Instrumentation for Transportation Applications

Geohazards in Transportation in the Appalachian Region

5 August, 2009
Presentation Overview

- Case Histories of Instrumentation used for Transportation Related Projects
  - Landslide
  - Bridge Reconstruction
  - Movement in Rock Below a Roadway
  - Airport

- Automated Data Acquisition Systems (Brief Discussion)
Bridge Abutment
Toe of Slide
Piezometers and Inclinometers
Cross Section

FS = 1.005

Graben

Scarp

Silty Clay

Weathered Shale

Shale

Zones of shear in MoDOT inclinometers

1-70

Scale (m)

Limestone

0 10
Site Plan
Final Slope
I-55 Over
Lake Springfield
Temporary Steel Hangar
Reasons for Instrumentation

- Weak and Variable Soils
- Poor Condition of Existing Structures
- Traffic Volume (42,000 vpd)
- Lack of Suitable Detour Routes
- Possible Uneven Lateral Loads and “Dozer Hits”
- Pier Cap Rotation Would Reduce Contact Area (Beams on Cap)
FIGURE 1 - Pier Instrumentation Schematic

- Precast Concrete Pile Cap
- Original Pier
- Pier Extension
- West End
- Elevation
- Rotational Axis "SA"
- Rotational Axis "EB"
- Data Logger/Cellphone Moun
- Remote Multiplexer
- In-Line Tensioner
- Warning Light

(URS logo at bottom right)
Tiltmeter Installation
FIGURE 2 - Sample Data (NB04 Delta Movement)
Warning Light
Typical RMU
Software

- Large Volume and Long-Term Data Management
- Automate Instrumentation Data Collection, Reduction, Reporting and Plotting
- Desktop PC at Field Trailer
- Output Includes Detailed Analytical Plots and Data Reports
Distress in Rock Pillar
Distress in Rock Pillar
Distress in Rock Pillar
View of Road Surface
Signs of Distress
Design Considerations

- Define Objectives/Purpose
- Early Warning System
- Instrumentation Selection (Types of Measurements and Accuracy)
- Installation Criteria
- Data Management System
- System Maintenance
Instrumentation

- PK Nails to measure lateral and relative displacement
- Brittle “sulfaset” patches
- GPS checks on benchmarks
- VW Crack Gages/Avongard Manual Back-up
- Tape Extensometers measure breaks in Jersey barriers
- Inclinometers and sondex casings to 400 ft
Instrumentation (Cont.)

- Vertical TDR cables - 400 ft deep
- Survey Prisms on quarry highwalls to measure lateral movement via total station
- Seismometer
- Piezometers
- Borehole Videos
- USBR Rock Overcoring (To 300 ft depth)
- Rock Dilatometer Testing
VW Crack Gage-Tunnel
2D Crack Gage Rock Wall
Dataloggers
Movements at Various Depths
Inclinometers
Movement with Time

- Crack Meters on Joliet Road Surface
  - CMR-19SR (Vector Sum)
  - CMR-10SL (X-Displacement)

- Inclinometer Movements within Bedrock at Various Depths below Joliet Road
  - B-2 (55'-55')
  - B-18 (25'-25')
  - B-2 (125'-127')
  - B-2 (260'-265')

- Midway Airport - Daily Rainfall

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DamSmart

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Lambert-St Louis Airport Expansion

- Project Introduction
  - New 9,000 ft Runway
  - Road Relocations
  - “Cut and Cover” Tunnel for Lindbergh Boulevard (6 lanes)
  - Stormwater Retention Structures
  - Miscellaneous
General Subsurface Conditions

- Upland Profile
  - Modified Loess
  - Residual Clay
  - Shale and Limestone Bedrock
  - Groundwater 15 to 30 ft deep

- Lacustrine (Lakebed) Profile
  - Lake deposited clays and silts, organics
  - Residual Clay
  - Shale Limestone Bedrock
  - Groundwater 2 to 5 feet deep
Key Geotechnical Issues

- Stability of Cut Slopes in Shale
  - Tunnel Portal Cuts 80+ ft Deep
  - Possible Partial Height Retaining Walls

- Lakebed Soils
  - Stability of Cut Slopes, Subgrade
Cuts and Fills

Note: The figure depicts the Lindbergh LK-A Alignment. Cuts and Fills for the LK-B alignment are similar.
Lessons Learned

- Keep It Simple
- Value of Obtaining Data From Various Sources
- Account for Future Expansions
- Multiple Alarm Thresholds
Cameras
Automated Data Acquisition System (ADAS) Design Considerations

- System Layout and Schematic
- Equipment and Software Selection
- Installation Criteria
- Data Management System
Equipment Selection

- Sensors
- Remote Monitoring Unit
- Power – AC/Solar Panels
- Telemetry Components
- Computer
- Data Output Devices
Installation Criteria

- Lightning Protection
- Physical Site Conditions
- Minimize Lateral Cable Runs
- Avoid Subsurface Construction
- Flexible Deployment Scheme
- Manual Readout Capability
Benefits of ADAS

- Provides Timely Data Collection and Reduction
- Reduces Human Error
- Increased Reading Frequency Can Provide Additional Insights
- Provides More Time for Analysis and for Field Personnel
- Can be Extended into Early Warning System
Thank You