Investigation and Development of a Post Tensioned Pile Splice for Prestressed Piles

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Splice Requirements

- **Capacity** – Spliced section should match both the axial and flexural strength of an un-spliced pile (incl. driving stresses).

- **Ductility** – Failure should occur in a ductile manner, not brittle.

- **Durability** – Splice components should be corrosion resistant to a level that would not hinder performance throughout the life of the structure.

- **Installation** – Installation should not be overly labor intensive, time consuming, or costly.
Current Practices

**Epoxy Doweled Splice**

- Predominant method in FL.
- Low material cost.
- Long epoxy cure time.
- Limited flexural and tensile capacity.
Current Practices

Kie-Lock Splice (formerly Sure-Lock)

- Most common mechanical splice.
- Good capacity.
- Some cracking from stress concentrations.
- No prestress adjacent to splice / most common break region
- Does not conform to Buy America provisions.
Proposed Concepts

1. Intermediate anchorages (Concept 1)
2. Embedded anchorages w/ full length post tensioning (Concept 2)
3. Combination of Intermediate/Embedded (Concept 3)
4. Embedded Strands w/ Intermediate Anchorages (Concept 4)
Durability / Corrosion

- Intermediate anchorages (Concept 1)
- Embedded anchorages w/ full length post tensioning (Concept 2)
- Combination of Intermediate/Embedded (Concept 3)
- Embedded Strands w/ Intermediate Anchorages (Concept 4)
Before Stressing

- Intermediate anchorages
  *(Concept 1)*

- Embedded anchorages w/ full length post tensioning
  *(Concept 2)*

- Combination of Intermediate/Embedded
  *(Concept 3)*

- Embedded Strands w/ Intermediate Anchorages
  *(Concept 4)*
Over-Stress Upper Segment

- Intermediate anchorages (Concept 1)
- Embedded anchorages w/ full length post tensioning (Concept 2)
- Combination of Intermediate/Embedded (Concept 3)
- Embedded Strands w/ Intermediate Anchorages (Concept 4)
Modified Concept
Move anchors from top to splice zone

Initial Jacking Forces

Final Splicing Strand Forces
Splice Header Plate

Precision drilled and faced for perfectly mated pile ends
Embedded Anchorages

- OTS prestressing chucks
- 2.5”x3”x½” plate, full weld
- Washer inserts to reduce seating losses
Splicing

Thread strands in upper pile
Each strand staggered to ease alignment
Strands locked in upper pile (right) while strands slide into and through lower pile anchorages (left).
Grout pumped through lower ducts and out all other ducts
4-Point Bending
Effective prestress same; Cracking load same; Ultimate moment 16.3% less

<table>
<thead>
<tr>
<th>Pile Size (in)</th>
<th>No Strands</th>
<th>Strand Size (in)</th>
<th>Strand Group Moment of Inertia (in^4)</th>
<th>Loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Prestressing</td>
<td>Splicing</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>8</td>
<td>0.5 standard</td>
<td>11.26</td>
<td>16.8</td>
</tr>
<tr>
<td>24</td>
<td>20</td>
<td>0.5 special</td>
<td>173.9</td>
<td>2.9</td>
</tr>
</tbody>
</table>
FULL SCALE 24in BENDING TESTS
Pile Driving Demonstration

- 24in, 100ft pile
- Spliced with 30ft upper segment (70ft lower)
- Driven along I-4 in Deland area
- Test pile from project used as control comparison
20 Splice Strands (bending tests)

16 Splice Strands (driving demo)
SCC Pile Mix
Lower Pile Honeycombing
Upper Pile Damaged
Initial State Prior to Driving
No change after 1200 blows (70ft embedment)
Test Pile 1 (control)

$s_{opt} = 1251\text{psi} \ (\text{maximum allowable tensile stress})$

$s_{pc} = 3486\text{psi} \ (\text{maximum allowable compressive stress})$

Used 13.75in plywood pile cushion
Test Pile 1-1 (spliced)

- Started with 11.75in cushion
- Add 7.5in
- 9in
- $s_{apt} = 1251\text{psi}$ (maximum allowable tensile stress)
- $s_{apc} = 3486\text{psi}$ (maximum allowable compressive stress)
- 500psi splice limit
At End of Drive

**Test Pile**
- 115ft long; 99.8ft driven
- 13.75in cushion; 1 change
- 4035 blows
- 150 blows/ft
- 9.9ft stroke
- 1400kip capacity

**Splice Pile**
- 100ft; 99.4ft driven
- 11.75in cushion; 2 changes
- 3231 blows
- 314 blows/ft
- 9.8ft stroke
- 1660kip capacity
Conclusions

- Post tensioned pile splice was successfully designed that satisfied both bending and driving requirements of an unspliced, one-piece pile
- No splice related stress limits needed
- Original splice concept was adapted to eliminate corrosion susceptibility
- Design is applicable to all FDOT pile sizes