Proposed Seismic Detailing Criteria for Piers and Wharves

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Overview

• Update on proposed seismic code

• Present goals of detailing provisions

• Review performance of several pile to deck connections

• Summarize spiral requirements
Update on Proposed Seismic Code

- New ASCE standard, “Seismic Design of Piers and Wharves” under development for 4 years

- Codifies current practice of performance-based seismic design

- Same format and legal standing as ASCE 7

- Pile supported structures only

- Volunteer effort
Proposed Table of Contents in Standard

Chapter 1 - General
Chapter 2 - Seismic Performance Requirements
Chapter 3 - Design Approach
Chapter 4 - Geotechnical Considerations
Chapter 5 - Force Based Analysis and Design
Chapter 6 - Displacement Based Analysis and Design
Chapter 7 - Design and Detailing Considerations
Chapter 8 – Ancillary Components
Chapter 7 Table of Contents

7.1 Introduction
7.2 Definitions
7.3 Symbols and Notation
7.4 Pile to Deck Connections
7.5 Confinement
7.6 Joint Region Dowel Anchorage
7.7 Joint Shear
7.8 Joint Detailing
7.9 Decks
7.10 Constructibility
Goals of Detailing Provisions

• Include all commonly used pile connections
  – Backed by testing
  – Ductile and suitable for seismic

• Include commonly used deck systems.

• Use existing codes
  – MOTEMS
  – POLA
  – POLB

• Address seismic detailing issues unique to piers and wharves
  – Pile driving tolerances
  – Pile cut-offs and build-ups
Pile to Deck Connection Testing

- Significant recent research and test data for prestressed concrete piles
- Limited research and test data for pipe piles
- Presentation focus is on prestressed concrete piles
Example Pipe Pile Connections

- Embedded
- Welded to Embed
- Dowelled Partially Embedded Shell
- Dowelled Isolated Shell
- Welded Dowels
Example Prestressed Concrete Pile Connections

- Embedded Pile
- Pile Build-Up
- Extended Strand
- Concrete Plug
- Dowelled Strand
- Dowels
- Deck
- Hollow Dowelled
- External Confinement
Prestressed Concrete Dowelled Connection Test Overview

• Define terms

• Review typical behavior
  – Strong pile
  – Weak interface

• POLA pile tests

• UW pile tests

• Summary
Pile to Deck Connection Terms

- Deck
- Pile
- Dowel
- Interface
- Strand
- Spiral
Typical Behavior of a Prestressed Concrete Pile Dowelled Connection

1. Hairline cracking
2. Dowels yield
3. Prying spall
4. Local deck and pile crushing
5. Pile spalling
6. Bar fracture

- Dowels in shear
- Strain penetration
- Large crack at interface
POLA Seismic Pile Tests (Ref. 2, 3)

- 36” deck
- 24” Octagonal Pile
- 16 - 0.6” dia. Strand
- 8 - #10 dowels
- W20 @ 2.5 Spiral

Embed 1 ½ spiral turns in deck
POLA Seismic Pile Behavior (Ref. 2, 3)

Slab Prying $\mu_\Delta = 1.5$ (1.2% drift)

Deck Crushing $\mu_\Delta = 2$ (1.6% drift)

Pile Crushing $\mu_\Delta = 3$ (2.4% drift)

Test Ended $\mu_\Delta = 16$ (12.9% drift)
POLA Full Scale Connection Tests (Ref. 4)

About 15% Drift

Test Frame (UCSD 2007)

Deck Prying Spall & Interface Gap

Deck

In-Ground Hinge
POLA Secondary Seismic Pile Tests (Ref. 2,3)

- 24” deck (600mm)
- 4-# 9 headed dowels
- 16 - 0.6 in. strands
POLA Secondary Pile Behavior (Ref. 2,3)

Deck Spalling $\mu_\Delta = 3$ (1.5% drift)

Spall Removed $\mu_\Delta = 4$ (2.3% drift)

Pile Crushing $\mu_\Delta = 6$ (3.4% drift)

Test Ended $\mu_\Delta = 18$ (10% drift)
2008 UW / NEES Test on Isolated Interface (Ref. 5)

- **End View**
  - Cotton duck pad
  - Closed cell foam ring on side of pile
  - Sleeves to debond dowels
  - 8-#10 grouted dowels

- **Elevation**
  - Shear transfer?
UW / NEES Isolated Interface Behavior (Ref. 5)

2.5% Drift

5% Drift

8.4% Drift
Possible Improvement to Isolated Interface Connection (verify by testing)

- Closed cell foam ring on side and ends of pile
- Dowel or other shear transfer mechanism
- Sleeve

End View

Elevation

8-#10

PORTS 2010
Summary of Dowelled Connection Tests

- Connections performed as expected
- Pile rocking dominated performance
- Interface gap complicates shear transfer
- Deck spalling may be preventable
- Interface isolation appears promising if positive shear transfer is provided
Possible Methods to Minimize Deck Spalling

- Chamfer Pile Top
- Side Wrap

- Closed cell foam ring
- Center dowel or other positive shear transfer
Pile Spiral Confinement Requirements

- Proposed minimum spiral requirements less than ACI 318
  - $\rho_s = 0.007$ in the ductile region
  - $\rho_s = 0.005$ outside the ductile region

- Spiral amount based on capacity versus demand analyses
  - Pile shear
  - Rotation in plastic hinge zones
  - Joint shear

- Spiral development requirements same as ACI 318.
Presentation Summary

- Connections considered
  - Pipe piles
  - Prestressed concrete piles

- Focused on prestressed concrete piles

- Presented damage reduction strategies

- Spiral requirements summarized
Acknowledgments

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2. Tim Mays
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References