Experimental Testing and Modeling of Steel Pile Bridge Bents

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Presentation Outline

- Introduction
- Old Town Creek Bridge Test
- US 331 Bridge Test
- NCAT/AUNGES Bent Tests
- Conclusions
Problem Statement

• Pile bents without sway bracing
  • Large design forces from load combinations including lateral loads (battered piles)
  • Significant variability in pile forces due to assumptions made in structural models
  • What boundary conditions should be used?
  • Is the pile embedment sufficient?
Research Objectives

- Perform a series of lateral load tests on bridge bents to:
  - Identify the gravity and lateral load transfer mechanism for steel pile bridge bents
  - Develop calibrated analytical models to determine appropriate boundary conditions including soil-pile interaction and pile to cap fixity
  - Develop analysis and LRFD design procedures
Bridge Testing Overview

- Macon County Route 9 over Old Town Creek
  - New Construction
- US 331 Montgomery
  - Existing Construction
- NCAT/AUNGES Bridge Bents
  - Standalone Bents
Field Testing – New Construction

- Macon County Route 9 over Old Town Creek
  - Six 40ft spans
  - Two travel lanes, 30’-9” wide deck
  - Four HP14x89 Piles per Bent
  - Measured strain in steel piles and encasements; applied lateral force; and bent displacement
  - Tested with and without bridge deck
  - Tested with and without Load Truck
  - Load Truck was centered and offset
Test Results – No Bridge Deck

Results for Pile #2
Test Results – with Bridge Deck

Results for Pile #2
Field Testing – Existing Construction

- **US 331 Bridge, South Montgomery**
  - Adjacent bridges pulled together
  - Six HP10x42 piles per bent with 16 in square encasements
  - Pile clear height $\approx 10$ ft
  - Outer piles battered
  - Measured strain in concrete encasements, applied lateral force and bent displacements
  - Tested with and without load truck
Northbound - Reaction Bent

Southbound - Test Bent
Test Results – Pile 1

Load Truck + Lateral

Lateral Only
Test Results
Field Test – NCAT/AUNGES Bents

- Two four pile test bents
  - Specimen 1 - Vertical piles with 18” pile embedment
  - Specimen 2 - Battered end piles with 12” embedment
- All piles HP12x53 x 35 ft
- Matches standard details provided by ALDOT
- Measured strain in piles, bent displacement, and applied lateral force
- Used inclinometer to determine pile deformed shape
Vertical Pile Bent
Battered Pile Bent
Reaction Pile Group
NCAT/AUNGES Test Bents
Vertical Bent Results

![Graph showing the relationship between Lateral Load (kips) and Deflection (in).]
Pile Flange Buckling (Vertical Bent)

Pile 5 (End Pile)  Pile 7 (Interior Pile)
Pile Deformation (Vertical Bent)
Battered Bent Results
Pile Flange Buckling (Batter Bent)
Interior Pile (Batter Bent)
Comparison of Analysis and Test (Vertical Bent)
Conclusions

- **Concrete encasements provide significant lateral stiffness**
- **Largest bending moments occur at top of piles**
- **Gravity load had minimal impact on the lateral behavior**
- **Battered piles created a pullout failure of the adjacent pile**
- **Current standard for 12 in embedment allowed development of yielding in pile flanges**
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