Importance of Substructure Evaluation

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Wiss, Janney, Elstner Associates, Inc.

Inspection Case Studies and Techniques

Introduction

Elise M. Love, P.E.

- Michigan Technological University
  - B.S. Civil Engineering (Structural) 2007
  - M.S. Civil Engineering (Structural) 2009
- Joined WJE in 2009
- Professional Engineer in MI and OH
- NHI Course 130055 – Safety Inspection of In-Service Bridges (NBIS-qualified team leader)

Introduction

Wiss, Janney, Elstner Associates, Inc. (WJE)

- Founded in 1956
- Architects, Engineers, and Material Sceintists
- Troublehsoot Problems with Buildings and Other Structures
- 27 Offices Nationwide (Headquarters in Northbrook, Illinois)
- Janney Technical Center

Learning Objectives

- Recognize the importance of substructure evaluation
- Identify techniques for improving routine substructure inspection
- Understand the effect of substructure deterioration on structural capacity

Routine Techniques - Concrete

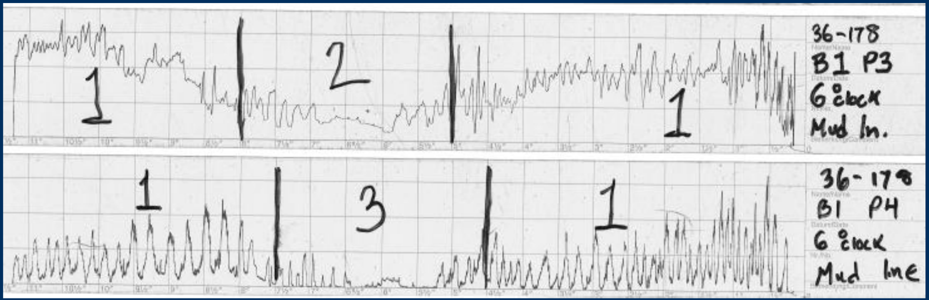
- Visual
- Sounding
- Measurement of deficiencies (L x W x D)
- Deficiencies: Cracking, spalling, scaling, delaminations, honeycombs, internal steel corrosion, overloading, wear, collision damage, and abrasion

Routine Techniques - Steel

- Visual
- Corrosion product removal (hammer, wire brush, and/or grinding)
- Section loss measurement (calipers and/or UT gauge)
- Deficiencies: Corrosion, fatigue cracking, overloading, collision damage, and coating failures

Routine Techniques - Timber

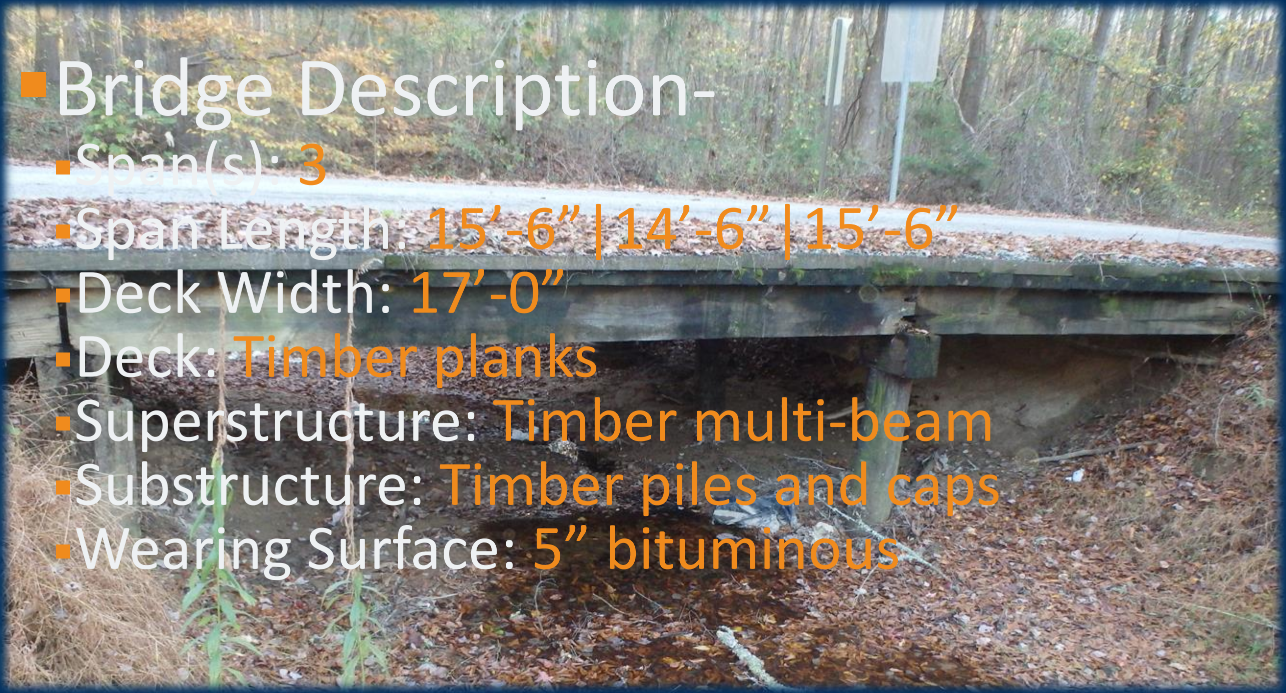
- Visual
- Sounding
- Probing
- Drilling



- Deficiencies: Inherent (checks, splits, shakes, knots), fungi, decay, crushing, insects, marine borers, loose connections, collision damage, wear, abrasion, overstress, and fire damage

Routine Techniques - Timber

Case Study #1

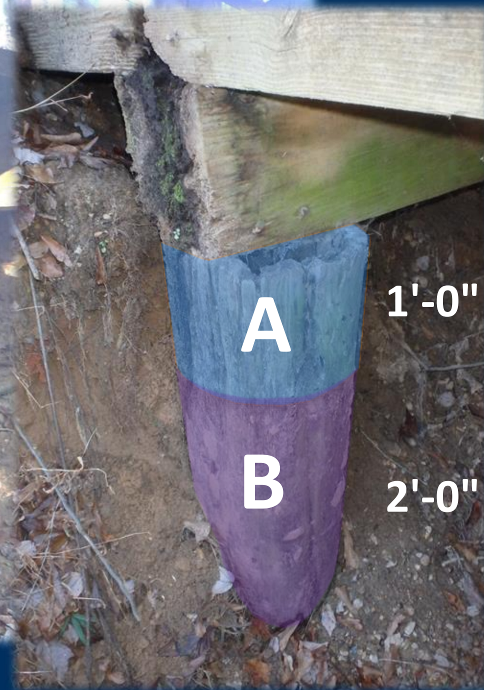


- Bridge Description-
  - Span(s): 3
  - Span Length: 15'-6"|14'-6"|15'-6"
  - Deck Width: 17'-0"
  - Deck: Timber planks
  - Superstructure: Timber multi-beam
  - Substructure: Timber piles and caps
  - Wearing Surface: 5" bituminous

Case Study #1 - Substructure

- Bent 3-Pile 1 (12"ϕ x 3' Long)

Inspection Techniques	
Visual	✗
Sounding	✗
Probing	N/A
Drilling	✗



Case Study #1 - Substructure

- Bent 3-Pile 1 (12”ϕ x 3’ Long)

Timber Pile Capacity Calculations

Per NDS 2015

$F_{c'} := F_c \cdot C_D \cdot C_t \cdot C_{ct} \cdot C_P \cdot C_{cs} \cdot C_{ls}$ Round timber poles and piles (Table 6.3.1)

$F_c := 1250 psi$ Treated round timber piles (Table 6A)

$C_D := 1.6$ Load duration factor (Table 2.3.2 - Wind/Earthquake Load)

$C_t := 1.0$ Temperature factor (Table 2.3.3 - Wet in-service, T</=100 deg. F)

$C_{ct} := 0.95$ Condition treatment factor (Table 6.3.5 - cresote treated)

$C_{cs} := 1.0$ Critical section factor (Eq. 6.3-1 - conservative to assume 1.0; based on strength at tip of pile rather than critical section)

$C_{ls} := 1.09$ Load sharing factor/pile group factor (Table 6.3.11 - 4 or more piles in group)

$F_{c\_star} := F_c \cdot C_D \cdot C_t \cdot C_{ct} \cdot C_{cs} \cdot C_{ls} = 2071 psi$ (Section 3.7.1.5)

$$F_{cE} := \frac{0.822 \cdot E_{min'}}{\left(\frac{l_e}{d}\right)^2} = 67250 psi$$

$c := 0.85$ (Section 3.7.1.5 - round timber poles and piles)

$$C_P := \frac{1 + \left(\frac{F_{cE}}{F_{c\_star}}\right)}{2 \cdot c} - \sqrt{\left[\frac{1 + \left(\frac{F_{cE}}{F_{c\_star}}\right)}{2 \cdot c}\right]^2 - \frac{\left(\frac{F_{cE}}{F_{c\_star}}\right)}{c}} = 0.995$$

$F_{c'} := F_c \cdot C_D \cdot C_t \cdot C_{ct} \cdot C_P \cdot C_{cs} \cdot C_{ls} = 2.06 ksi$

F_c’=2.06 ksi → $A = \pi r^2$=113 in^2

(2.06ksi)(113 in^2)=<u>233 k</u>

Section A:

$A = \pi(r_1{}^2 - r_2{}^2)$=62.8 in^2

(2.06ksi)(62.8 in^2)=<u>129 k</u>

→ <u>45%</u> loss in capacity

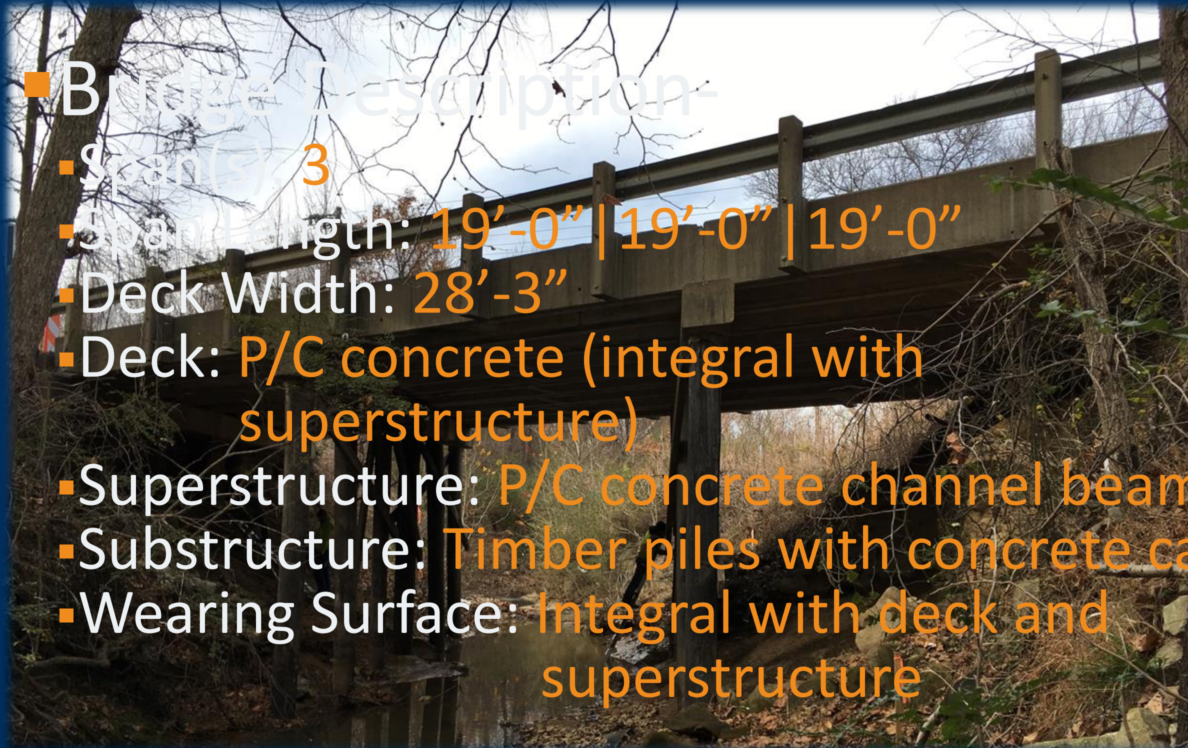
- No decay
- Moderate
- Advanced
- Severe

Case Study #1 - Substructure

- Bent 2-Pile 1 (10”ϕ x 3’ Long)

Inspection Techniques	
Visual	✓
Sounding	✗
Probing	N/A
Drilling	✗

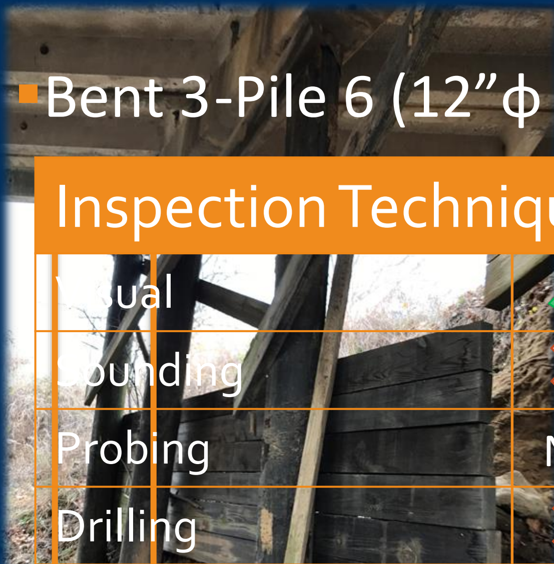
Case Study #2



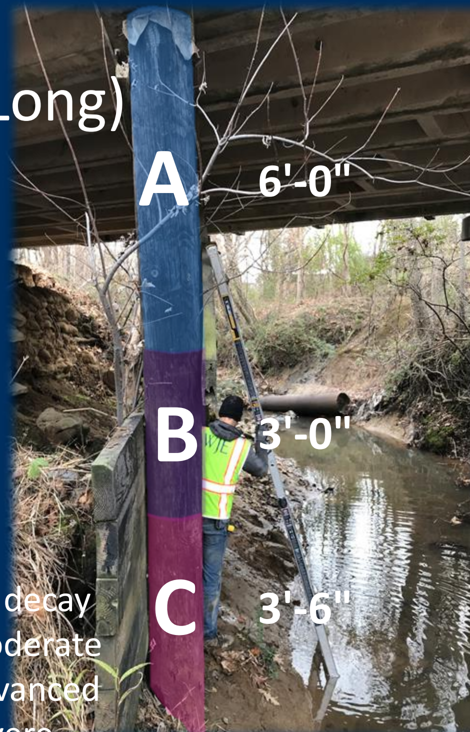
- Bridge Description-
  - Span(s): 3
  - Span Length: 19’-0” | 19’-0” | 19’-0”
  - Deck Width: 28’-3”
  - Deck: P/C concrete (integral with superstructure)
  - Superstructure: P/C concrete channel beams
  - Substructure: Timber piles with concrete caps
  - Wearing Surface: Integral with deck and superstructure

Case Study #2 - Substructure

- Bent 3-Pile 6 (12”ϕ x 12’-6” Long)



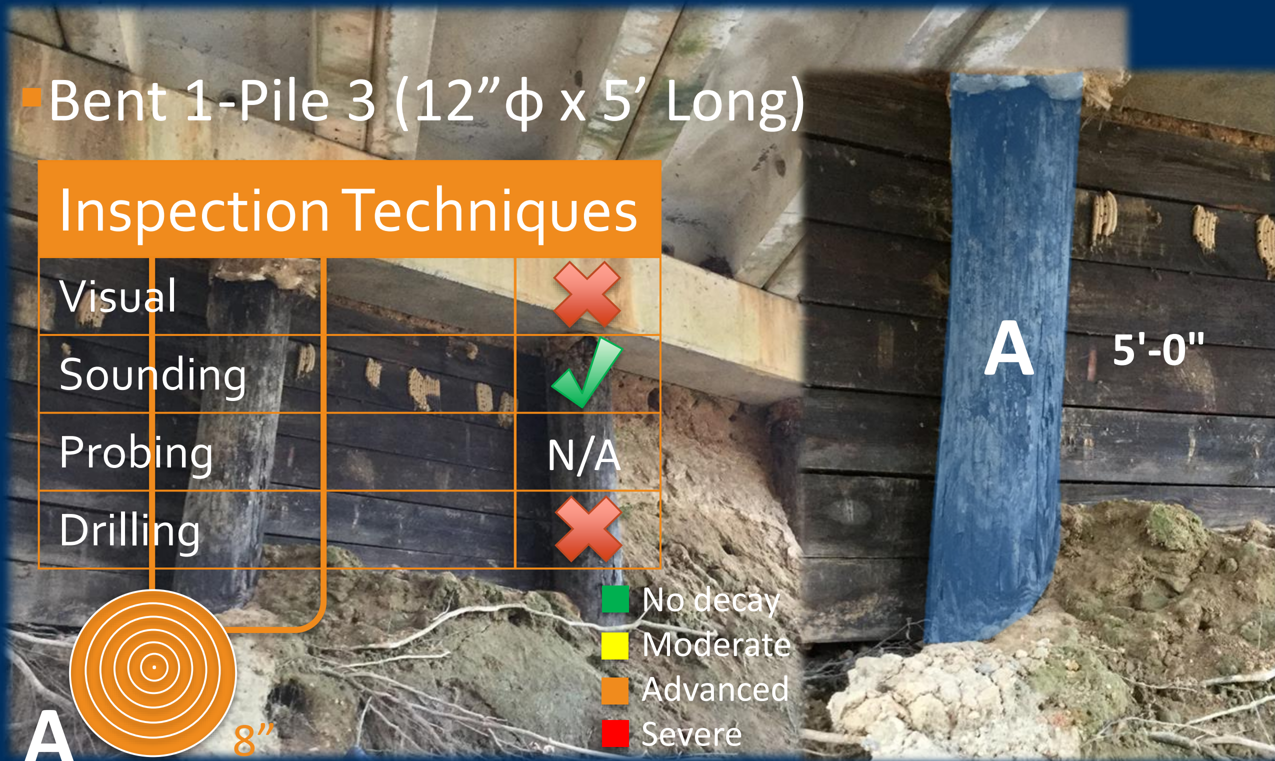
Inspection Techniques	
Visual	✓
Sounding	✗
Probing	N/A
Drilling	✗



Case Study #2 - Substructure

- Bent 1-Pile 3 (12”ϕ x 5’ Long)

Inspection Techniques		
Visual		✗
Sounding		✓
Probing		N/A
Drilling		✗



Case Study #3

- Bridge Description-
  - Span(s): 1
  - Span Length: 30'-0"
  - Deck Width: 19'-0"
  - Deck: Timber planks
  - Superstructure: Steel multi-beam
  - Substructure: Timber piles and caps
  - Wearing Surface: 6" gravel

Case Study #3 - Substructure

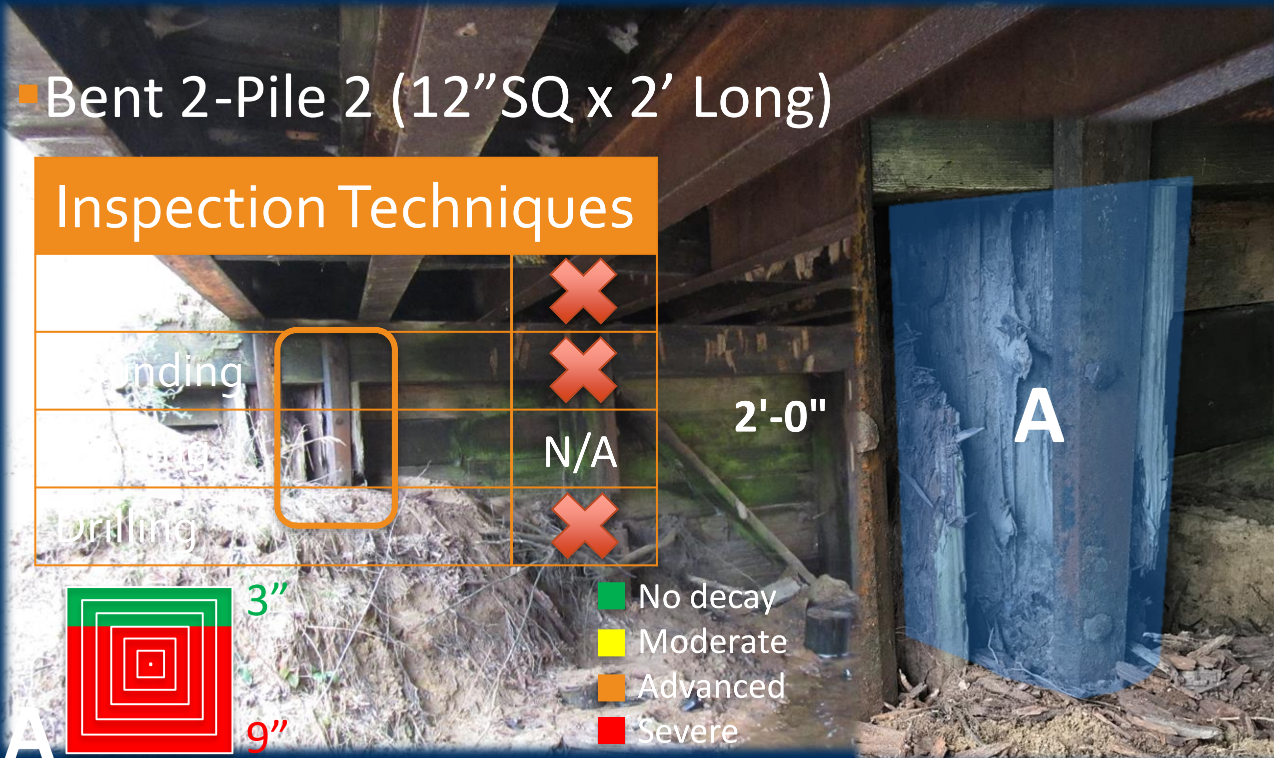
- Bent 2-Pile 1 (12”SQ x 1’-6” Long)

Inspection Techniques	
	✗
nding	✗
ng	N/A
Drilling	✗

Case Study #3 - Substructure

- Bent 2-Pile 2 (12"SQ x 2' Long)

Inspection Techniques	
[illegible]	✖
unding	✖
ing	N/A
Drilling	✖

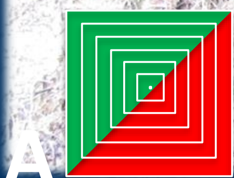


- No decay
- Moderate
- Advanced
- Severe

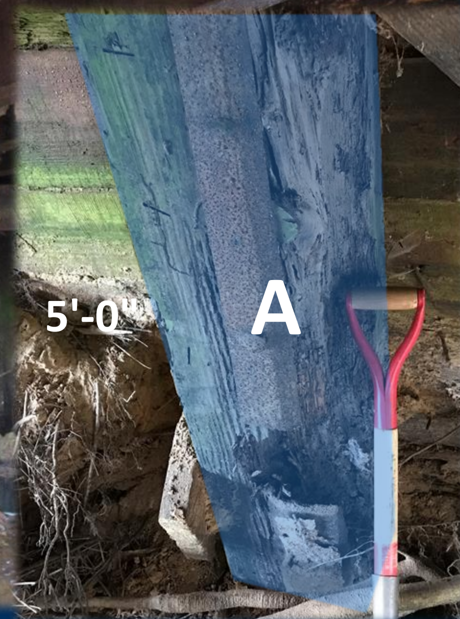
Case Study #3 - Substructure

- Bent 2-Pile 3 (12"SQ x 5' Long)

Inspection Techniques	
[illegible]	✖
Sounding	✖
[illegible]	N/A
Drilling	✖



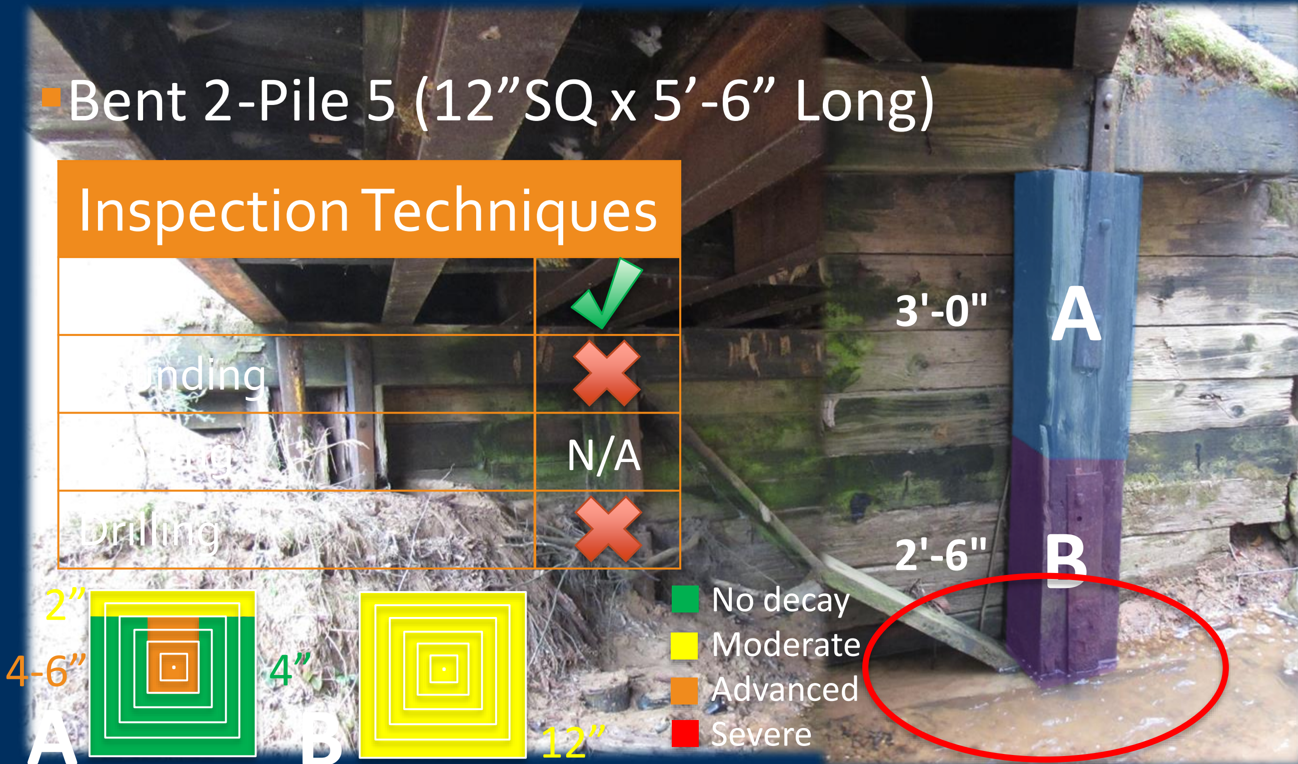
No decay
Moderate
Advanced
Severe



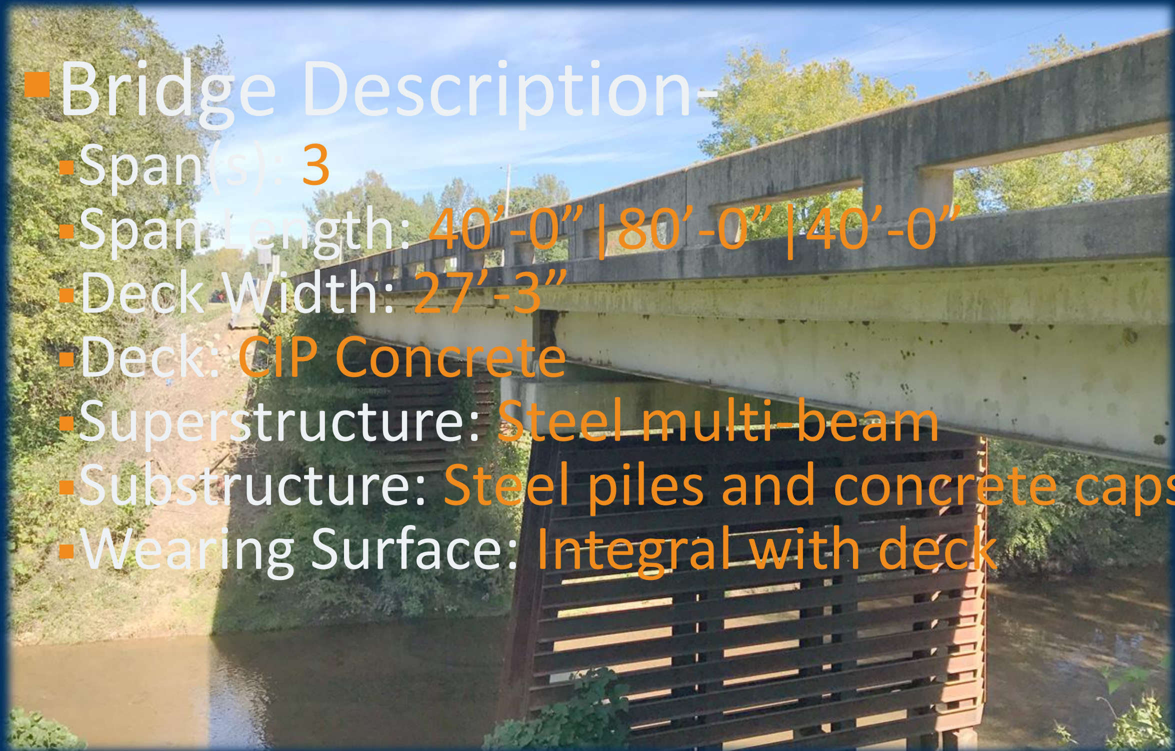
Case Study #3 - Substructure

- Bent 2-Pile 5 (12”SQ x 5’-6” Long)

Inspection Techniques	
	✓
Sounding	✗
[illegible]	N/A
Drilling	✗

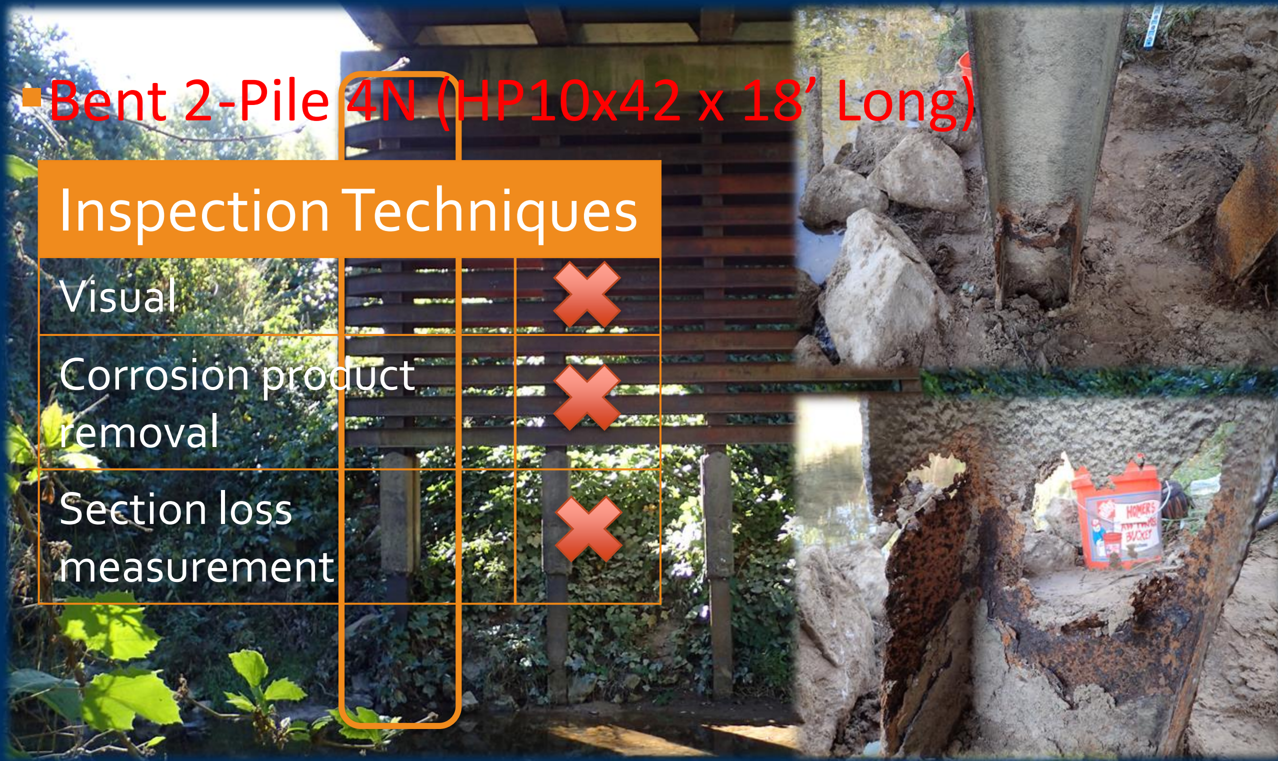


Case Study #4



- Bridge Description-
  - Span(s): 3
  - Span Length: 40'-0"|80'-0"|40'-0"
  - Deck Width: 27'-3"
  - Deck: CIP Concrete
  - Superstructure: Steel multi-beam
  - Substructure: Steel piles and concrete caps
  - Wearing Surface: Integral with deck

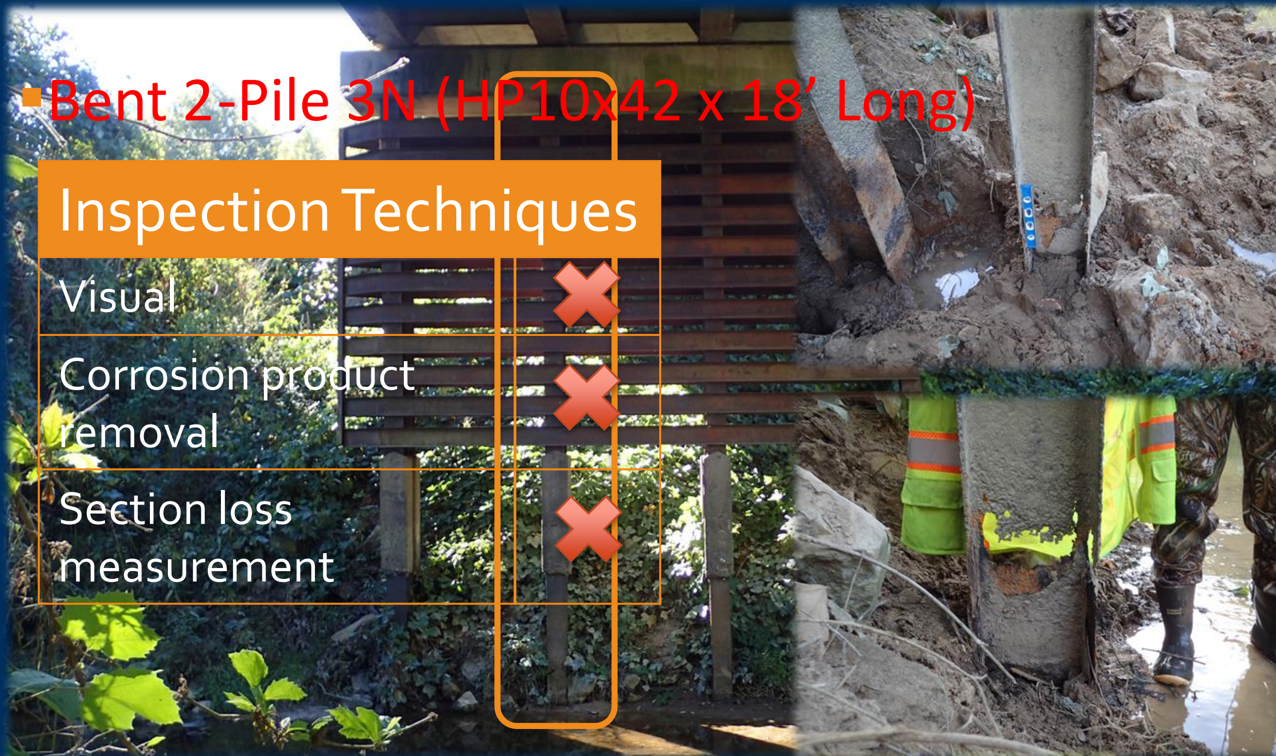
Case Study #4 - Substructure



- Bent 2-Pile 4N (HP10x42 x 18’ Long)

Inspection Techniques		
Visual		✗
Corrosion product removal		✗
Section loss measurement		✗

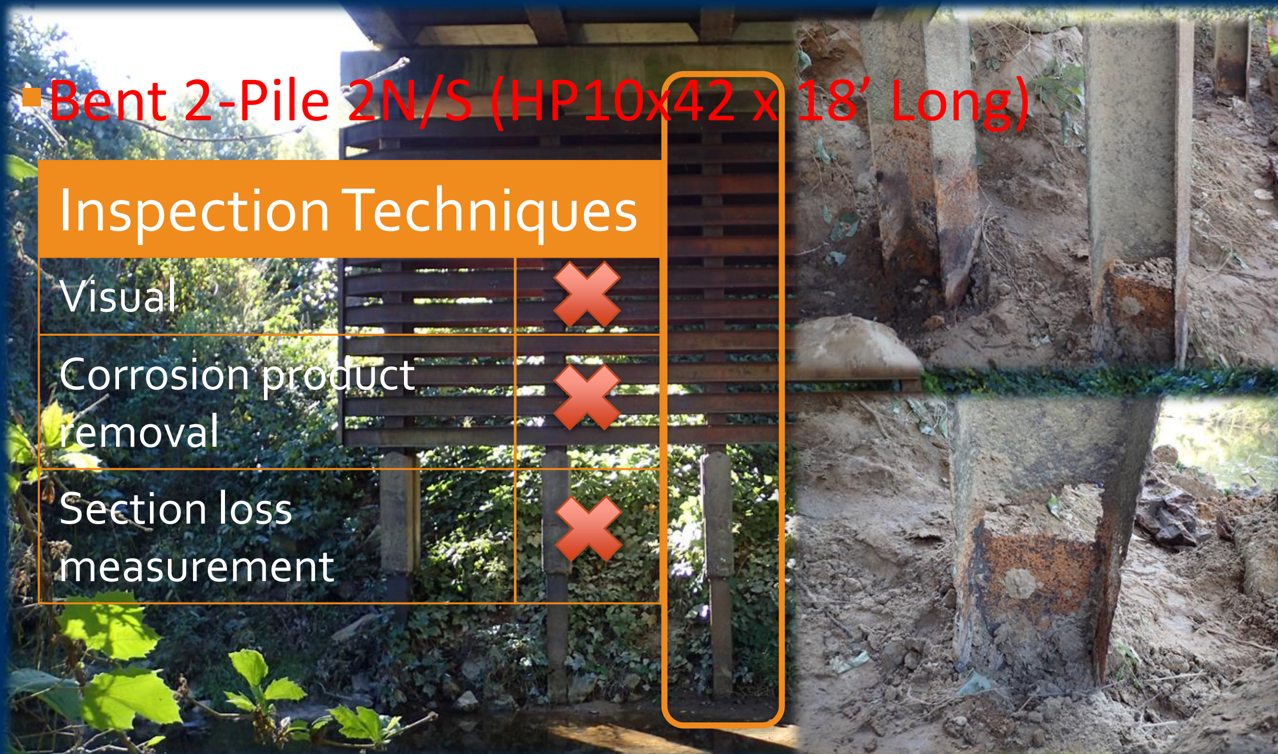
Case Study #4 - Substructure



- Bent 2-Pile 3N (HP10x42 x 18' Long)

Inspection Techniques	
Visual	✖
Corrosion product removal	✖
Section loss measurement	✖

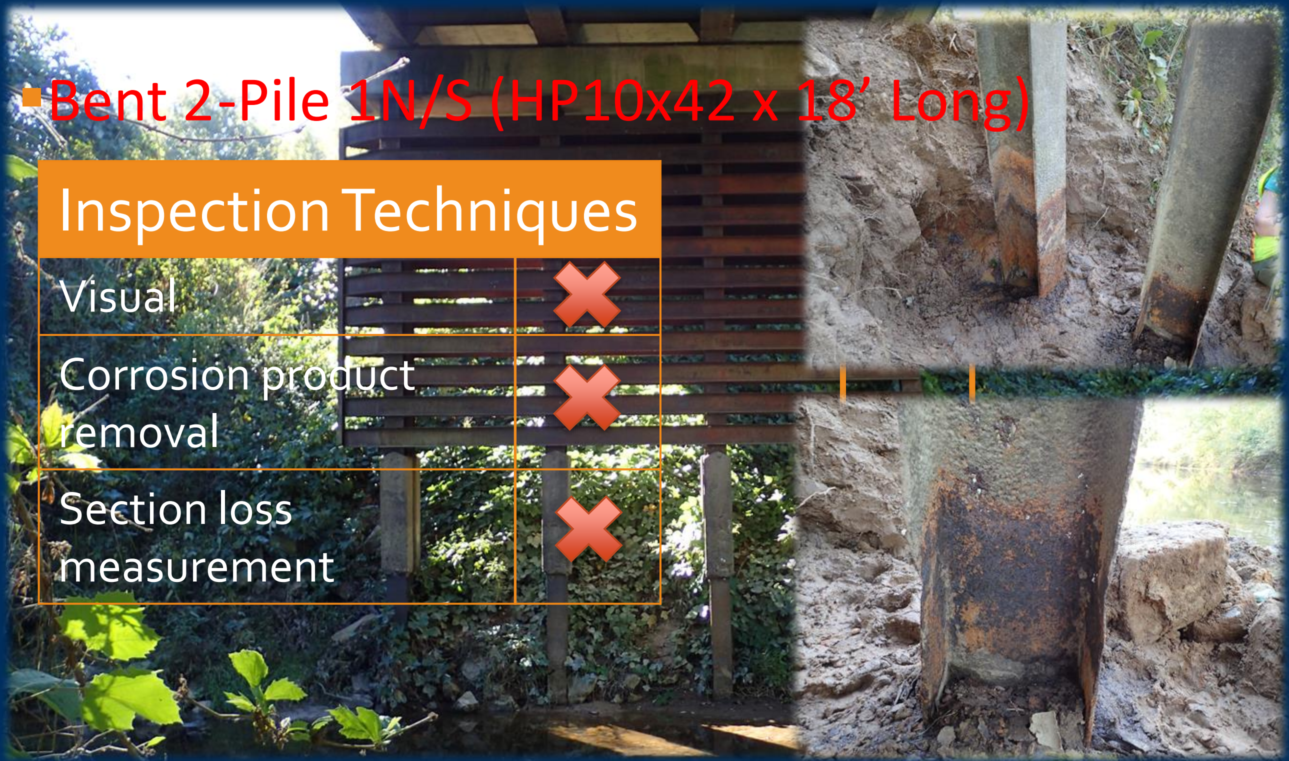
Case Study #4 - Substructure



- Bent 2-Pile 2N/S (HP10x42 x 18' Long)

Inspection Techniques	
Visual	✗
Corrosion product removal	✗
Section loss measurement	✗

Case Study #4 - Substructure



- Bent 2-Pile 1N/S (HP10x42 x 18’ Long)

Inspection Techniques	
Visual	✖
Corrosion product removal	✖
Section loss measurement	✖

Case Study #4 - Substructure

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Summary

- Sometimes, beauty is only skin deep…
- "It was the best of times, it was the worst of times…"
  – Charles Dickens
- "A very little key will open a very heavy door." –Charles Dickens

Questions?

Thank You!
For More Information Please Contact:

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