASUREMENT SYSTEMS - AUXILIARY METHODS II

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Round about the turn of the past year we have prepared application of 2 other auxiliary methods, which have to observe two selected parts of tunnel lining and complement the base monitoring system. Installation was completed at monitoring profile on line C, rail Nr.2, kilometer spacing 18,725 of Prague METRO, and aimed to:

a) monitoring of dynamic behaviour changes time-development of selected parts under the traffic loads,

b) monitoring of fatigue failure time-development by means of examination of elastic waves spreading parameters.
Situation of the monitoring profile near the Holešovice
Scheme of complex monitoring profile instrumentation under the Holešovice Station - auxiliary methods (METRO Prague, line C, rail Nr. 2, kilometer spacing 18,725).
Geophones coated by copper cases with cabling prior to the installation into a tunnel lining.
Frequency response of geophones G-5, declared by the manufacturer (GEOSPOL Uhřínov) for particle velocity of 1 mm/s.
Drilling holes for geophones nests.
Sticking of monitoring geophone into its nest by a silicon sealant.
Detailed view of acoustic sampling field and monitoring geophone G1 installed.
Monitoring geophone after the instalation (G1 in the defected slab).
The key moment of the cabling installation - passing through the hydraulic safety barrier of the Holešovice Station.
Hydraulic safety barrier of the Holešovice Station (at the back are technical spaces of the station).
Passing through the pressure safety barrier of Holešovice Station (the outer side of the closure).
Passing through the pressure safety barrier of Holešovice Station with the detailed view to cable grommets (the outer side of the closure).
Fixation of acoustic sampling points by dowel pins.
Acoustic sampling field with hole prepared for monitoring geophone installation.
Set of fixed points for acoustic sampling application and the geophone G1 at monitored profile near the Holešovice Station.
Scheme of complex monitoring profile instrumentation under the Holešovice Station - auxiliary methods (METRO Prague, line C, rail Nr. 2, kilometer spacing 18,725).
FREQUENCY SPECTRUM (10 – 120 Hz):

METRO Prague  profile: km 18,625 / line C  14.02.2007

A (damaged slab)
B (intact slab)
difference (A-B)
3. dominant frequency (32 Hz):

A (damaged slab)
B (intact slab)
difference (A-B)
WSN in Prague metro

Martin Vaníček - CTU
Contents

- Site location
- Coordination with Prague metro
  - Paperwork / permits
  - Site & work logistics
- Installation of the WSN
  - Requirements
  - Actual work
- Handover to Oleg Podsechin
Site location

- WSN trial network near Dejvická station
- Reasons:
  - Section with Signalling already operation in the same wireless spectrum
  - Close to the University
  - Determination of maximum distance from station
Site location - map
Coordination - permits

1. Specification what we want to do
2. Metro to specify restrictions / requirements / possible collisions with existing systems
3. Meeting with all interested parties
4. Submission of our proposal with implemented requirements from Metro
Coordination – site logistics

- In advance specification of our work
- Determination of required personal resources from Metro
- Determination of required machinery, equipment for the work from Metro
- Determination of our own resources (personal & material)
- Works schedule agreement
WSN installation - requirements

- All installations to be in yellow boxes
- Main WSN node / gateway – mains power requirement all the time
- Distance from station – GPRS signal strength
- Cabling – tightly connected to tunnel lining
WSN installation – actual work

- Off site preparation
  - Painting of boxes
  - WSN motes programming
  - Gateway / Stargate interconnection & box fitting
WSN installation – actual work

Site work:
- Drilling for plugs / fastening of boxes via screws with washers
- Placement of motes with sensors / gateway into boxes
- Fixing of the cables to the tunnel facilities / installations
WSN installation – actual work

Diagnostics if the WSN as installed works
Handover to Oleg Podsechin

Thank you for your attention
Prague Installation

implementation and issues encountered
WiFi and ZigBee
WiFi and ZigBee 2

• Interference to WiFi comms from ZigBee a concern for infrastructure operators

• Reality: WiFi drowns out ZigBee
  • Solution: use non-overlapping channel 26

• Problem: only one channel → scalability issues
System Breakdown

Data Flow:

Sensors
→ Local Connection
→ Remote Connection
→ Database
Local Connectivity

- effective mote-to-mote range: 15 m
- predictable network topology for small net
- both star and mesh topologies tested
- relay nodes the weakest point
- integration of sensing and comms an issue
Local Improvements

- mote-to-mote range increase
- ease of replacing batteries
- ease of disabling motes to reconfigure net
- adaptive sampling frequency
Remote Connectivity

• crucial as it allows for reconfiguration, real time updates

• problematic due to:
  – limited connectivity options (GPRS)
  – unreliable components (router, modem)
  – external provider policies (operator)
  – complexity of software/scripts/setup
Remote Connectivity 2

- router behind firewall/NAT, but needs to act as server

- client/server roles reversed → worst possible scenario

- router is a black box, if something goes wrong only way to debug is to go on-site

- should try to maintain connection at all costs by
  - constantly sending keep-alive data (ping)
  - resetting the hardware and connection
Summary

- 8 node network, 50 m down a running tunnel
- 12 s between samples, 500 ms remote delay
- 4-6 weeks before batteries need replacing

- Stargate configured to back up data to memory card: raw and readings
- Scripts to automatically upload data to Internet

- Data and config shell remotely accessible