Kentucky Lake Bridge Pile Load Testing Overview
3rd Annual Bridge Seminar Day
Lexington, KY – 2/4/14

Presented by:
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Kentucky Official Highway Map
Proposed Bridge Rendering

www.lakebridges.com
Presentation Scope

1. Subsurface Conditions
2. Pier Foundation Design Considerations
3. Load Test Program Considerations
4. Load Test Program Results
1. Subsurface Conditions

Qal – Alluvium and Bedded Chert (≈ 150 to 250 ft. thick)

Mfp - Fort Payne Formation

Geotechnical Overview Report by Florence & Hutcheson, 1994
Comprehensive Field Sampling / Testing Program

- Conventional Soil Borings
  - Extensive Laboratory Testing
- Piezo-Cone Penetration Tests
- Specialized In-Situ Tests
  - Downhole & Crosshole
  - P-S Suspension Logging
  - Pressuremeter
  - Shear Wave Seismic Reflection
Typical Soil Profile

Alluvial Deposits

Bedded Chert

In-Situ Outcrop of Similar Material
2. Pier Foundation Design Considerations

- Open-ended driven pipe piles selected as appropriate foundation
  - Considered 48”, 60”, 72” & 96” Diameter for Piers - Final Design 72”
  - Prior to this Project 48” Believed to be Largest Diameter Driven Piles by KYTC

- API RP 2A method for axial resistance analyses considers “plugged” and “unplugged” conditions

- Constrictor plates (i.e. “artificial” plugs) to allow required penetration but force the piles to plug to achieve end bearing

- Drivability/Constructability also a key factor in these analyses
  - Many combinations of hammers, target depths considered
Constrictor Plate (i.e. Artificial Plug)

Placed ≈70 to 100 ft. above Pile Tips
Based on Depth to Bedded Chert

Artificial Plug Design Calculations by Genesis Structures, 2013
Uncertainties Could Lead to Potential for:

- Construction Delays
- Construction-Phase Foundation Redesign
- $$$ Overruns on $100M+ Contract
3. Load Test Program Considerations

- Unusual soil conditions – chert gravel presence in clays & sands & “bedded chert”
- Uncertainties over drivability / achievable depths / axial & lateral resistance
  - Maximum required nominal axial resistance $\approx 9000 - 10,000$ kips
- Decision to perform significant design-phase Pile Load Test Program with “Advance Contract”
  - Contract also included Lagoon Bridge & Expanded Causeways
  - February 2013 Letting
Load Test Program Scope

- Three 48” & Three 72” diameter pipe piles
- One Axial Static Load Test (48”)
  \( \approx 6000 \text{ kips} \)
- Two Axial Pseudo-Static (i.e. Statnamic) Load Tests (48” & 72”)
  \( \approx 6950 & >8500 \text{ kips} \)
- One Lateral Pseudo-Static (i.e. Statnamic) Load Test (72”)
- Dynamic Pile Testing During Installation
  Every Pile/Every Stroke
- Total Cost \( \approx \$7.9 \text{ Million} \)
Purpose

- Confirm Soil Parameters
- Evaluate Pile Drivability
- Evaluate Hammer
- Evaluate Pile Capacity
- Pile Handling (185’ and 210’ test lengths)
Video – Statnamic Axial Load Tests
Geotechnical Considerations - Load Test Program Results

Video – Statnamic Lateral Load Test
Geotechnical Considerations - Load Test Program Results

- Static Load Test – 48-inch-diameter pile
- Six 1200-kip jacks
- Test duration 24 hours
- Hold time at 5000 kips (8 hrs)
Test Program

- Dynamic Pile Testing (PDA)
- Statnamic Load Tests
  - Axial (6950 kips and 8500+ kips)
  - Lateral (4 loads up to 425 kips ESL)
- Static Axial Load Test (6000+ kips)
- Fully Instrumented Piles
  - Soil Resistance
  - Load Transfer (axial and lateral)
Test Piles

- 48” Piles
  - 1” & 1.5” Wall
- 72” Piles
  - 1.5” & 2” Wall
- Near Causeway
- Deep Water
- Open End-partial
- Constrictor Plate
Summary of Results

- Nominal Resistance (capacity) achieved near estimated tip elevations
- Menck MHU 800S Hammer used successfully
- Relatively easy to drive to target tip elevations with plate placed high
- Constrictor plate functional for plugging - extended drives
- Deeper penetrations achievable
Summary of Results

• Pile lengths and wall thicknesses can be handled with heavy marine equipment
• Soil resistance during pile driving is less than long-term static resistance (ranged from 40% to 80%, typically about 70%)
Summary of Results

• Thinner Pile Walls?

No Apparent Significant Damage but some uncertainty and site variability drives choice of 2-inch-thick wall (some harder driving observed but only on the 2-inch wall piles at deeper penetrations)
Summary of Results

- Recommendations developed for production pile verification test program
- Dynamic Pile Testing required
- Longer-term pile restrikes required
• Special Note For Steel Pipe Piles-Install
• Special Note for Dynamic Pile Testing
  Dynamic Pile Testing required (minimum of 2 per substructure per LRFD code)
  Pile restrikes required
• Special Note for Vibration Monitoring
  Pre-Construction Surveys
  Vibration Monitoring
  Post-Construction Surveys
Kentucky Lake Bridge
Pile Load Testing Overview

QUESTIONS????????

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