Technical Report Documentation Page

1. Report No. FIU-EDPSE-03	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle **Epoxy Dowel Pile Splice Evaluation**		5. Report Date April 2020 – Revised May 2020 6. Performing Organization Code
7. Author(s) Armin Mehrabi https://orcid.org/0000-0003-4736-850X Saman Farhangdoust https://orcid.org/0000-0002-5061-3513		8. Performing Organization Report No.
9. Performing Organization Name and Address Department of Civil and Environmental Engineering Florida International University 10555 West Flagler Street, EC 3680 Miami, FL 33174		10. Work Unit No. (TRAIS) 11. Contract or Grant No. BDV29-977-52
12. Sponsoring Organization Name and Address FDOT Research Center Phone: (850) 414-5260 605 Suwannee Street Tallahassee, Florida 32399-0450 Email: research.center@dot.state.fl.us		13. Type of Report and Period Covered Interim Report- Task 3 Deliverable 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

The objective of this project is to investigate the behavior and effectiveness of epoxy dowel splice, experimentally and analytically, for prestressed precast concrete piles using corrosion resistant material for dowels (SS, CFRP, and GFRP), and comparing their performance to conventional carbon steel dowel splices. The research project aims to verify the effectiveness of SS and CFRP dowels, and applicability of substitute GFRP dowels as a more economical alternative. It will develop design procedure and details for GFRP epoxy dowel splices, aims at recommending refinements to current designs, and develop design drawings for the recommended details. It will also develop an analytical framework that can be used for design of future variations of pile and splice systems. The primary focus will be on the flexural behavior of the pile splices. This report covers Task 3 of the project which focuses on: Written procedures for installing, testing and evaluating pile splice flexural capacity; detailed design and construction drawings of the test specimens, with construction specifications; detailed drawings depicting the design for loading and instrumentation to monitor and record the flexural response of each splice configuration; and detailed calculations predicting the capacity of each pile splice test specimen.

17. Key Words Prestressed Precast Concrete Pile, Pile Splice, Epoxy Dowel Splice, CFRP, HSSS, SS, GFRP, bending test.		18. Distribution Statement No Restriction	
19. Security Classification Unclassified	20. Security Classification (of this page) Unclassified	21. No. of Pages 29	22. Price

(this page is intentionally left blank)

Epoxy Dowel Pile Splice Evaluation

Project No. BDV29-977-52

Interim Report – Task 3 Deliverable

April 2020 (Revised May 2020)

Principal Investigator: Armin Mehrabi
Co-PI: David Garber
Co-PI: Seung Jae Lee
Graduate Assistant: Saman Farhangdoust

Department of Civil and Environmental Engineering
Florida International University
Miami, FL

Authors

Saman Farhangdoust
Armin Mehrabi

Sponsored by

Florida Department of Transportation

A report from

FLORIDA INTERNATIONAL UNIVERSITY

Contents

List of Figures

List of Tables

Abstract

The objective of this project is to investigate the behavior and effectiveness of epoxy dowel splice, experimentally and analytically, for prestressed precast concrete piles using corrosion resistant material for dowels (SS, CFRP, and GFRP), and comparing their performance to conventional carbon steel dowel splices. The research project aims to verify the effectiveness of SS and CFRP dowels, and applicability of substitute GFRP dowels as a more economical alternative. It will develop design procedure and details for GFRP epoxy dowel splices, aims at recommending refinements to current designs, and develop design drawings for the recommended details. It will also develop an analytical framework that can be used for design of future variations of pile and splice systems. The primary focus will be on the flexural behavior of the pile splices. This report covers Task 3 of the project which focuses on:

- Written procedures for installing, testing and evaluating pile splice flexural capacity.
- Detailed design and construction drawings of the test specimens, with construction specifications.
- Detailed drawings depicting the design for loading and instrumentation to monitor and record the flexural response of each splice configuration.
- Detailed calculations predicting the capacity of each pile splice test specimen.

1 INTRODUCTION

1.1 Problem Statement

Establishing bridge foundations where there is a top layer of weak soils normally requires application of deep foundations such as pile foundation. Driving prestressed-precast concrete piles (PPCP) is one of the options among various types of piles and installation methods. This option provides in many cases an economic and rapid alternative. However, traditional prestressed piles that use carbon steel strands and bars are prone to corrosion, especially when they are in a marine environment. In such environment, alternating water levels and water splash cause deposit and migration of salts into the pile that can accelerate corrosion. Florida Department of Transportation (FDOT) has recently implemented programs to use alternative prestressing strand material that are corrosion resistant. The use of Carbon Fiber Reinforced Polymers (CFRP) and High Strength Stainless Steel (HSSS) for strands and other reinforcement in concrete piles have shown great improvements in the resistance against corrosion.

For various reasons, it often happens that splicing of pile segments has to be performed at the site to achieve longer lengths. The shipping and transportation constraints may limit the length of precast prestressed pile segments that can be delivered to the bridge site. Also, when there is headroom limitation for pile driving, the length of pile segments may be smaller than the length required to establish adequate resistance. In such cases, splicing can be preplanned. Another reason that the pile segments would be less than the length required for resistance is the case of unpredictable soil resistance, which leads to unplanned splicing. Dowel-type splicing using epoxy grout is the focus of this project. In the dowel-type splice, holes are cast or drilled into the top of the lower pile to receive dowel rebars protruding out of the lower end of the upper pile. Dowel rebars can be made of carbon steel as in conventional splicing, or of Stainless Steel (SS), Carbon Fiber Reinforced Polymer (CFRP), or Glass Fiber Reinforced Polymer (GFRP) bars. FDOT has Standard Plans s showing CFRP and SS dowels, but does not cover a GFRP dowel application. Despite occasional use of alternate corrosion resistant dowel splicing, their true behavior is not fully understood yet. Analytical and experimental investigations for structural evaluation of these splices in comparison with splices using conventional bars are scarce.

1.2 Research Objectives

The objective of this project therefore is to investigate the behavior and effectiveness of the epoxy dowel splice for prestressed-precast concrete piles using corrosion resistant material for dowels (SS, CFRP, and GFRP), and comparing their performance to conventional carbon steel dowel splices. The project includes reviewing previous investigations on this subject and design of pile splices according to available codes and analytical models. Pile segments will be fabricated at an approved precast plant, then moved to the FDOT Structures Laboratory, spliced and tested in bending. Using the test results, the project will aim to verify the effectiveness of SS and CFRP dowels, and applicability of GFRP dowels. Design procedure and details will be developed for GFRP epoxy dowel splices, and if applicable, refinements to the current designs for CFRP and SS dowels will be introduced, and design drawings for the recommended details will be developed. It will also develop an analytical framework that can be used in future for systems not covered in this project. The focus of this study will be on the flexural behavior of pile splices.

The objective includes quantifying the effectiveness of the current pile splice details and developing cost-effective versions for corrosion-resistant piles. The research intends to provide a better understanding of the performance and behavior of spliced bearing piles along with a refined design that will be incorporated within the FDOT Standard Plans (Index 455-series).

Task 1 including literature review was completed in July 2019, and the report was submitted to FDOT. The second report was completed and submitted to FDOT in January 2020 which covers Task 2: Design calculations for the GFRP Epoxy Dowel Pile Splice capacities, and detailed drawings depicting the design for incorporation into the testing phase. This report covers Task 3 of the project which focuses on:

- Written procedures for installing, testing and evaluating pile splice flexural capacity.
- Detailed design and construction drawings of the test specimens, with construction specifications.
- Detailed drawings depicting the design for loading and instrumentation to monitor and record the flexural response of each splice configuration.
- Detailed calculations predicting the capacity of each pile splice test specimen.

2 TEST SPECIMENS

This research involves development of full-scale test specimen configuration and loading procedure to evaluate Epoxy Dowel Pile Splices for 18”x18” precast prestressed concrete pile specimens using different materials for reinforcement including steel and corrosion resistance FRPs (GFRP, and CFRP). Ten full-scale test specimens are considered in this study. This section introduces a design for test specimens and test setup. The experimental tests were designed for 28-ft specimens comprised of two 14-ft pile segments connected using epoxy dowel pile splice.

2.1 Test Matrix

A test matrix was designed for the full-scale test covering the epoxy dowel splices developed for both drivable unforeseen and preplanned pile splices using various strand and dowel materials. As it was stated before, the laboratory testing is limited to piles of 18x18 in. cross-section and the flexural resistance of pile splices. The original test matrix included the use of CFRP, SS, and GFRP dowel splices as well as carbon steel dowels connecting pile segments of compatible material. As part of investigation in Task 2, it became clear that the behavior of piles and splices using stainless steel (SS) material is expected to be similar to those using carbon steel material for strands and dowels. Accordingly, in coordination with the FDOT Project Manager (PM) and technical committee, the test matrix was modified by eliminating specimens using stainless steel material and adding to the number of specimens using GFRP dowels in combination with piles using CFRP and carbon steel strands. It is believed this serves better the purpose of the study. As a result, test matrix shown in Table 1 is considered for flexural testing

2.2 Detailed Drawings of the Test Specimens

Design and details of the test specimens follow the drawings presented in Figures 22 and 23 of Task 2 report for splices using GFRP dowels, and FDOT Standard Drawings Index Series 455 for other dowel material as well as for the piles. Taking into account the results of literature review and the designs developed in the Task 2 of this project, as well as considering FDOT Standard Designs and Specifications, a 14-ft pile length for the test segments is selected to be able to provide adequate transfer lengths for the pile strands. Each flexural test specimen will consist of two segments (14ft + 14ft =) with a total length of 28 ft.

Table 1: Matrix of the test specimens

Dowel	Specimen	Pile 18 x 18" Strand	Splice for Drivable Unforeseen/Preplanned	Segment 1 Length-ft	Segment 2 Length-ft	Spliced Length- ft
GFRP	1	Steel SP-Index-455-018	Unforeseen SP-455-[Fig. 22, Task 2 Report]	14	14	28
	2	CFRP SP-Index 455-118	Unforeseen SP-455-[Fig. 23, Task 2 Report]	14	14	28
GFRP	3	Steel SP-Index-455-018	Preplanned SP-455-[Fig. 22, Task 2 Report]	14	14	28
	4	Steel SP-Index-455-018	Preplanned SP-455-[Fig. 22, Task 2 Report]	14	14	28
	5	CFRP SP-Index 455-118	Preplanned SP-455-[Fig. 23, Task 2 Report]	14	14	28
	6	CFRP SP-Index 455-118	Preplanned SP-455-[Fig. 23, Task 2 Report]	14	14	28
Steel	7	Steel SP-Index-455-018	Preplanned SP-455-002	14	14	28
	8	Steel SP-Index-455-018	Preplanned SP-455-002	14	14	28
CFRP	9	CFRP SP-Index 455-118	Preplanned SP-455-102	14	14	28
	10	CFRP SP-Index 455-118	Preplanned SP-455-102	14	14	28

Therefore, each 28-ft test specimen will consist of two 14-ft pile segments; one with dowels embedded during casting (Male Segment) and the other with holes to receive the dowels (Female Segment). Figures 1,2, and 3 show the generic drawings for female segments of preplanned splice specimens, female segments of unforeseen splice specimens, and male segments (for both preplanned and unforeseen), respectively. The specific information is shown in Table 2 for each test specimen numbered according to Table 1. In this table, L_A, L_D, L_H, and L'_D , respectively are the lengths of auxiliary bar, projected part of dowels, holes (preformed for preplanned specimens and drilled for unforeseen specimens), and embedded part of dowels.

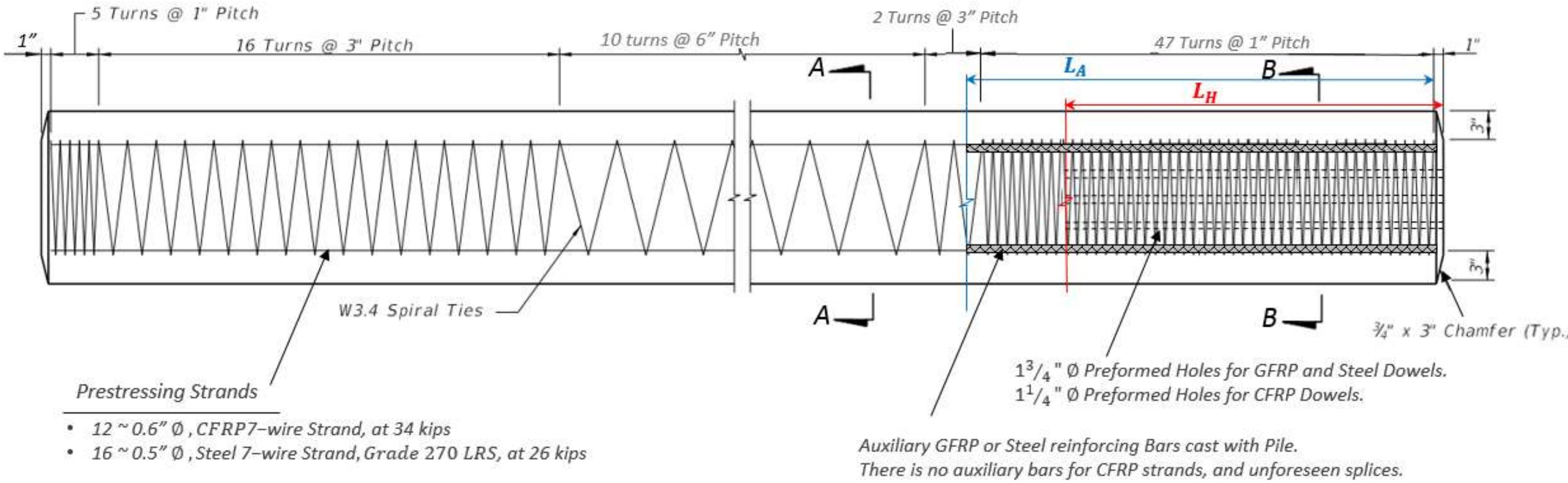


Figure 1: The elevation view of the female pile segment (Preplanned- Specimens 3 through 10)

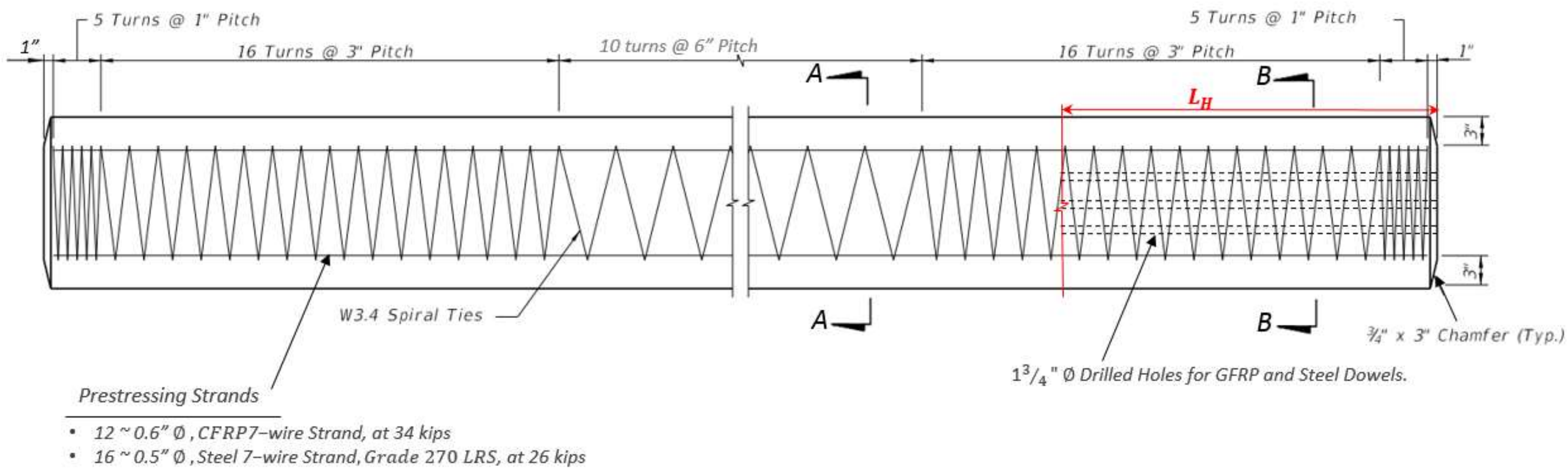


Figure 2: The elevation view of female pile segment (Unforeseen- Specimens 1 and 2)

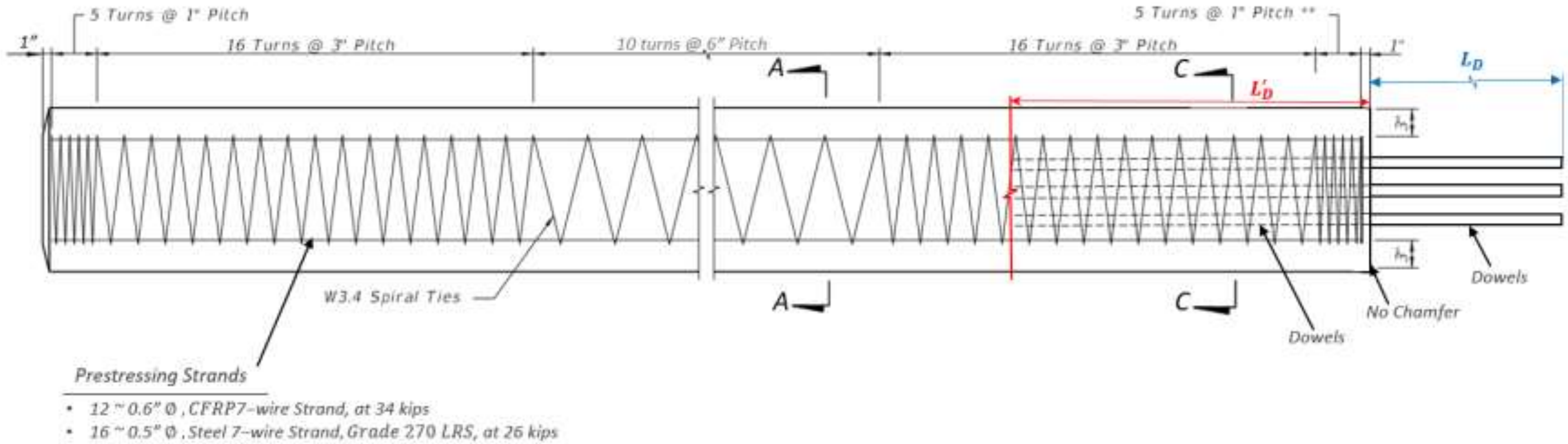
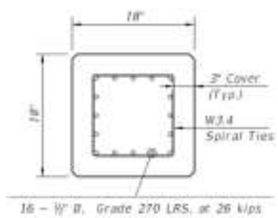
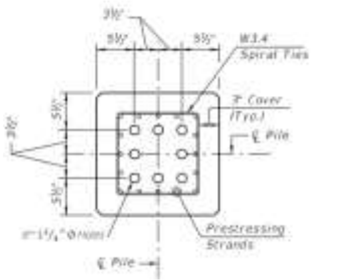
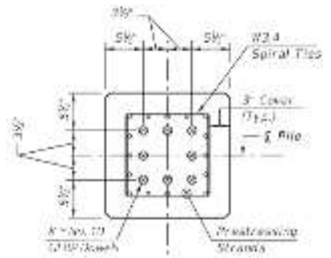
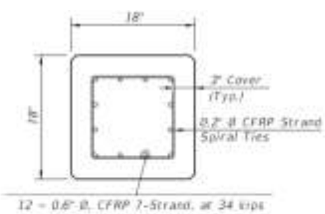
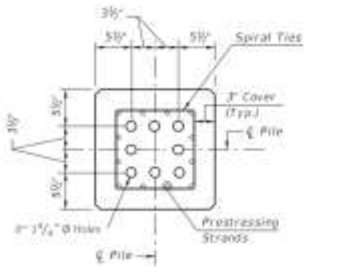
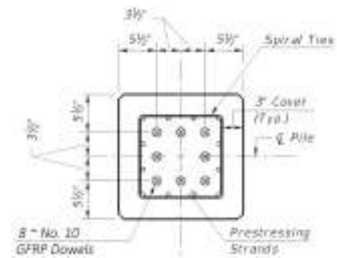
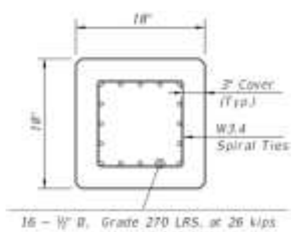
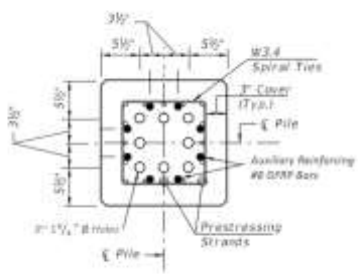
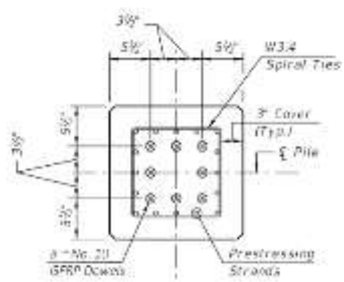
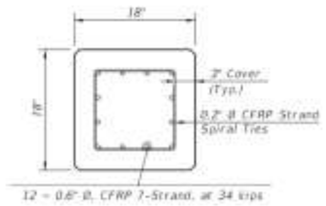
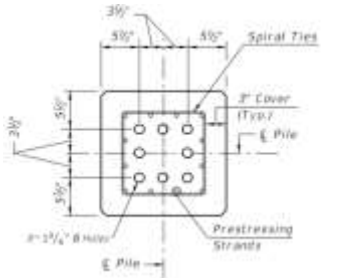
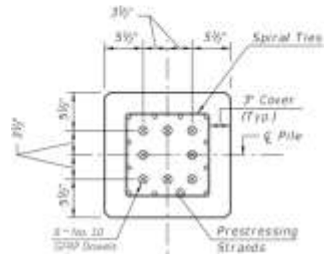
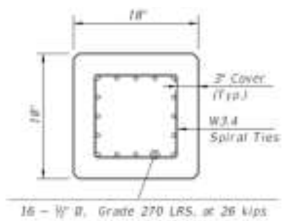
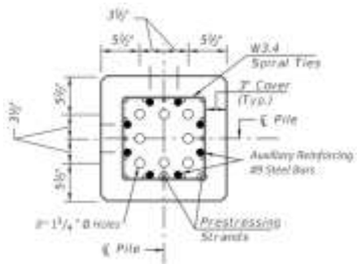
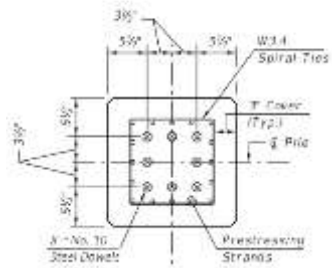
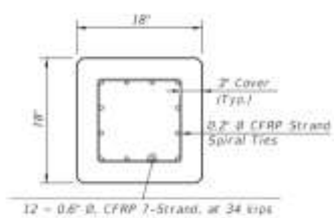
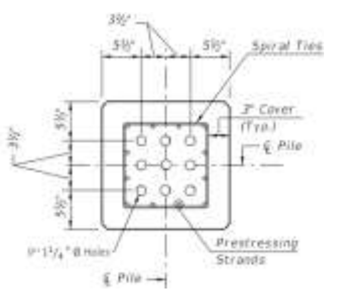
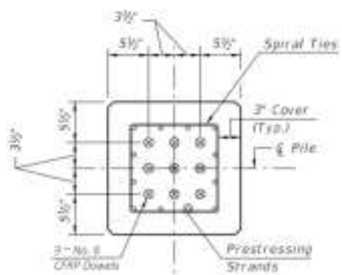


Figure 3: The elevation view of male pile segment

Table 2: Specifics of the test specimens

		Details						
		A-A Section	**B-B Section**	**C-C Section**	L_A	L_D	L_H	L'_D
Specimen #	1				0	2’-6”	2’-8”	6’-9”
Specimen #	2				0	2’-6”	2’-8”	4’-6”
Specimen #	3&4				6’-9”	3’-4”	3’-6”	6’-9”

	5&6				0	4’-6”	4’-8”	4’-6”
	7&8				10’-6”	4’-0”	4’-2”	10’-6”
	9&10				0	4’-6”	4’-8”	4’-6”

2.3 Construction Specification

Construction of test specimens shall follow all relevant specifications within FDOT Standard Specifications [2020] and especially notes and specifications within FDOT Standard Drawings Index 455. Some of the considerations for before, during, or after the construction are highlighted below, but it does not relieve the precast contractor from following all applicable specifications:

1. Dowel Bars:
   - ✓ Carbon-Steel dowels shall meet the requirements of FDOT Standard Specifications Section 415.
   - ✓ GFRP and CFRP dowels shall meet the requirements of ASTM D7957-17 and FDOT Standard Specification for Road and Bridge Construction [January 2020] Section 932. However, the exact material for GFRP and CFRP will be selected in consultation with the precast contractor and communication with FDOT project manager.
   - ✓ According to FDOT Standard Drawings Index 455-102 and 455-118 Standard Drawings, #6 CFRP dowel bars are used for piles splices using CFRP dowels.
   - ✓ According to FDOT Standard Drawings Index 455-002 and 455-018,, #10 Steel Dowels are used for pile splices using steel dowels.
   - ✓ According to proposed Drawings in the Task 2 of this research, GFRP Dowels #10 are used for pile splices using GFRP dowels.

2. Prestressing Strands:
   - ✓ Carbon-Steel strands shall meet the requirements of FDOT Standard Specification Section 933.
   - ✓ CFRP strands shall meet the requirements of FDOT Standard Specification Section 933.
   - ✓ Tie each wrap of the spiral strand to a minimum of two corner strands.
   - ✓ One full turn required for spiral splices

3. Epoxy:

Following are specifications related to epoxy material in accordance with FDOT Standard Specification Sections 926.

- ✓ Type AB Epoxy shall be used for assembling the test specimens. The epoxy shall be used to fill the holes and spaces between dowel and the holes, and form the joint between pile segments. The epoxy shall be mixed, applied, and cured in accordance with the manufacturer's directions, or as directed otherwise by the Department or its designee.
- ✓ Before installation, concrete members receiving dowels needs to be checked to be structurally sound and free of cracks in the vicinity of dowel to be installed. The size and position of the holes are specified in the drawings in Table 2. The interior surfaces of the holes shall be free of loose particles, oil, and other contaminants. Use the manufacturer's instruction for cleaning the surfaces to be bonded.
- ✓ For installation, all debris, oils, and any other deleterious material from dowels should be removed first to avoid contamination of the adhesive bonding material. Dowels should be installed in accordance with the details shown in the Plans and the manufacturer's instructions, with particular attention to requirements and limitations due to anchor position, dampness, ambient temperature, and curing. An adequate quantities of the adhesive bonding material should be used to fill the drilled hole and the joint between segments at the splice.
- ✓ The epoxy material shall be presented to the research team and FDOT PM for approval prior to procurement.

4. Concrete:
    - ✓ As per FDOT Standard Plans Index 455-001, Class V (Special) type of concrete shall be used for the pile specimens. According to the concrete classes and strength included in the FDOT Structures Manual Volume 1 [January 2020], the minimum 28-day compressive strength (f'_c) is considered 6 (ksi) for concrete Class V (Special) (Table 3). The yield strength of steel (f_y), minimum ultimate tensile strength of strands, and other properties for section analysis are adopted from FDOT Standard Plans Index 455-000 series.

Table 3: FDOT concrete classes and strengths

Class II	3.4
Class II (Bridge Deck)	4.5
Class III	5.0
Class III (Seal)	3.0
Class IV	5.5
Class IV (Drilled Shaft)	4.0
Class V (Special)	6.0
Class V	6.5
Class VI	8.5

5. FRP:
   - ✓ According to the FDOT Standard Specifications for Road and Bridge Construction (January 2020), section properties of FRP reinforcing bars shall meet the requirements in Table 4. However, the exact material for GFRP and CFRP will be selected in consultation with the precast contractor and communication with FDOT project manager.

Table 4: Sizes and mechanical properties of FRP bars

Bar Size Designation	Nominal Bar Diameter (in)	Nominal Cross Sectional Area (in^2)	Measured Cross-Sectional Area (in^2)		Minimum Guaranteed Tensile Load (kips)	
			Minimum	Maximum	GFRP Bars	CFRP Bars
2	0.250	0.049	0.046	0.085	6.1	10.3
3	0.375	0.11	0.104	0.161	13.2	20.9
4	0.500	0.20	0.185	0.263	21.6	33.3
5	0.625	0.31	0.288	0.388	29.1	49.1
6	0.750	0.44	0.415	0.539	40.9	70.7
7	0.875	0.60	0.565	0.713	54.1	-
8	1.000	0.79	0.738	0.913	66.8	-
9	1.128	1.00	0.934	1.137	82.0	-
10	1.270	1.27	1.154	1.385	98.2	-

6. The 1-in. spiral tie pitch shall be continued to 4-ft. below the head of the pile where the dowel holes are utilized.
7. The holes for "Unforeseen Splice" specimens (Specimens 1 and 2) shall be drilled using proper drill and drill bits to create conditions similar to that in the field.
8. Both methods of "removable preforming material" or "stay-in-place corrugated galvanized steel ducts" may be used to utilize the preformed holes.
9. Stay-in-place corrugated galvanized steel ducts shall be utilized from galvanized sheet steel covering the requirements of ASTM A653, Coating Designation G90, 26 gauge.
10. A minimum corrugation (rib) height of 0.12 in shall be considered for the ducts with 2in diameter.
11. Welded or interlocked seams may be used to fabricate the ducts.
12. There is no need to Galvanize the welded seams.

2.4 Instrumentation during Construction

There will be no instrumentation, embedded or otherwise, during construction. This testing program focuses on the global behavior and flexural capacity of the epoxy dowel splices. In specific, it is highly desired that the disturbances to the surfaces of the dowels are avoided. Local behavior of embedded and adhesively bonded dowels using sensors attached to the dowel though important, is not part of this study. Such investigation through a separate project can be developed if FDOT Research sees the necessity.

2.5 Material Sampling and Testing

Material samples will be collected for testing to determine the mechanical properties of the material used for fabrication of the test specimens. These will include;

- ✓ Concrete cylinders to determine the compressive strength at the time of flexural testing. At a minimum, 9 cylindrical specimens for each batch of concrete used for fabrication of the pile segments. The cylinders will be tested at 28 days and the time of splice flexural testing.
- ✓ Strands- at least five 6-ft strand pieces for each size and type (steel and CFRP) will be collected from the coil(s) used for fabrication of pile segments for tension testing. Accurate mill certificates and production testing results may be used in lieu of these tests.

- ✓ Rebars- at least five 6-ft bars for each size and type of bars (steel, CFRP, and GFRP) will be collected for tension testing. Accurate mill certificates and production testing may be used in lieu of these tests.
- ✓ Epoxy samples maybe taken for bond testing with concrete. Otherwise, the manufacturer's specification will be used to determine the mechanical properties of the epoxy material. Instructions and specification for mixing, setting and curing time provided by the manufacturer will be used during assembly of the test specimens.

3 TEST SET-UP

3.1 Specimen Preparation

For the test specimens, holes are cast or drilled into one end of female pile segments to receive dowel rebars protruding out of the male pile segment according to FDOT standard specifications and the notes in the previous sections. Type AB Epoxy Compound in accordance with FDOT Standard Specification Section 962 [2020] is used to fill the holes and form the joint between pile sections. The exact epoxy compound and its source (manufacturer) will be determined in consultation with the FDOT project manager and precast contractor. In the test specimens, epoxy is commonly used to fill the interface and sockets of the lower segment so that the dowel bars of the upper segment can be fully enveloped with the epoxy.

3.2 Specimen Assembly

After 14-ft pile segments are cast at the precast yard, they need to be assembled to form the 28-ft test specimens. There are two options for the assembly; 1) assemble the specimens at the precast facilities, and 2) assemble the specimens at the FDOT structures laboratory. The position for assembly should be with pile segments in vertical alignment to mimic the site condition. Therefore, it is necessary to secure the lower segments vertically and install the upper segment with the use of crane. The ideal case is to perform the assembly at the FDOT structures lab to avoid damage to the splice during transportation from the precast plant to the laboratory. Otherwise, necessary means for supporting the splices during shipment will need to be utilized. The FDOT project manager and precast contractor will be consulted to determine the availability of the necessary space and facilities and capabilities for the assembly, and the appropriate option will be selected accordingly.

3.3 Support and Loading Condition

The spliced specimens with a length of 28 ft will be supported at ends with the help of neoprene pads with the center of pads at 6-in from the end of the specimen to produce a 27-ft overall bending span. A two-point loading scheme will be used straddling at equal distance from the splice section. The distance between the loads was determined according to the spreader beam configuration available at FDOT SRC laboratory to be 6'-6". The specimen setup will be as shown in Figure 4.

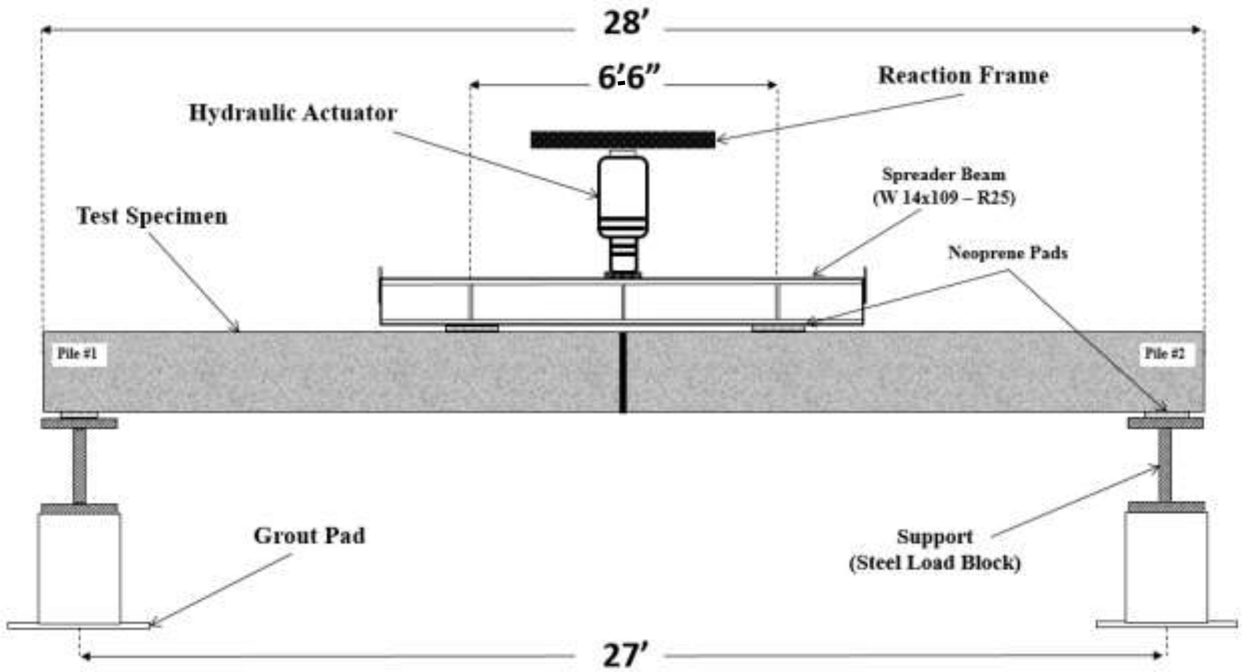


Figure 4: Setup for flexural testing

3.4 Instrumentation

The test specimen will be instrumented to capture the flexural behavior of the splice. The instrumentation suggestion includes;

- Load transducers for measuring the force (separate load cells or integrated load cells with actuators depending on the FDOT SRC availability)
- Displacement transducers (vertically oriented) to measure vertical deformation at three points along the span including near the splice.
- Displacement/crack transducers (horizontally oriented) to measure relative displacement of pile ends at the splice section, i.e., opening at the splice section.
- Other instrumentation per coordination with FDOT project manager.

A schematic of instrumentation is shown in Figure 5. As shown in this figure, displacement/crack transducers will be installed straddling the epoxied splice section to determine the potential debonding/crack development at the joint. Furthermore, three displacement transducers (possibly laser sensors) will be installed between the bottom of the pile specimen, one near the splice section and two with a distance of 4ft from the splice section to obtain the deflected shape of the pile at different loading stages.

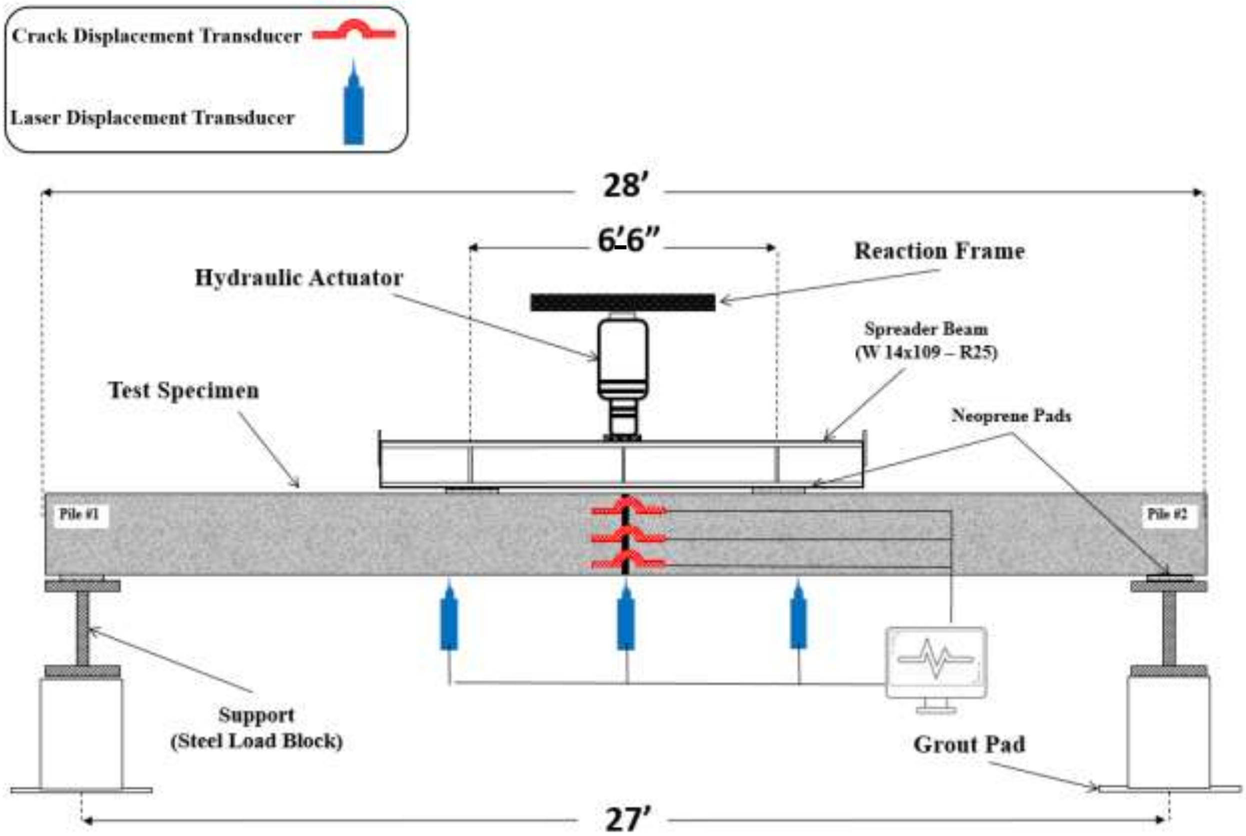


Figure 5: Instrumentation of the test Specimen

4 FLEXURAL CAPACITY OF THE TEST SPECIMENS

Figure 6 shows the moment diagram for a simply supported beam with two point loads in which the maximum moment is expressed by Eq. (1).

$$M_{max} = \frac{P}{2} * a \quad (1)$$

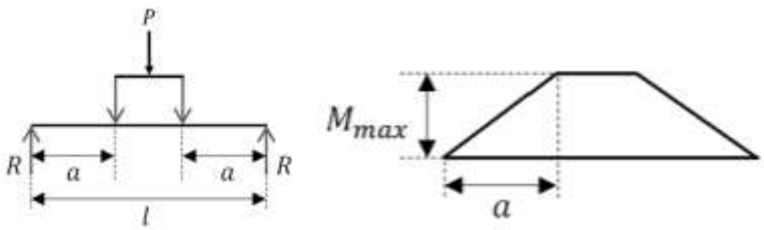


Figure 6: Moment diagram for two-point loading

Three load levels are used as reference during the flexural testing. “Initial Loading” is a low-level loading that is used to set the test setup before taking initial readings of the instrumentation. “Cracking Load” is a load level at which first flexural cracking occurs and the load-deflection curve deviates from linear elastic (Fig. 7). The “Ultimate Load” refers to the maximum load in flexural testing that corresponds to Maximum Moment Resistance of the section. The cracking load corresponds to cracking moment, M_{cr}, of the splice section. At the point of the cracking moment, the maximum tensile stress is considered to be f_t (Eq. 2).

$$f_t = 7.5\sqrt{f_c'} = \frac{7.5*\sqrt{6000}}{1000} = 0.581 \text{ ksi} \quad (2)$$

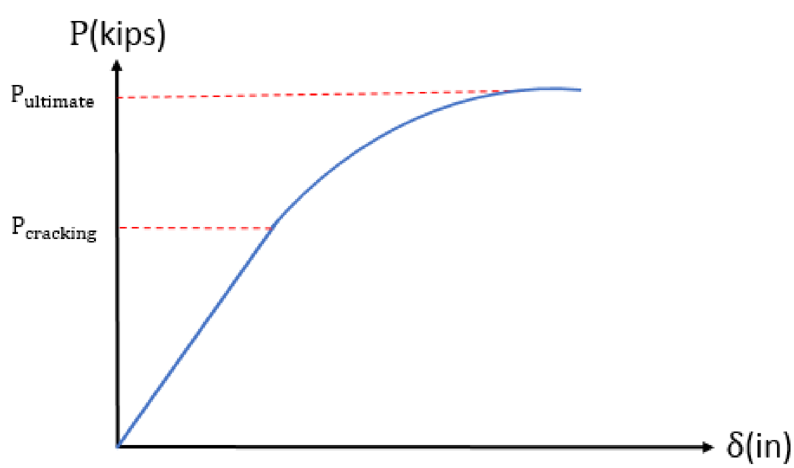


Figure 7: Schematic applied load against deflection in flexural testing

As a result, the cracking moment was calculated to be 47.06 k-ft for a 18x18 pile section. Using Eq. 2, the total applied load corresponding to cracking moment is estimated to be 9.2 kips.

$P = M_{cr}*2/a = 47.06 * 2 / 10.25 = 9.2$ kips (3)

To estimate the Ultimate Load, maximum moment resistance calculated in Task 2 of this project can be used. Maximum moment resistances (before application of resistance factor) for various types of dowel material for 18x18 in. piles splices are listed in Table 5. The ultimate load corresponding to each type of splice is also estimated and included in this table.

Table 5: Estimated ultimate loads of the test specimens

Dowel Material	Maximum Moment Resistance	Ultimate Load
Steel	293 ft-k	57.17 kips
GFRP	206.1 ft-k	40.21 kips
CFRP	207.69 ft-k	40.52 kips

5 LOADING PROCEDURE

The assembled test specimens will be handled and moved to install in the test setup with extreme caution to avoid damage to the splice section. Depending on the lifting devices, proper lifting locations will be determined to avoid application of significant moment at the splice location.

5.1 Loading Procedure

A 1-kip load will be initially applied and removed to set the supports and will be removed. Initial readings will be taken at this interval. Then the applied load will be increased at stages with different load rates and intervals to investigate the cracking and failure load and deflection at pile splice as shown in Tables 6 and 7.

Table 6: Loading details for test specimens using GFRP and CFRP Dowels (Specimens 1, 2, 3, 4, 5, 6, 9, and 10)

Steps	Start Load	End Load	Load Rate
Initial Loading	0 kips	1 kips	150 lbs/s
Initial Loading	1 kips	0 kips	150 lbs/s
1	0 kips	5 kips	150 lbs/s
2	5 kips	Cracking Load (~ 10 kips)	100 lbs/s
3	Cracking Load	20 kips	100 lbs/s
4	20 kips	30 kips	100 lbs/s
5	30 kips	35 kips	100 lbs/s
6	35 kips	Failure Load (~ 40 kips)	100 lbs/s

Table 7: Loading details for test specimens using Steel Dowel (Specimens 7 and 8)

Steps	Start Load	End Load	Load Rate
Initial Loading	0 kips	1 kips	150 lbs/s
Initial Loading	1 kips	0 kips	150 lbs/s
1	0 kips	5 kips	150 lbs/s
2	5 kips	Cracking Load (~ 10 kips)	100 lbs/s
3	Cracking Load	20 kips	100 lbs/s
4	20 kips	30 kips	100 lbs/s
5	30 kips	40 kips	100 lbs/s
6	40 kips	50 kips	100 lbs/s
7	50 kips	Failure Load (~ 57 kips)	100 lbs/s

5.2 Data Collection, processing and Interpretation

The entire test process will be videotaped. Data from instrumentations will be collected at acceptable frequency, e.g., 10 per second, and stored in data acquisition. At each loading interval, the test will be paused to inspect the specimen for cracks, openings and other events. The cracks and openings will be traced and marked with identifying designation. Photographs will be taken at the end of each pause.

After completion of the test, data will be processed to obtain;

- Load-displacement curves for each displacement transducer
- Load-deflection curves for the entire length of the specimen
- Load versus crack opening at splice section
- Moment-deflection curve at the splice location
- Moment-curvature curve at splice location

The maximum moment capacity of the spliced specimen will be calculated from the data.

6 REFERENCES

Standard Plans – Index Series 455. Florida Department of Transportation, Tallahassee, 2020-2021.

Standard Specifications for Road and Bridge Construction. Florida Department of Transportation, Tallahassee, January, 2020.