Use of In-Place Inclinometers During Lateral Load Testing

John Rowley, Nicholson Construction
Joel Swenson, Barr Engineering
Tom Richards, Nicholson Construction
In-Place Inclinometers for Lateral Load Testing

• Discussion Outline
  • Project Background
  • Predicting Pile Performance
  • Verifying Pile Performance
  • Test Setup
  • Test Procedure
  • Results
  • Project Conclusions
Project Background

- Micropiles Installed to Support Sensitive Structure at Reclaimed Mine Site
- Design Loadings Cyclic
- Unique Ground Conditions
- Thorough Testing Program Specified
Project Background

• Meeting Design Demands

  • Lateral Load Test Information Valuable

  • Pile Deflected Shape Required to Verify Design

  • In-Place Inclinometers (IPI’s) Decided Upon to Record Lateral Movements Along Length of Pile
• **In Place Inclinometers:**
  - Geokon Model 6150 MEMS (Micro-Electrical Mechanical Sensors)
    - Use Standard Inclinometer Casing
    - Uniaxial
    - Individually wired
    - Installed in a single ‘string’ connected by universal joints

• **But why not just a simple load test?**
Predicting Pile Performance

- **Why are Lateral Loads Different from Axial Loads?**
  - Soils provide non-linear resistance
  - Lateral Load performance is very sensitive to the soil type
Predicting Pile Performance

- Navfac Methods:

\[ P = \frac{\delta_p}{F_\delta} \times \frac{EI}{(EI/f)^{1/5}} \]

- Mathematical Models:

\[ EI \frac{d^4 y}{dx^4} + P_x \frac{d^2 y}{dx^2} - p - w = 0 \]
Predicting Pile Performance

- Software Analysis: LPILE, GROUP
- Soil Properties; Friction Angle, Unit Weight, Water Table
- Pile Properties
Verifying Pile Performance: Test Set up
Verifying Pile Performance

• Lateral Load Test: Two Test Piles

• Pile 1: Two Inclinometer Casings
  • One IPI string, One Standard Inclinometer

• Pile 2: One Inclinometer Casing
  • Standard Inclinometer
In-Place Inclinometers: Quantity & Location

- 9 IPI’s spaced at 2.5’ were chosen
- Based on:
  - Depth of Lateral Displacement
  - Relative Change in Displacement Along the Pile
- Depth of lowest IPI at 20 ft from load application
IPI Installation
IPI Installation (2)
IPI Installation: Wiring
Inclinometer Installation: Pile 1
IPI Wiring
Verifying Pile Performance

• Standard ASTM D3966 Lateral Test Set Up
Verifying Pile Performance

- Standard Dial Gage Arrangements
Dial Gage Placement
In-Place Inclinometer System
Test Procedure: Components

- 6 Dial Gages
- 9 In-place Inclinometers
- Standard Inclinometer
- Wires, Mirrors & Scales
- Load Cell
- Hand Pumped 20T Jack
Test Procedure (2)

- Synchronize Readings of IPI’s with Dial Gage Readings
- Included Auto Recording of Load Cell
- Instant view of Pile Deflections
Test Results Load vs. Deflection

- Comparing Dial Gage at Loading Point to IPI #1

![Graph showing load vs. deflection comparison]
Test Results: Deflection vs. Depth

In-Place Inclinometer Displacement vs. Depth

(Sticky notes)

- 25% test load
- 50% test load
- 75% test load
- 100% test load
- unloaded
- Std Inclinometer @100%

(inches)

(depth (ft))
Test Results

- Compare to Initial Design Model Assumptions
- Adjust and Iterate Soil Parameters to Refine Model
- Input Site Specific P-Y curve into LPILE
Test Results: Predicted vs. Measured

Displacement (inches)

Depth (feet)

IPI - 14.9k
Ground
Trav. Incl. - 14.9k
LPILE - 14.9k
Project Conclusions

• In-Place Inclinometers Provide Accurate Measurement of Lateral Displacement
• Coordination of Measuring Devices is Key
• End Results can Allow for Refined Designs and Cost Savings
Questions?

John Rowley
Design Engineer
jrowley@nicholsonconstruction.com