#### **Relaxation of Driven Piles in Florida Soils** BED25-977-05



#### **GRIP 2023**

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### Background/Introduction

- Driven piles can exhibit an increase or decrease in capacity relative to end of drive conditions defined as *set-up* or *relaxation*, respectively.
- Set-up is beneficial to pile performance; relaxation is not.
- The mechanism of pile relaxation has been attributed to dilative soil conditions that cause negative pore pressure making the soils respond stronger during driving (until the pore pressure dissipates).

### Pile Relaxation

- Case studies have shown restrikes have regained capacity in as little as 0.5in or as much as 7 ft.
- Large displacement required to regain capacity is likely to be caused by negative pore pressure
- Small displacements required to regain capacity could be due to concrete creep/shortening
- Creation of a database to include all information from PDA EOID and Restrikes is the primary effort (Task 2)

### Problem Statement

*Relaxation is the reduction in pile capacity with time. It is a phenomenon that* has been observed in several projects, especially Design Build projects as a result of verification testing. There have been reported cases in which over 25% of the original measured capacity has been lost after initial pile driving. Currently the Department does not have a methodology to assist designers estimate relaxation (protocols for In-Situ testing or laboratory testing), nor a process to establish a pile driving criteria to accept piles during construction when relaxation occurs. This creates delays, extra testing and extra costs during construction, especially because the problem is typically found after pile driving begins. In most cases the issue has been resolved by additional driving *until the piles reach a stable bearing layer.* 

# Objectives

- The primary focus of this study is to document as many cases as possible from within the state of Florida where pile relaxation has been experienced.
- Determine what soil types and conditions are likely to create relaxation conditions
- Part 2?: to determining appropriate field and lab testing and/or protocols suitable for construction and design.

### Revised Approach

 Collect any restrike data sets to show where both set-up and relaxation might occur

### Work Tasks

- Task 1: Literature Search
- Task 2: Data Collection (data mining of the FDOT EDMS)
- Task 3: Data Analysis
- Task 4a: Draft Final Report
- Task 4b: Closeout Meeting / Presentation
- Task 5: Final Report

## Work Tasks

### • Task 1: Literature Search (Completed)

- Task 2: Data Collection (data mining of the FDOT EDMS)
- Task 3: Data Analysis
- Task 4a: Draft Final Report
- Task 4b: Closeout Meeting / Presentation
- Task 5: Final Report

# Work Tasks

- Task 1: Literature Search
- Task 2: Data Collection (in progress)
- Task 3: Data Analysis
- Task 4a: Draft Final Report
- Task 4b: Closeout Meeting / Presentation
- Task 5: Final Report

### Task 2 Data Collection

- 948 piles evaluated (EOID and Restrikes)
- 185 boring logs (some piles have same boring)
- 21 bridge sites throughout the state; 6 districts



# Collected Data Types

- Pile
  - o Manufacturer
  - $\circ$  Number
  - o Length
  - o Size
  - o Type
  - $\circ$  Acceptance
  - Date Cast
  - Plumbness

- Hammer
  - o Type
  - $\circ$  Rated E (k-ft)
- Boring Logs

   SPT Counts
   Soil Type
  - Soil Depth

- Ground Elevation
- Tip Elevation
- Time Driven
- Time Checked
- Total Drive Time
- Total Stopped Time
- Wave Speed

# Collected Data Types

- Driving Records EOD
  - Blow Count
  - BLC (bl/ft)
  - RMX Values (RX4-RX8 depending on what is available) (kips)
  - CSX (ksi)
  - CSB (ksi)
  - STK (ft)
  - EMX (k-ft)

- Driving Records Restrike
  - Final and Max EMX of RS
  - Blow Count
  - BLC (bl/ft)
  - RMX Values (RX4-RX8 depending on what is available) (kips)
  - CSX (ksi)
  - CSB (ksi)
  - STK (ft)
  - EMX (k-ft)

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27 34 34 34 34 34 34 34 34 34 34 34 34 34		11         1         1         1         1           11         1         1         1         1         1           11         1         1         1         1         1         1           11         1         1         1         1         1         1         1         1           11         1 <td></td> <td>31         81         FER         FILMU         -34           31         81         FER         FILMU         -31.1           31         81         FER         FILMU         -31.1           31         81         FER         FILMU         -31.1           31         81         FER         FILMU         -31.3           31         81         FER         FILMU         -31.3           31         81         FER         FILMU         -31.4           31         81         FER         FILMU         -31.4           31         81         FER         FILMU         -31.4</td> <td></td> <td>1423.43 1213.47 01 140 232.53 · · · · · · · · · · · · · · · · · · ·</td> <td></td> <td>1012 246 1000 20 460 1007 1012 246 1000 20 204 1004 1013 246 1000 20 640 1407 1013 246 1000 20 640 1407 1013 246 1000 20 24 602 1013 246 1000 20 244 100 1013 246 1000 20 204 100</td> <td>1007 1034 1004 1030 1405 1434 1405 1434 105 100 1070 1040</td> <td>3.6 3.8 3.4 3.4 3.4 3.4 3.4 3.4 3.4 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8</td> <td></td> <td>6 3 6 4 7 543 7 743</td> <td>3150 1944 1850 3006</td> <td>3178         1734         3.4           1784         1838         3.4           1878         3.4         3.4           1878         3.4         3.4           1878         3.1         3.4           1878         3.4         3.4           1878         3.1         3.4</td> <td>3.5 11.85 3.3 18.88 3.3 8.13 3.6 4.41</td> <td>105.0 051 40.0 340 60.7 345 101.1 1333</td> <td>131 183 348 48 343 1333 686</td> <td>1.4         1.8         2.28         42.8           8.8         1.1         2.29         22.5           1         8.4         1.1         1.15           2.1         2.23         1.16         18.1</td> <td>1.333 1.333 1.184 1.184 1.854 1.854 3.437 3.437</td> <td>1.053 1.004 1.054 1.015 1.005 1.006 1.024 1.000 1.005 1.024 1.020 1.007 1.025 1.025 1.001 1.025 1.025 1.001 1.015</td> <td></td>		31         81         FER         FILMU         -34           31         81         FER         FILMU         -31.1           31         81         FER         FILMU         -31.1           31         81         FER         FILMU         -31.1           31         81         FER         FILMU         -31.3           31         81         FER         FILMU         -31.3           31         81         FER         FILMU         -31.4           31         81         FER         FILMU         -31.4           31         81         FER         FILMU         -31.4		1423.43 1213.47 01 140 232.53 · · · · · · · · · · · · · · · · · · ·		1012 246 1000 20 460 1007 1012 246 1000 20 204 1004 1013 246 1000 20 640 1407 1013 246 1000 20 640 1407 1013 246 1000 20 24 602 1013 246 1000 20 244 100 1013 246 1000 20 204 100	1007 1034 1004 1030 1405 1434 1405 1434 105 100 1070 1040	3.6 3.8 3.4 3.4 3.4 3.4 3.4 3.4 3.4 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8		6 3 6 4 7 543 7 743	3150 1944 1850 3006	3178         1734         3.4           1784         1838         3.4           1878         3.4         3.4           1878         3.4         3.4           1878         3.1         3.4           1878         3.4         3.4           1878         3.1         3.4	3.5 11.85 3.3 18.88 3.3 8.13 3.6 4.41	105.0 051 40.0 340 60.7 345 101.1 1333	131 183 348 48 343 1333 686	1.4         1.8         2.28         42.8           8.8         1.1         2.29         22.5           1         8.4         1.1         1.15           2.1         2.23         1.16         18.1	1.333 1.333 1.184 1.184 1.854 1.854 3.437 3.437	1.053 1.004 1.054 1.015 1.005 1.006 1.024 1.000 1.005 1.024 1.020 1.007 1.025 1.025 1.001 1.025 1.025 1.001 1.015	
				31         01         PER         PIULI         -31           31         10         PER         PIULI         -31         -           31         10         PER         PIULI         -         -           31         10         PER         PIULI         -         -		BILL         BILL <th< td=""><td></td><td>0-12 346 10000 431 44 030 1-12 346 10000 0 33 34 00 1-13 346 1000 0 33 35 1-13 346 1000 34 00 1-13 346 1000 3 39 53 1-13 346 10000 3 39 53 1-13 346 10000 0 4 46 1334</td><td>715 711 717 711 717 711 711 714 1314</td><td>3.3 1. 3.7 3 3 1. 3.3 3 3.3 1. 3.3 1. 3.3 1.</td><td></td><td>333         8           1         3           1         3           1         3           3         38           38         38</td><td></td><td>141 111 3.1 </td><td>1.8 4.45 3.1 4.34 1.6 4.31 3.5 4.53 1.7 4.34 3 4.83 3 4.83</td><td>11.1         374           57.5         438           73.7         111           14.1         111           71.4         324           75.3         1831</td><td>374 334 181 31 384 334 143 1838</td><td>I.I.I.         2.722         2.154           I.S.         I.I.I.         2.783         I.I.I.           I.S.         I.I.I.         2.783         I.I.I.           I.S.         I.I.I.         2.783         I.I.I.           I.S.         I.I.I.         2.763         22.51           I.S.         I.I.I.         2.763         22.51           I.S.         I.I.I.         2.763         22.51           I.S.         I.I.I.         2.754         22.51</td><td>1.483 1.483 1.788 1.178 1.483 1.178 1.483 1.483 2.888 2.888</td><td>1.413 1.400 1.000 1.310 1.110 2.410 1.210 1.010 1.510 1.510 1.510 1.520 1.201 1.520 1.201 1.520 1.201 1.520 1.201 1.520 1.201 1.520</td><td></td></th<>		0-12 346 10000 431 44 030 1-12 346 10000 0 33 34 00 1-13 346 1000 0 33 35 1-13 346 1000 34 00 1-13 346 1000 3 39 53 1-13 346 10000 3 39 53 1-13 346 10000 0 4 46 1334	715 711 717 711 717 711 711 714 1314	3.3 1. 3.7 3 3 1. 3.3 3 3.3 1. 3.3 1. 3.3 1.		333         8           1         3           1         3           1         3           3         38           38         38		141 111 3.1 	1.8 4.45 3.1 4.34 1.6 4.31 3.5 4.53 1.7 4.34 3 4.83 3 4.83	11.1         374           57.5         438           73.7         111           14.1         111           71.4         324           75.3         1831	374 334 181 31 384 334 143 1838	I.I.I.         2.722         2.154           I.S.         I.I.I.         2.783         I.I.I.           I.S.         I.I.I.         2.783         I.I.I.           I.S.         I.I.I.         2.783         I.I.I.           I.S.         I.I.I.         2.763         22.51           I.S.         I.I.I.         2.763         22.51           I.S.         I.I.I.         2.763         22.51           I.S.         I.I.I.         2.754         22.51	1.483 1.483 1.788 1.178 1.483 1.178 1.483 1.483 2.888 2.888	1.413 1.400 1.000 1.310 1.110 2.410 1.210 1.010 1.510 1.510 1.510 1.520 1.201 1.520 1.201 1.520 1.201 1.520 1.201 1.520 1.201 1.520	
				20         00         PER         PINUL         -20           30         00         PER         PINUL         -31           31         00         PER         PINUL         -31           31         01         PER         PINUL         -31           31         01         PER         PINUL         -33           31         01         PER         PINUL         -33           31         01         PER         PINUL         -33           31         01         PER         PINUL         -33         -41           31         01         PER         PINUL         -33         -41           31         01         PER         PINUL         -33         -41	1777 101.00 00000 000000 1777 101.00 000000 000000 1778 101.00 000000 000000 1789 1784.00 000000 000000 1799 1784.00 000000 000000 1799 1784.00 000000 000000 1799 1784.00 000000 000000	2001.23         2001.01         100           0103         201.23         2010.01         0.01           0104         201.23         0.01         0.01           0105         1243.45         4701.03         0.01           0105         101.01         1.02         1.03           0105         1016.03         0.01         1.03           0105         1016.03         0.01         0.01           0105         1016.03         0.01         0.01           0105         1016.03         0.01         0.01		0 11 246 1000 014 47 234 101 246 1000 0 23 40 101 246 1000 0 334 101 246 1000 0 334 112 246 1000 0 41 833 113 246 1000 01 10 113 246 1000 120 0 111 246 1000 120 0 111 111 111 111 111 111 111 1111 111 111 111 111 111 111 111 111 111 1111 11	724 877 945 100 1440 155 100 105 100 1075	3.7 1. 3.3 3 1.4 1. 3.8 1. 3.1 1. 3.3 1. 3.3 1.	0.3         0.4         0.4           2.3         7.6         0.4           3.4         0.3         0.4           3.5         0.4         0.4           3.5         0.4         0.4           3.5         0.4         0.4           3.5         0.4         0.4           3.5         0.4         0.4           3.5         0.4         0.4           3.5         0.4         0.4           3.5         0.4         0.4           3.5         0.4         0.4	1  1  13 4 4 3 3 3 4 4 4 5 747 8		H31         F45         2.7           IB3         3.7         3.7           IB4         IB4         3.7           IB4         3.7         3.7           IB4         3.7         3.7           IB4         3.7         3.7	1.0 0.20 3.0 4.13 1.4 00.03 1.4 00.03 1.4 7.03 3.3 00.46	10.4 (13) 10.7 155 10.1 (77) 10.3 14.7 71 155	103 - 20 305 	International         Interna         International         International<	1.624 1.623 3.733 1.634		
		Image: Construction of the second		31         81         FER         FILMU         -23.48           31         81         FER         FILMU         -31.48           31         81         FER         FILMU         -31.44           31         81         FER         FILMU         -34.34		1010 1210.12 1210.12 1010 1010 12240.23 1636.78 600 1010 1216.13 1636.78 600 1010 1216.43 1131.44 600 1010 1216.43 1131.44 600 1010 1256.43 1154.13 600 1010 1256.43 1154.13 600		1012         24%         11000         1100         23         11000           1012         24%         10000         0         20%         1414           1012         34%         10000         0         20%         1034           1012         34%         10000         0         24         1034           1012         34%         10000         0         143         1341           1012         34%         10000         0         145         1045           1012         34%         10000         0         145         1045           1012         34%         10000         0         24         1053           1012         34%         10000         0         24         1053           1012         34%         10000         0         24         1053		3.8 1. 3 3 1000 3.5 1. 478 3.3 3 480 3 1. 1386 3 1.			1143	1843 1813 3.1 1384 3.3 1884 4.3 148 4.3	3 (.13 3.1 ().17 3.3 (.3 3.3 (.3	77.7 20 0.1 440 13.1 400 14.7 740	311 385 874 148 148 451	1.5         1.5         1.31         1.5.3           1.61         1.51         3.2.34         21.5           1.61         1.52         1.64         21.5           1.61         1.52         1.64         21.5           1.64         1.63         1.61         21.5	1.384 1.384 3.136	1.383 1.388 1.828 1.88 1.714 1.142 1.423 1.243 1.142 1.423 1.243 1.148 1.485 2.653 1.183 1.488 1.457 2.684 1.824	133
		Image: Strands     Image: Strand		31         01         PER         PILLU         -33,34           31         01         PER         PILLU         -33,41         -           31         01         PER         PILLU         -33,41         -           31         01         PER         PILLU         -33,14         -           31         01         PER         PILLU         -33,15         -           31         01         PER         PILLU         -33,16         -           31         01         PER         PILLU         -31,13         -           31         01         PER         PILLU         -31,24         -		010         010.15         0144.85         010           010         217.41         -         024           010         010.35         013.23         010           010         234.81         -         244           010         234.81         -         244           010         235.81         -         244           010         255.81         014.33         014           010         252.34         -         245		1713         346         10100         10         306         10101           1713         346         10100         010         30         10101           1713         346         10100         010         20         406           1713         346         10100         010         34         4135           1713         346         10100         010         34         1140           1713         346         10100         010         34         1140           1713         346         10100         010         32         1351           1713         346         10100         010         33         1351	1347	1300 3.4 3 1300 3.4 3 3.7 3 1134 3.3 1. 1351 3.5 3			1683 1874 1856	1311 4.3 1841 4.3 1321 5.3	3.4 4.1 3.3 4.44 3.8 7.35	16.3 161 11.1 551 51.7 221	147		1.737		1.34
		11         11         11         7         14           12         11         11         14         14         14           13         14         16         16         16         14         14           13         14         16         16         16         16         16         16           14         16         16         16         16         16         16         16           15         16         16         16         16         16         16         16           16         16         16         16         16         16         16         16           16         16         16         16         16         16         16         16           16         16         16         16         16         16         16         16           16         16         16         16         16         16         16         16		20         00         PEP         PIDUL         -31.34           30         00         PEP         PIDUL         -31.43           31         01         PEP         PIDUL         -31.63           31         01         PEP         PIDUL         -31.64           31         01         PEP         PIDUL         -31.64           31         01         PEP         PIDUL         -47.04           31         01         PEP         PIDUL         -47.04	144 133.00 00000 000000 144 133.25 00000 000000 144 133.25 00000 000000 149 130.31 00000 000000 149 130.31 00000 000000 149 130.31 00000 000000 140 130.31 000000 000000	1710.01         1127.01         0.04           1010         212.01         -         1.014           1011         1210.01         1122.33         0.01           1011         1210.01         1122.33         0.01           1011         230.01         1122.33         0.01           1011         1210.01         1122.33         0.01           1011         1210.01         11010.21         0.01           1011         1217.01         10101.23         0.01           1011         1217.01         10101.23         0.01		IP12         34k         INUM         IP12         143           IP12         34k         INUM         IP10         31         7k4           IP12         34k         INUM         IP10         31         7k4           IP12         34k         INUM         IP12         14         1348           IP12         34k         IAUM         IP14         1348           IP12         34k         IAUM         IP14         1448           IP12         34k         IAUM         IP14         1448           IP12         34k         IAUM         IP14         IP44           IP13         34k         IAUM         IP44         IP44           IP13         34k         IAUM         IP44         IP44	1812 446 1912 446 1938 445 1934 445	1121 2.6 2 787 2.4 1 1881 3.3 2 3.3 1 3.7 1 3.7 1 3.7 1 3.7 1			1814 1611 3334	3334 (143) 34.3 3534 (143) 3534 (143) 353	3.3 0.43 3.3 0.44 3.4 10.51	10.7 147 76 1313	1915 115		1.812 2.348 1.844 1.844	1.436 1.484 3.133 1.143 1.681 1.448 5.838 1.531 2.831 8.478 1.583 1.185 1.881 8.478 1.583 1.185	
		1         1         1         1         1           1         1         1         1         1         1           1         1         1         1         1         1         1           1		31         81         FEP         FILMU         -32.1         -           38         88         FEP         FILMU         -32.1         -           38         88         FEP         FILMU         -32.1         -           31         88         FEP         FILMU         -32.3         -           31         88         FEP         FILMU         -32.3         -           31         88         FEP         FILMU         -32.3         -           31         86         FEP         FILMU         -32.3         -           31         87         FILMU         -         -         -           31         87         FILMU         -         -         -           31         87         FILMU         -         -         -		111         1231.31         1743           111         1646.33         418.33         610           111         1646.41         418.43         610           111         1646.41         418.43         610           111         3134.43         1311.41         610           111         314.43         1311.41         610           111         314.33         1311.41         610           111         3143.43         1311.41         610           111         3143.43         3113.43         610           111         3343.43         3113.43         610		171         246         1010         010         20         51           171         246         1010         64         23         51           171         246         1010         14         24         23           171         246         1010         15         44         26           171         246         1010         7         324         1344           171         246         1010         7         324         1344           171         246         1010         104         44         76           172         246         1010         104         44         76           172         246         1010         14         306         1010           172         246         1010         14         306         1010           173         246         1010         14         306         1010	618 614 738 643 768 733 1344 413 788 787 1018 1137 1018 1137	3.8 1 3.6 3 3.6 3 3.6 3 3.7 3 3.7 1 3.7 1 3.7 1 3.7 1		4 3 4 3 137 34 4 334 7 141 11 4 311	111 775 1433 664 1386	III         733         2.4           772         173         2.6           1433         IIII3         3.4           1435         III3         3.4           1316         1345         3.3	2.8 9.48 3 9.14 3.0 10.48 1.4 9.44 2.7 10.49	It.1         It1           II.3         III           II.3         III           II.3         III           II.1         251	148 188 188 18 187 2318 84 84 7771 528	1.1         1.54         1.544         20.4           0.0         0.4         0.64         0.4         0.4           0.1         0.4         0.64         0.4         0.4           0.4         0.64         0.64         0.4         0.4           0.4         0.4         0.64         0.4         0.4           0.4         0.4         0.4         0.4         0.4           0.4         0.4         0.4         0.4         0.4           0.4         0.4         0.4         0.4         0.4	1.384 1.384 1.382 1.382 3.538 3.538 1.888 1.888 3.5384 3.5384	1.176 1.244 1.245 1.244 1.245 1.	
				21         01         FER         FIGU1         -31,41           31         01         FER         FIGU1         -31,45           31         01         FER         FIGU1         -31,34           31         01         FER         FIGU1         -31,34           31         01         FER         FIGU1         -31,34           31         01         FER         FIGU1         -32,34	14         137.54         111111         111111           14         137.54         111111         111111           14         137.54         111111         111111           14         137.54         111111         111111           147         137.54         111111         111111           147         137.54         111111         1111111           147         137.64         111111         1111111           143         137.64         1111111         1111111	Image: Number of the second		1713         246         14000         4         300         1413           1713         246         14000         4         300         1413           1713         246         14000         400         43         1413           1713         246         14000         100         43         1413           1713         246         14000         100         310         3343           1713         246         14000         100         10         45           1713         246         14000         100         10         45           1713         246         14000         100         10         45           1713         246         14000         100         10         45           1713         246         14700         100         10         103         103	1013 1030 046 033 3343 1535 460 430 3103 1430 1331 1430 1330 1031	3.4 3.4 3.7 3.7 3.7 3.7 4.3 3.7 3.7 5.7 5.7 5.7 5.7 5.7 5.7 5.7 5.7 5.7 5		2 7 7 7 7 7 7	3183 3478 3783	3783 1638 3 3438 1413 4.1 3583 3848 4.1	2.1 4.10 2.1 11.00 2.5 14.17	10 1014 1016.1 1634 133 1545	1014 365 1634 1888 1945 1058	Intel         Intel         Intel         Intel           Intel         Intel         Intel         Intel         Intel           Intel         Intel         Intel         Intel         Intel           Intel         Intel         Intel         Intel         Intel	1.312 3.312 1.315 3.315 1.315 3.315	1.044         1.431         1.231         1.449           3.340         1.014         3.210         1.222           3.2560         1.324         2.400         1.401	
32         7           32         32           31         1           31         1           31         1           31         1		Image: Construction of the second		10         10         FER         FILML         -327,33           10         10         FER         FILML         -327,34           21         10         FER         FILML         -327,14           21         10         FER         FILML         -337,14           21         10         FER         FILML         -337,41           21         10         FER         FILML         -337,41           21         10         FER         FILML         -331,41		1441.51         1823.41         111           1441.51         1823.41         111           1411.14         1843.41         111           1411.14         1843.41         111           1411.14         1843.41         111           1411.14         1843.41         111           1411.14         1843.41         111           1411.14         1843.41         111           1411.14         1843.41         111           1411.14         1843.41         111           1411.14         1843.41         111           1411.14         1843.41         111           1411.14         1843.41         111           1411.14         1843.41         111           1411.14         1843.41         111           1411.14         1843.41         111           1411.14         1843.41         111           1411.14         1843.41         111           1411.14         1843.41         111           1411.14         111         111           1411.14         111         111           1411.14         111         111           1411.14         111         111		1012 246 14700 0 314 3123 1012 246 10000 000 441 1446 1012 246 10000 7 160 1793 1012 346 10000 7 160 1793 1013 346 14400 000 03 340 448 1013 346 14400 033 340 448 1013 346 14400 033 540 448	2123 1604 1446 1401 1703 1304 233 313 733 40 733 40 733 40 733 40 733 40 733 40 733 40 733 40 733 70 733 70 747 70 70 70 70 70 70 70 70 70 70 70 70 70 7	3.3 3 3.1 3 3.4 3 3.8 1 1.3 1 1.3 1 3.8 1		8 3 6	3461 1983	34b1         1111         4           1164         1446         3.1           784         3         3           663         637         3	5.3 (5.3) 5.4 (.3) 1.7 7.75 1.4 7.41	116.3 1341 17.3 373 14.3 171 13.4 26.1 -21	1341 814 375 38		2.07 2.07 1.244 1.244 1.224		
						110         2114.73         1331.11         111           110         2114.12         1331.23         1231           110         2114.23         1331.23         1231           111         2114.23         1331.23         1231           111         2114.23         2114.31         111           111         2114.23         2114.31         2141           111         2114.23         2114.31         2141           111         4115.23         2114.31         2141           111         4115.23         2114.31         2141           111         4115.23         2114.31         2141           111         4115.23         2114.31         141           111         4115.33         2141.31         141           111         4115.33         2141.31         141		IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	121 1187 121 1187 227 226 1238 1182 1238 1182	3.5 5 3.5 1 3.3 3 3.7 1 3.7 1 3.7 1		3 3 4 103 143 4 4 5 300 331 3 14	1796 1910 1910	IIII         IIII         J.           IIIII         3.0         3.0           IIIII         1017         3.0           IIII         112         3.1           IIII         112         3.1	2.3 11.79 2.3 1.84 2.3 1.84 3.3 8.44 3.3 8.44 3.3 8.44	11.1 214 17.3 214 21.4 171 25.3 112	378 378 135 148	1.1         1.2         2.14         42.2           1.1         0.7         1.44         31.1           0.4         1         1.14         14.2           0.5         0.8         1         1.6           1.2         1.24         1.6         1.5	2.044 1.740 1.724 1.724 1.724		
		Art and     Bit and if     3     16       Art Bit     Bit and if     4     16       Art Bit     Bit and if     4     16       Art Bit     Bit and if     8     16       Art Bit     Bit and if     8     16       Art Bit     Bit and if     8     16       Art Bit and if     8     16		II         IFER         IIIIII         -36,73           31         10         REF         FIGURE         -36,73           31         11         REF         FIGURE         -36,73		122,28         171,87         11           101         221,28         21,27         21,27           101         432,293         141,62         61,01           101         432,293         141,62         61,01           101         144,61         112,21         161,01           101         144,61         112,21         61,01           101         144,63         44,63         21,01		Trip         24%         14600         7         33%         173%           TC1         24%         14600         100         46           TC1         24%         14600         100         46           TC1         24%         14600         2         5/3         1414           TC1         24%         14600         100         144         107           TC1         34%         14600         000         144         107           TC1         34%         14600         000         40         1730           TC1         34%         14700         000         130         130	1030 1036 1030 1036 105 005 105 005 105 005 105 005					1934 3.3 1946 3.3 1946 3.3 1946 3.3 1946 3.3 1946 3.3	3.5 16.31 3.7 1.11 3.3 16.13 3.4 1.55	22.4 25.4 25.3 1014 21.8	572 584 725		3.387	1.020 1.023 1.223 1.016 1.622 1.000 1.600 1.000 1.013 1.000 3.000 1.000 1.013 1.000 3.000 1.000	
11 11 b 11 11 b 11 11 7				31         31<		3737.31         -         371           1010         444.41         104.32         6.13           1010         415.43         -         373           1010         415.43         -         373           1010         440.41         24.21         6.13		1         246         14600         010         235         1470           0-12         246         14600         20         1044         1044           0-12         246         14500         20         1044         1044           0-12         246         14500         20         1044         10         10           0-12         246         14700         7         1200         1200         1200	1384 484 1641 634 634 1144	1.3 1. 3.1 3 1.2 1. 3.4 1.	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		3486	3116 3.0 1378 3.1	3.4 13.43 1.4 8.83	101.3 101.5	1110				

### Sample Pile Installation Information

Howard Frankland Bridge - End Bent 1-1 Pile 3 15DSC Double Splice 30" PSC Pile Total Length 220ft.											220ft.				
(	OP: [	DFC/BF									Date	e: 13-July	/-2022		
A	AR:	900.00	in²									SP: 0.1	50 k/ft <sup>3</sup>		
L	_E:	215.00	ft					EM: 5,8	13 ksi						
<u>\</u>	NS:	13,400.0	f/s									JC: 0.6	50		
F	RMX:	Maximur	n Case N	Aethod C	apacity	(JC)			DMX: Maximum Displacement						
(	CSX:	Compres	ETR: Energy Transfer Ratio - Rated												
٦	TSX:	Tension	BTA: Integrity Factor (1)												
EMX: Maximum Energy TLS: Tension Stress at Splice												1			
STK: Hammer Stroke															
	BL#	Depth	BLC	TYPE	RMX	CSX	TSX	EMX	STK	DMX	ETR	BTA	TLS		
		ft	bl/ft		kips	ksi	ksi	k-ft	ft	in	(%)	(%)	ksi		
	1	139.01	72	AV1	1,457	2.8	0.4	64.6	9.58	0.44	26.1	83.0	0.00		
Exceed NBR							_			_					
	2	139.03	72	AV1	1,444	3.0	0.4	75.6	10.24	0.49	30.5	82.0	0.00		
	~	400.04	70	A) (4	4 000	0.0	0.4	00.5	10.10	0.44	00.0		0.00		
	3	139.04	72	AV1	1,388	2.9	0.4	69.5	10.13	0.44	28.0	80.0	0.00		
	1	139.06	72	۵\/1	1 389	3 1	0.4	79.7	10 52	0.51	32.1	81.0	0.00		
Average =	ר ו	155.00	12		1,505	5.1	0.4	13.1	10.52	0.51	J2.1	01.0	0.00		
1.372 kips	5	139.07	72	AV1	1.350	3.2	0.4	84.7	10.92	0.52	34.2	80.0	0.00		
.,			. –		.,		••••	•							
	6	139.08	72	AV1	1,290	3.1	0.3	80.6	10.60	0.55	32.5	80.0	0.00		
	7	139.10	72	AV1	1,295	3.1	0.4	79.0	10.30	0.54	31.8	79.0	0.00		
All exceed	8	139.11	72	AV1	1,314	3.1	0.4	79.9	10.48	0.51	32.2	79.0	0.00		
90% NBR	_	100.10	70						40.50						
_	- 9	139.13	12	AV1	1,290	3.1	0.4	11.4	10.52	0.50	31.2	/9.0	0.00		
			A	verage	1,357	3.0	0.4	76.8	10.37	0.50	31.0	80.3	0.00		
Total number of blows analyzed: 9															

RS Instance vs. Hours Driven after Initial Drive (n=910)



Time between EOID and RS (days)



### Example Restrike Capacity Ratio (Pen Bay)



RMX Multiplier vs Set Time (n=895)





Strength Gain / Lost per Bearing Soil Type

■ No Change ■ Setup ■ Relaxation



### Update on Work Performed

- Data continues to be collected and processed
- Data collection more difficult than expected
- Data mining using Python code is now in progress
- Data numbers are expected to be into the thousands
  - examples
  - US331 (Choctawhatchee) has 1300 restrike documents from 85 piers
  - Howard Frankland has 400 restrike documents from 113 piers
  - Pensacola Bay 119 piers

### Timeline / Schedule

Deliverable # / Description as provided in the scope (included associated task #)	Anticipated Date of Deliverable Submittal (month/year)	TO BE COMPLETED BY RESEARCH CENTER (performance monitoring)	
Project Kickoff Teleconference / Presentation webinar	4/2022		-
Task 1: Literature Search Deliverable 1 – a written report providing a summary of literature collected and gaps in the literature	9/2022		
Task 2: Data Collection Deliverable 2 – a written report providing a summary of case studies will be submitted.	8/2023		
Task 3: Data Analysis Deliverable 3 – a written report providing the results of the data analysis will be submitted.	1/2024		
Deliverable 4a – Draft Final Report – Ninety (90) days prior to the end date of the contract, the university will submit a draft final report. The draft final report will contain at a minimum a description of all the work conducted, a discussion of the test results, final conclusions and recommendation, and related documents.	1/2024		
Deliverable 4b – Closeout Meeting / Presentation	3/2024		-
Deliverable 5 – Final Report	4/2024		