2018 FDOT-FRP Industry 2nd Winter Workshop

February 9, 2018

Orlando, FL

Part 1-Reports

Part 1 - Reports

a. FDOT FRP-RC implementation status

b. FDOT Materials Office update on durability focused research projects

c. Update on AASHTO LRFD Guide Specification for GFRP-RC (Antonio Nanni & Will Potter)

d. ACMA FRP-RMC update

e. Action Item Status from last year

2018 FDOT-FRP Industry 2nd Winter Workshop

February 9, 2018

Orlando, FL

FDOT State Materials Office - Update on durability focused research projects

(two projects)

Ivan Lasa ivan.lasa@dot.state.fl.us

Florida Department of TRANSPORTATION

BDV30 TWO 977-18

"Performance Evaluation of GFRP Reinforcing Bars Embedded in Concrete Under Aggressive Environments"

(May 2016 – May 2018)

FLORIDA STATE UNIVERSITY 1851

UNIVERSITY OF MIAMI

Research Goal

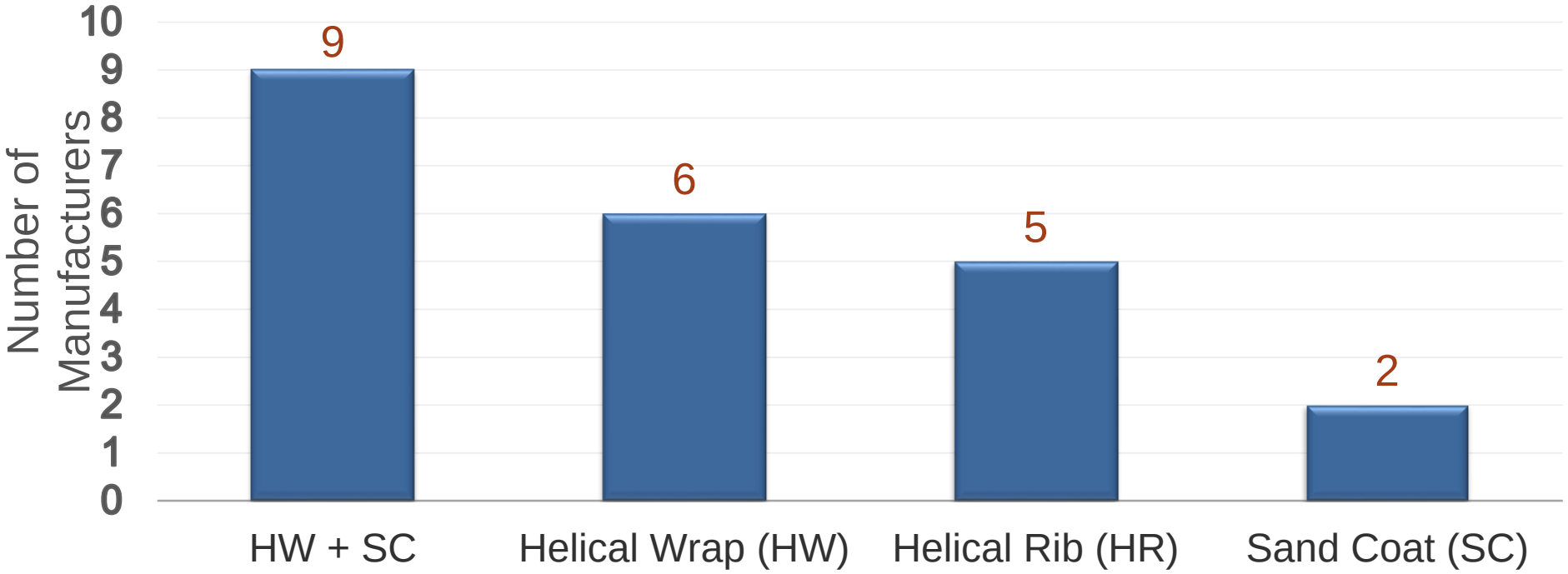
Goal:: Due to the variety in materials and manufacturing processes of FRP bars, the goal of this project is to identify any differences regarding performance and durability between these products.

This will assist in the modification of our specifications, as needed, to only use high performers. It should also provide us with a good idea of the most important properties to assist in the development of a good testing protocol for acceptance of bars at project level.

Research Focus

- Survey manufacturers
  - Types, sizes, surface features and properties of bars produced
- Select representative types of bars based on type of surface features
- Evaluate performance and durability of bond to concrete for each type under various exposure regimes
  - Establish durability model(s)

Types of surfaces produced



- Types selected for evaluation:
  - HW+SC, HW, and HR

Surface types selected for evaluation

- Three representative surface types

Helical Wrap + Sand (type A), Helical Wrap (type B), Helical Rib (type C)

Durability of bond

- Specimen preparation (ASTM D7913 Bond Strength to Concrete)

Figure 2: Concrete casting (left) and grip installation (right)

Durability of bond

- Exposure and testing
  - Circulating seawater at controlled temperatures

Figure 3: Exposure process of bond samples

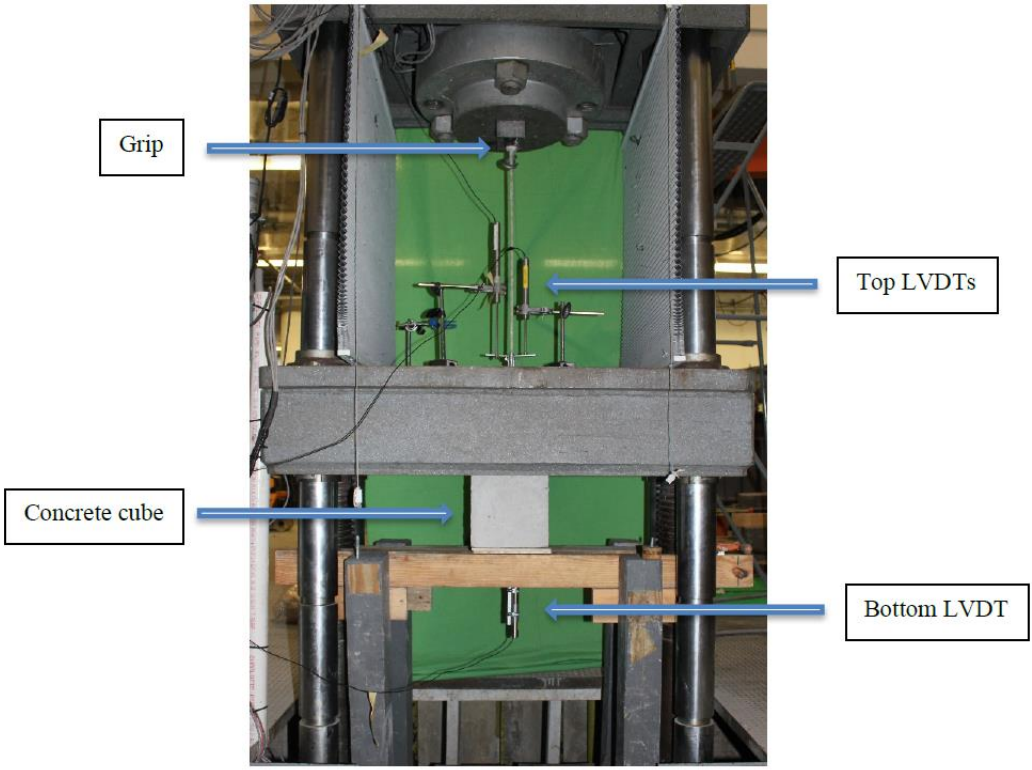
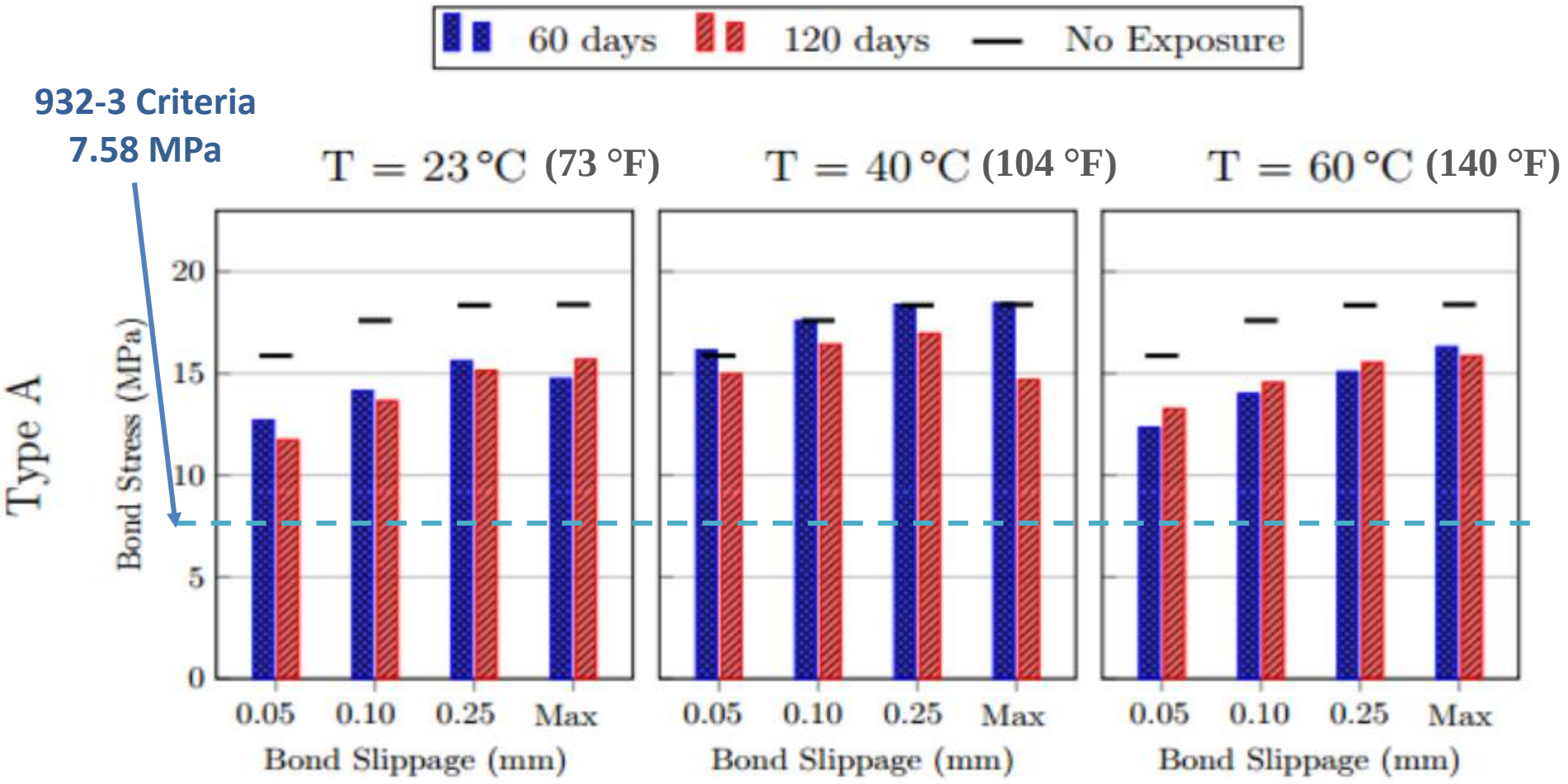


Figure 4: 'Pull-out test' configuration per ASTM D793

Ruiz, De Caso, Kampmann, Nanni; CICE 2018

Durability of bond

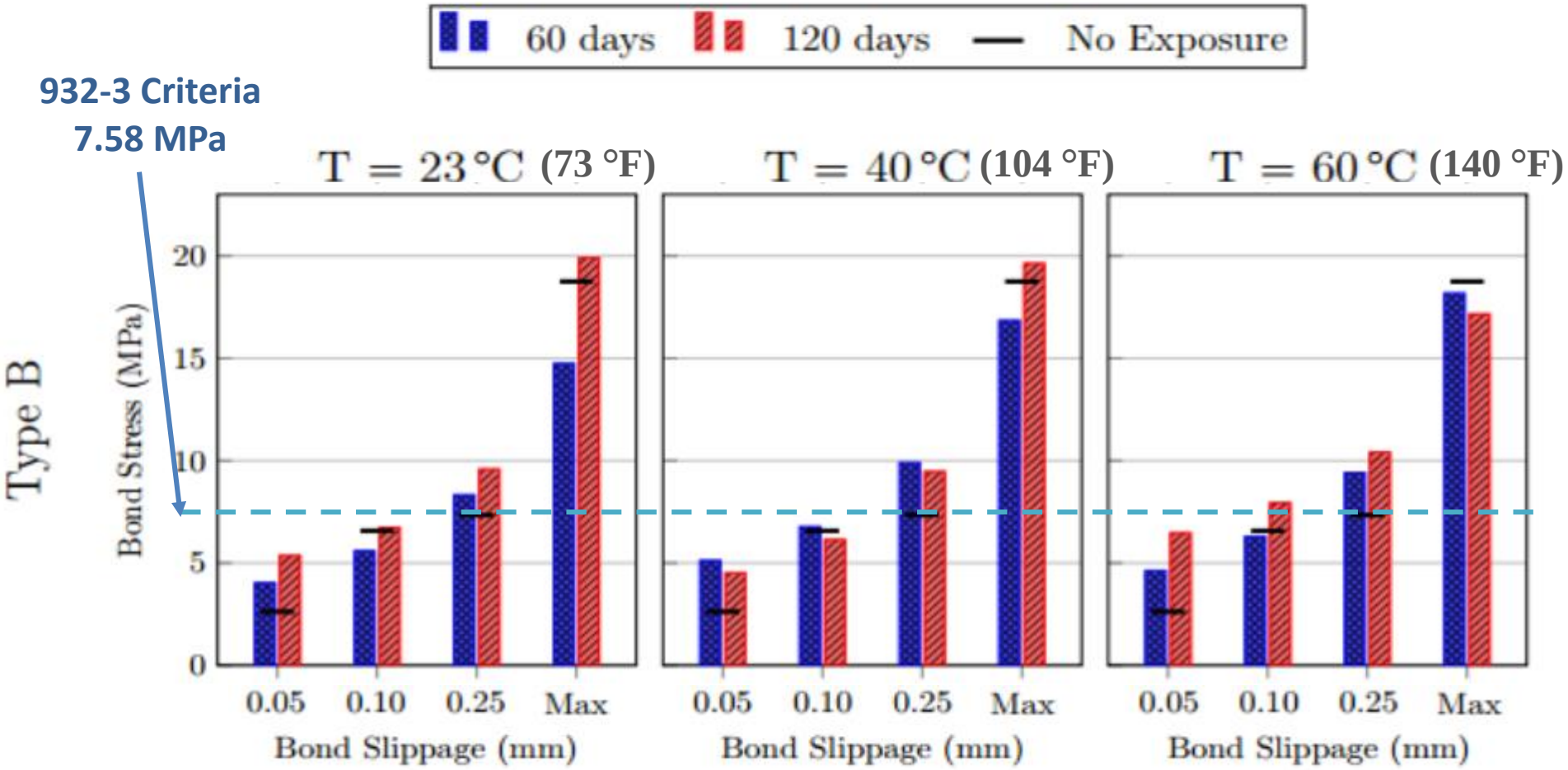
- Type A bars (HW+SC) up to 120 days



Ruiz, De Caso, Kampmann, Nanni; CICE 2018

Durability of bond

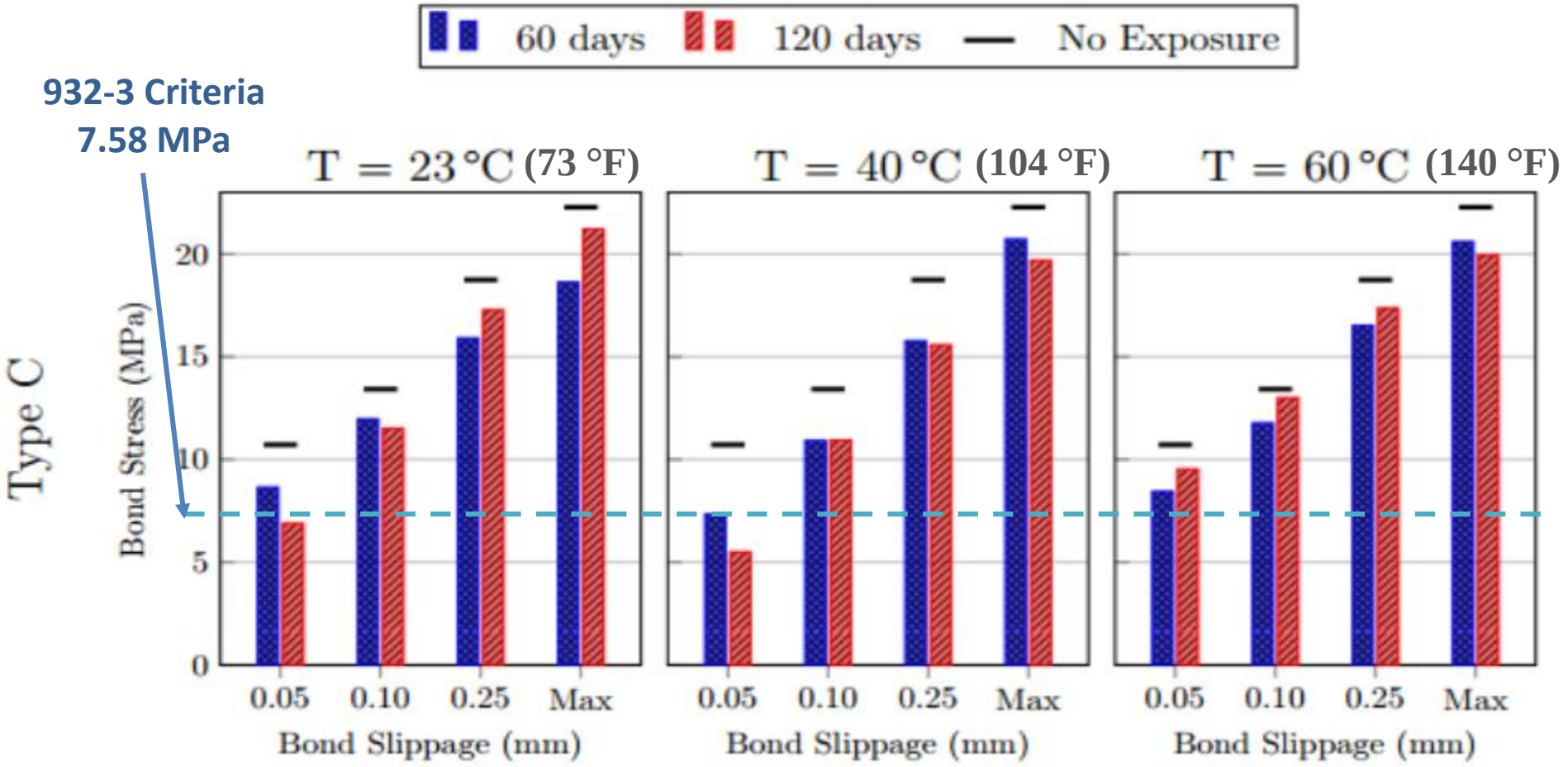
- Type B bars (HW) up to 120 days



Ruiz, De Caso, Kampmann, Nanni; CICE 2018

Durability of bond

- Type C bars (HR) up to 120 days



Ruiz, De Caso, Kampmann, Nanni; CICE 2018

Work to be completed

- Evaluate bond strength of samples aged for 210 and 365 days
- In-depth analysis of findings
- Propose durability model(s) and test protocol
- Propose updates to FDOT Specifications (Section 932) as necessary

Florida Department of TRANSPORTATION

BDV34 TWO 977-05

"Degradation Mechanisms and Service Life Estimation of FRP Concrete Reinforcements"

(April 2015 – June 2018)

UNF UNIVERSITY of NORTH FLORIDA

UNIVERSITÉ DE SHERBROOKE

NC STATE UNIVERSITY

Research Goal

Goal:: This project is a continuation of previous work by the same group.

The goal is to identify the level of degradation of CFRP strands under several accelerated aging regimes by means of alkali resistance monitoring.

The work also includes some testing on GFRP bars.

CFRP Strand – Research Focus

- Alkali resistance of CFRP strands under load
- Accelerated aging of CFRP prestressed concrete elements
- Durability of constituent materials using accelerated methods
- Some testing on GFRP bars also included

CFRP Strand – Alkali Resistance

- ASTD D7705 (Alkali Resistance of FRP Bars)

w/ specimens tested under following conditions:

  - Sustained loading 65%
  - Alkaline solution: 12.6-13.0 pH
  - Temperature: 77 °F and 130 °F
  - Duration : 3000, 5000 and 7000 hours

CFRP Strand – Alkali Resistance

- Test Matrix

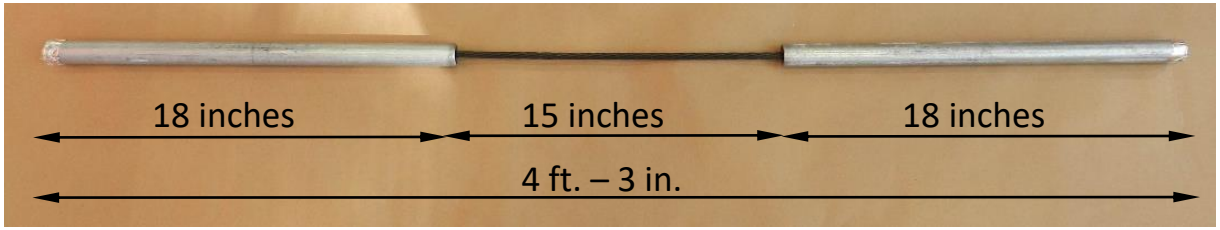
Load	Alkali Solution	Duration of exposure (hr)	Temp. (°F)		No. of specimens
0%	No	As received	77		5
	No	3000	130		5
	No	5000	130		5
	No	7000	130		5
	Yes	3000	77	130	10
	Yes	5000	77	130	10
	Yes	7000	77	130	10
65%	No	3000	77	130	10
	No	5000	77	130	10
	No	7000	77	130	10
	Yes	3000	77	130	10
	Yes	5000	77	130	10
	Yes	7000	77	130	10
Total					110

Highlighted testing performed in previous Phase

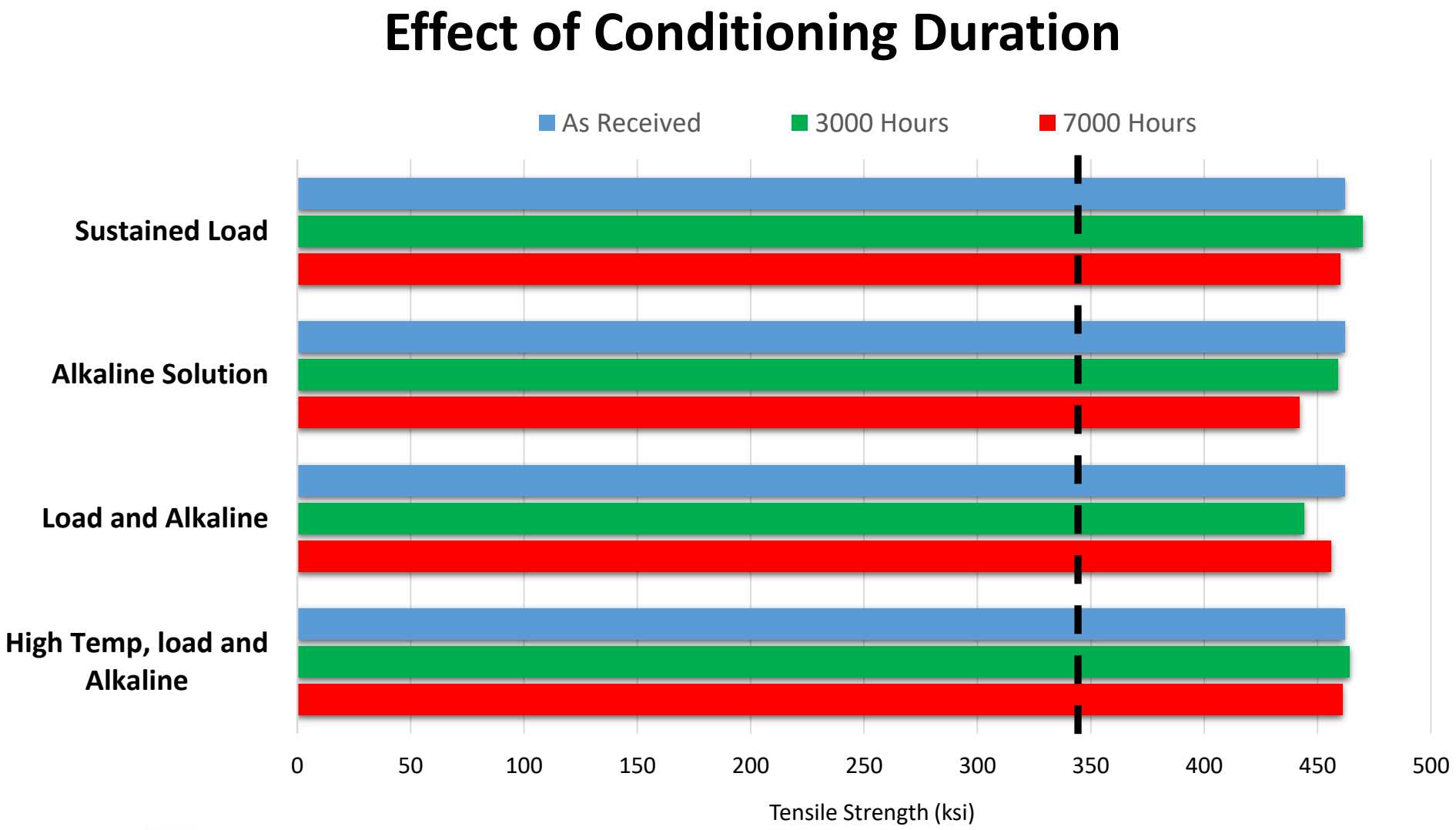
CFRP Strand – Alkali Resistance

Accelerated Aging Apparatus

Typical Dimensions of Tensile Test Specimens

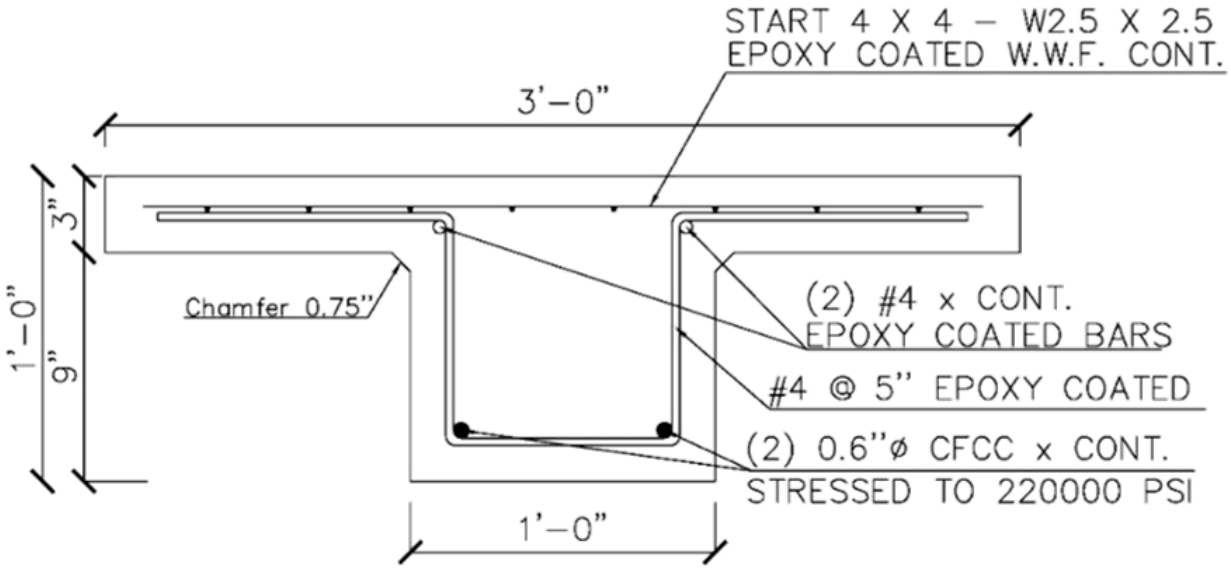


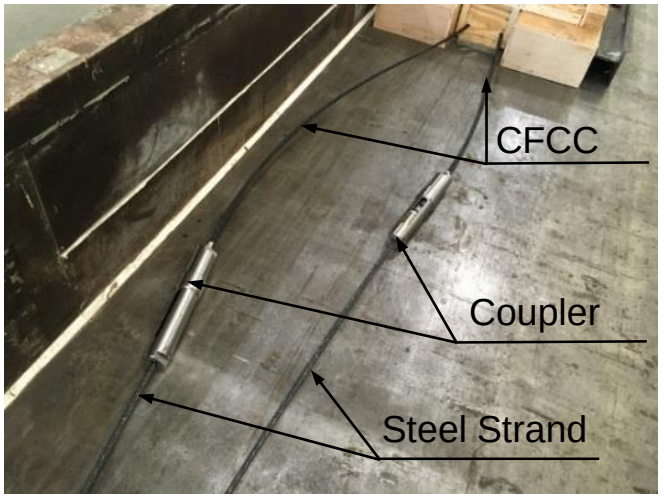
CFRP Strand – Alkali Resistance



CFRP Strand – Aging in Concrete

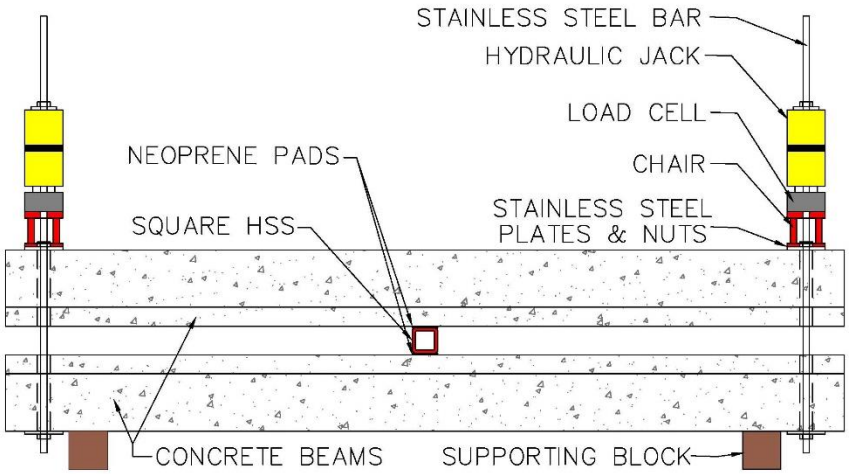
Construction of 12 Concrete Beams Gate Precast Company, Jacksonville, Florida.

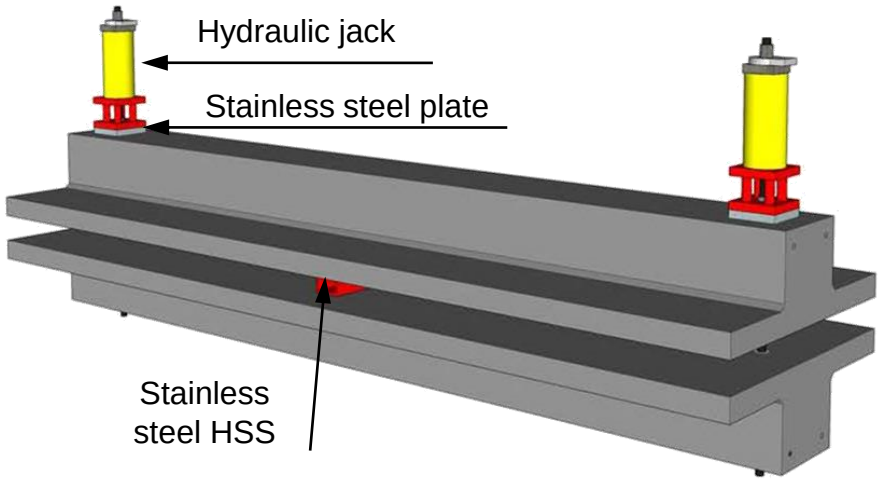


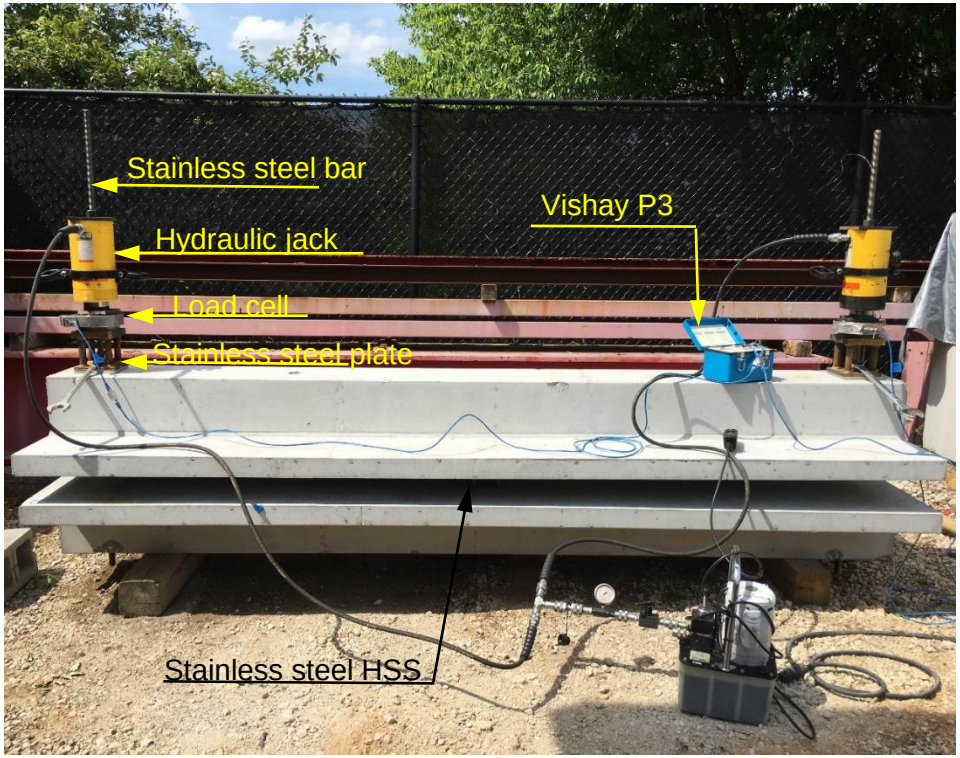


Design Criteria: Rupture of strands

CFRP Strand – Aging in Concrete

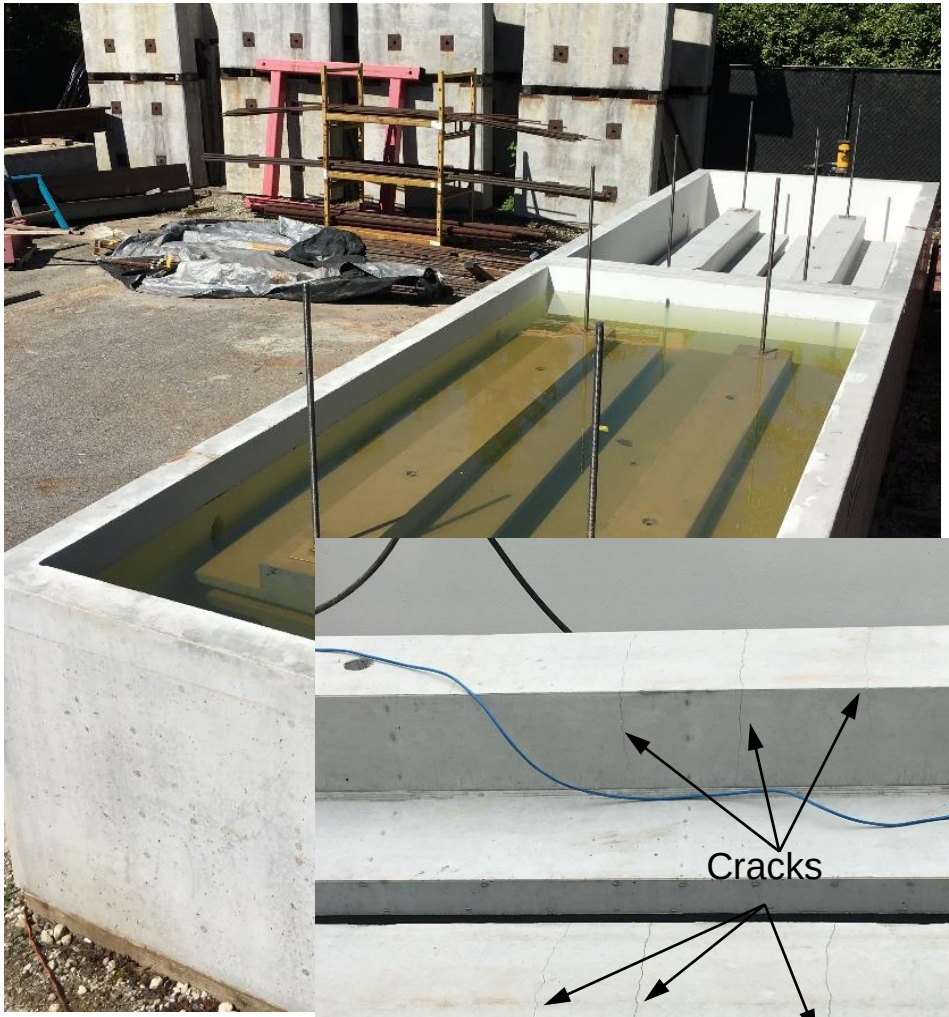






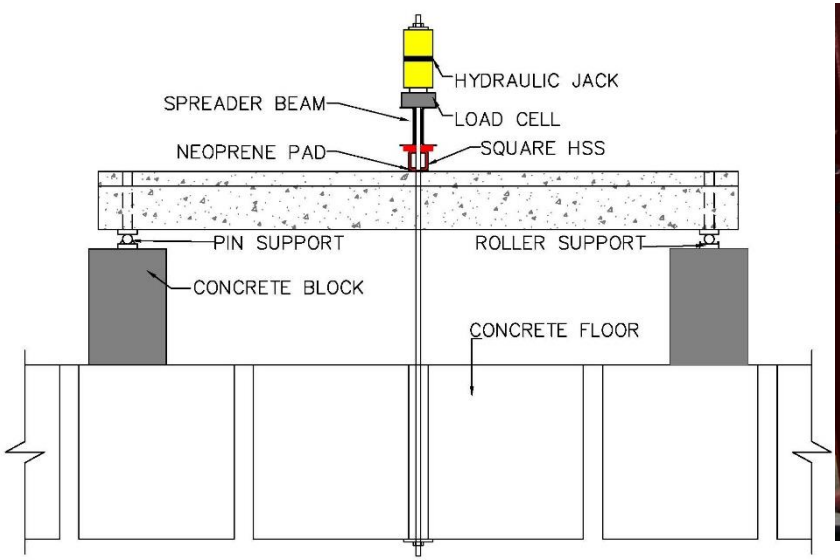
Pre-cracking beams before placing in solution

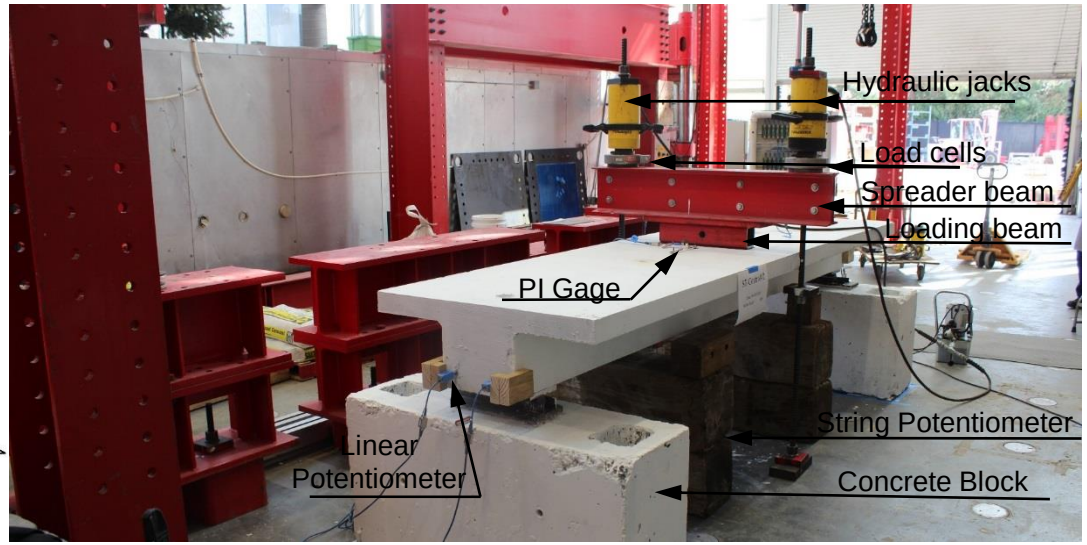
CFRP Strand – Aging in Concrete

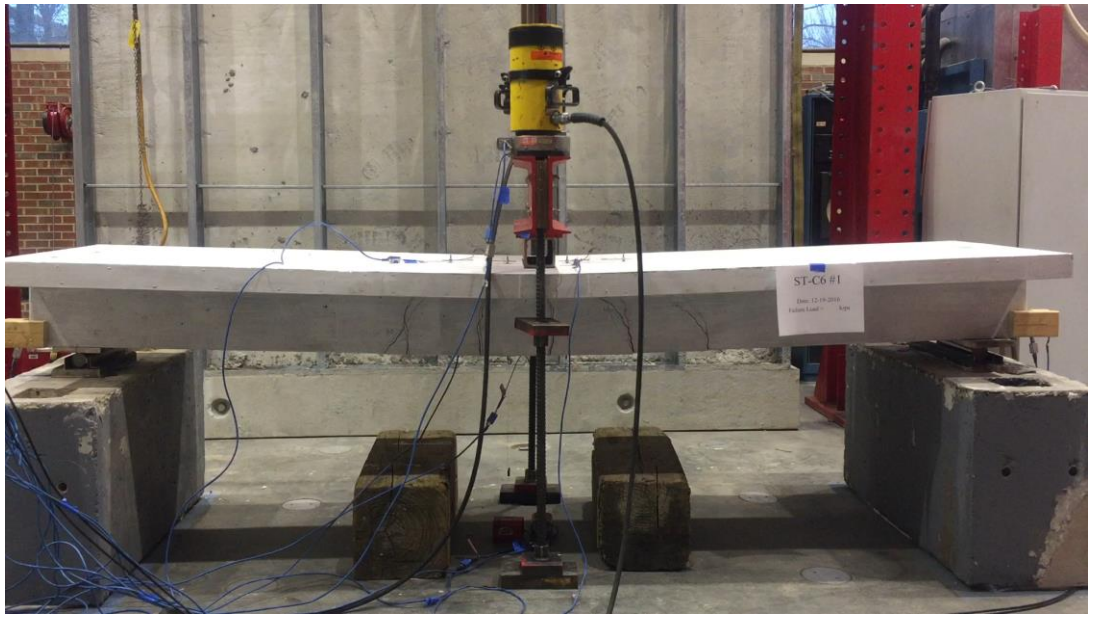


Placing pre-cracked beams in solution

CFRP Strand – Aging in Concrete

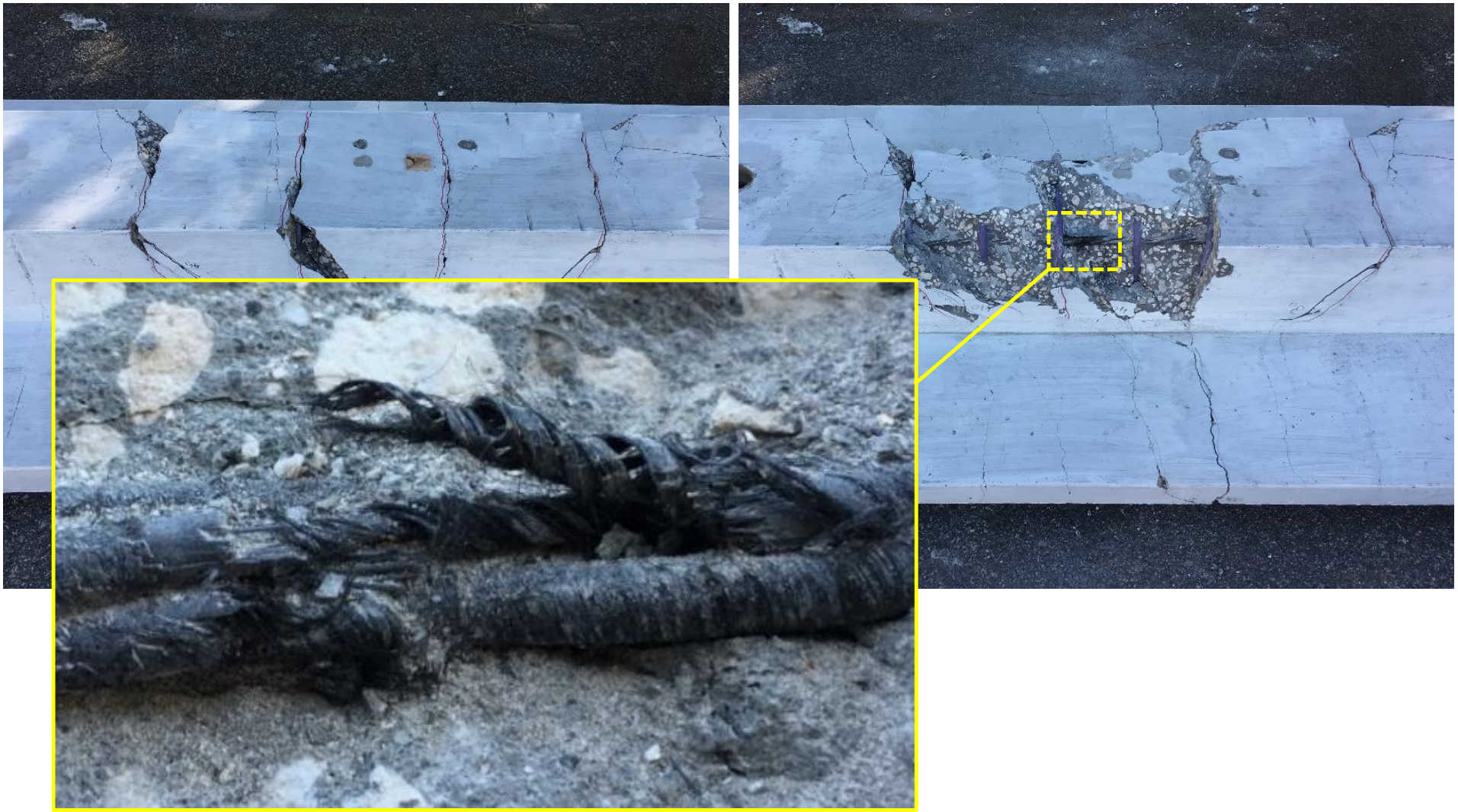




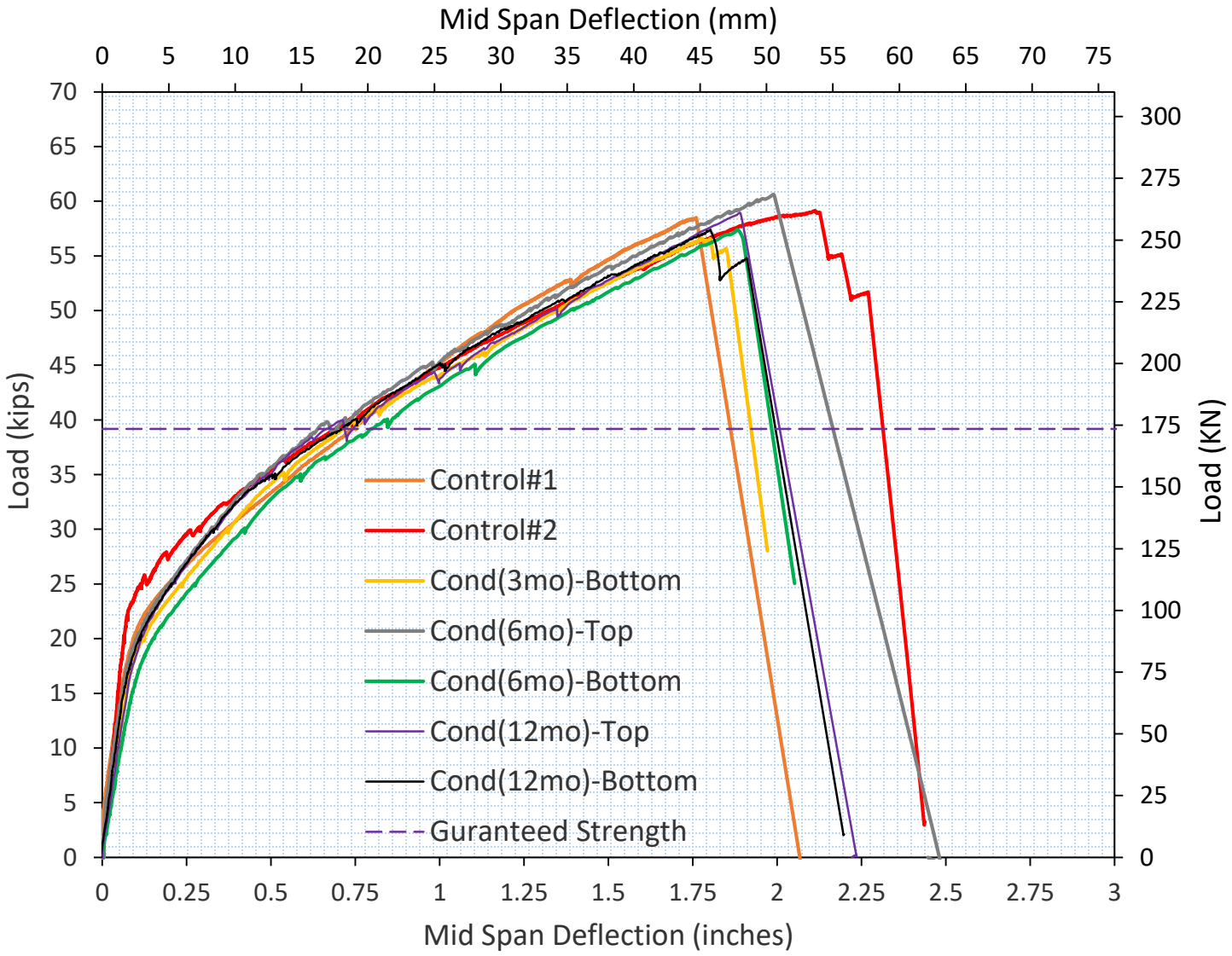


CFRP Strand – Aging in Concrete

Strand Rupture (achieved desired failure mode of beams)



CFRP Strand – Aging in Concrete



Ongoing test

CFRP Strand – Constituent durability

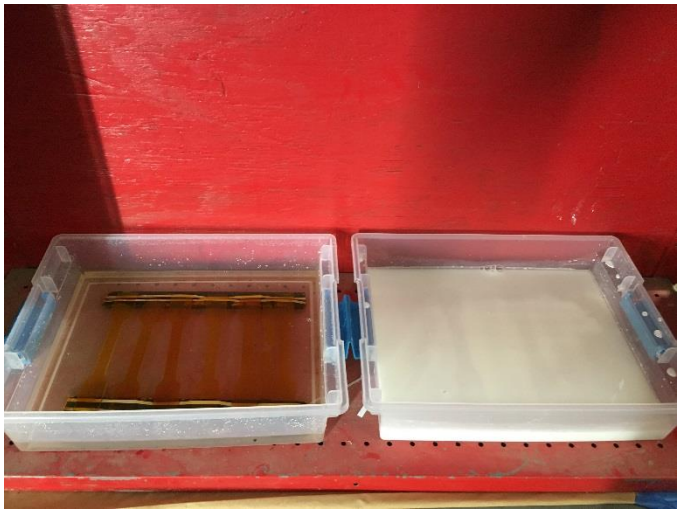
Epoxy Plate

Solution	Duration of exposure (hr)	Temp. (°F)	No. of specimens
N/A	As received	N/A	3
Water	3000	77 & 130	6
Water	7000	77 & 130	6
Alkali	3000	77 & 130	6
Alkali	7000	77 & 130	6
Total			27

Carbon Fibers

Solution	Duration of exposure (hr)	Temp. (°F)
N/A	As received	N/A
Water	3000	77 & 130
Water	5000	77 & 130
Water	7000	77 & 130
Alkali	3000	77 & 130
Alkali	5000	77 & 130
Alkali	7000	77 & 130

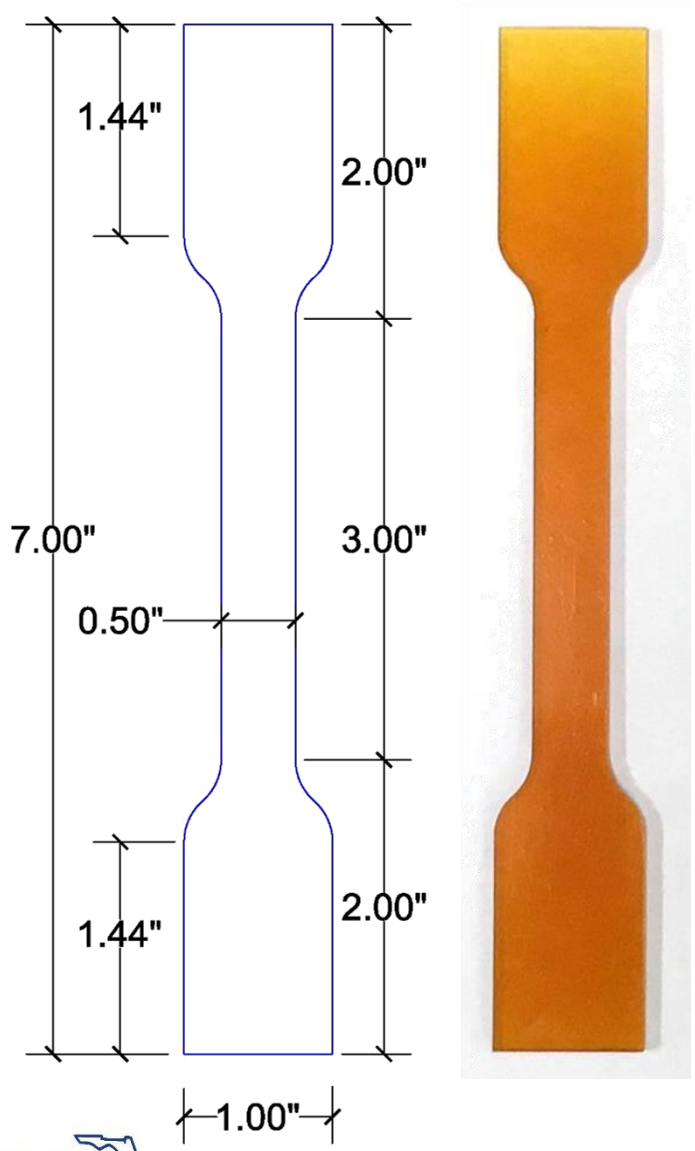
CFRP Strand – Constituent durability

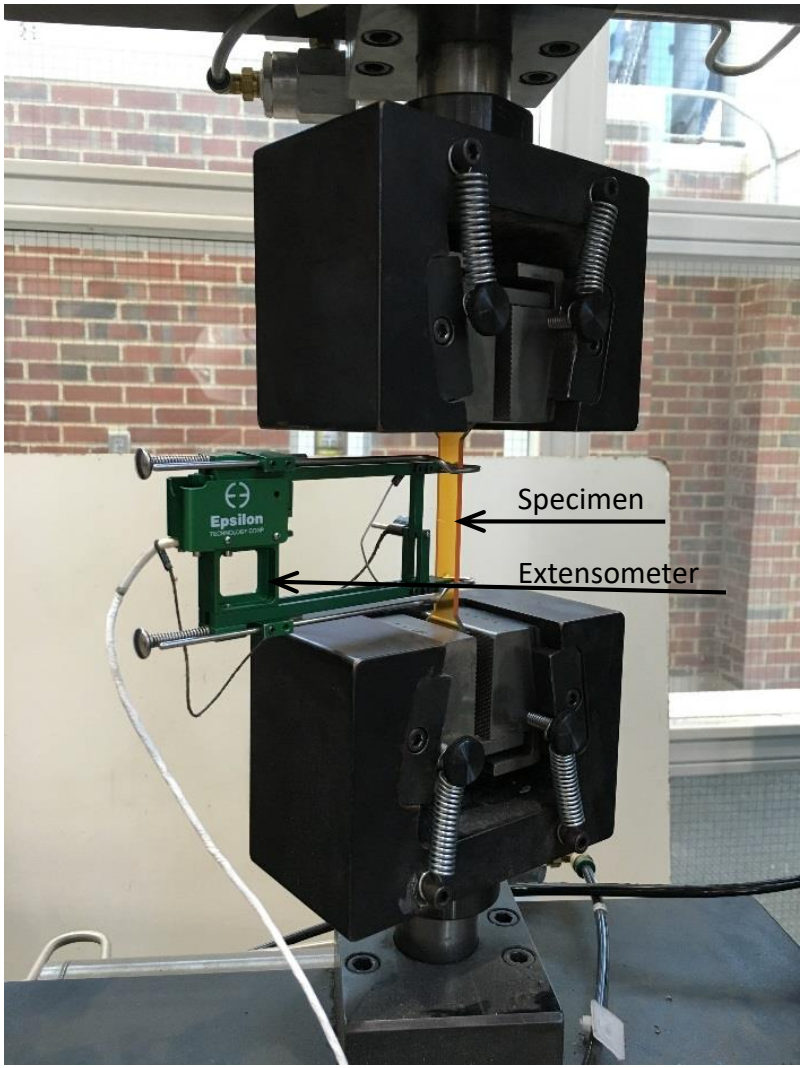


Epoxy coupons and fibers subjected to water and alkaline solution at 77 ^{o}F.

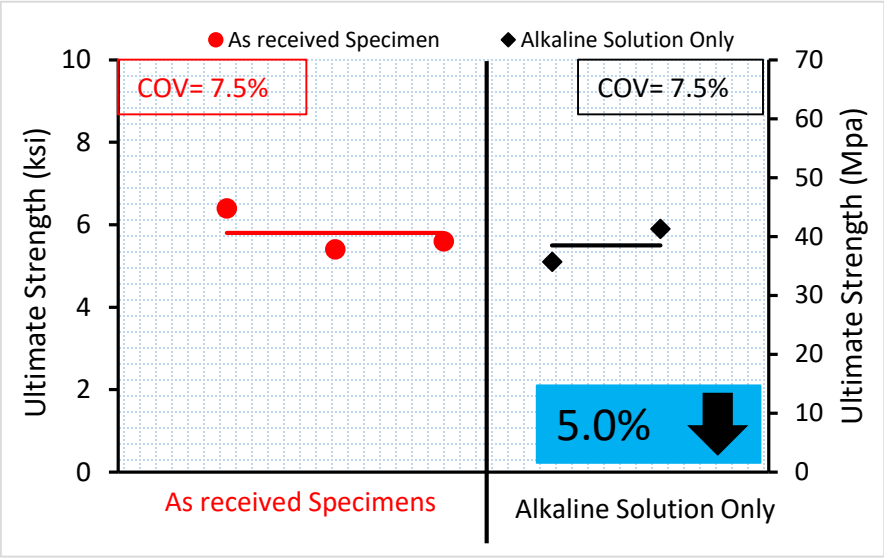
Epoxy coupons and fibers subjected to water and alkaline solution at high temperature.

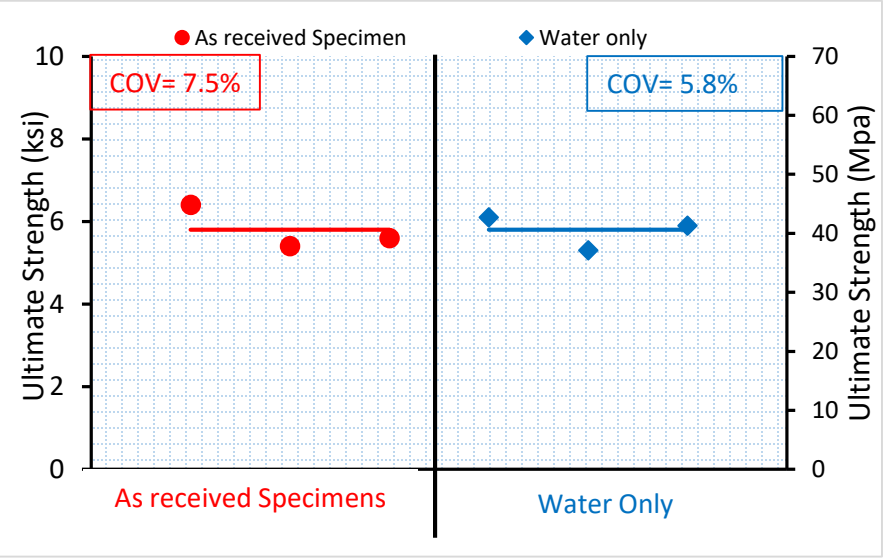
CFRP Strand – Epoxy durability

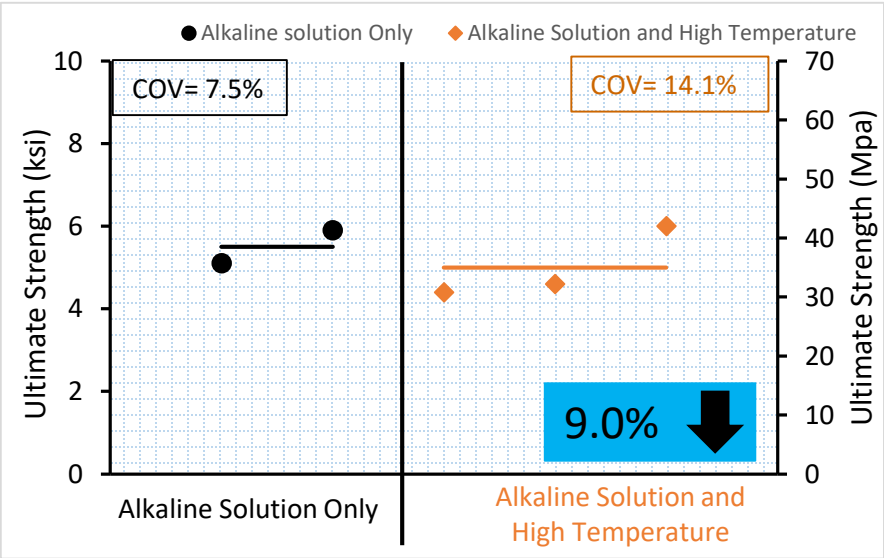


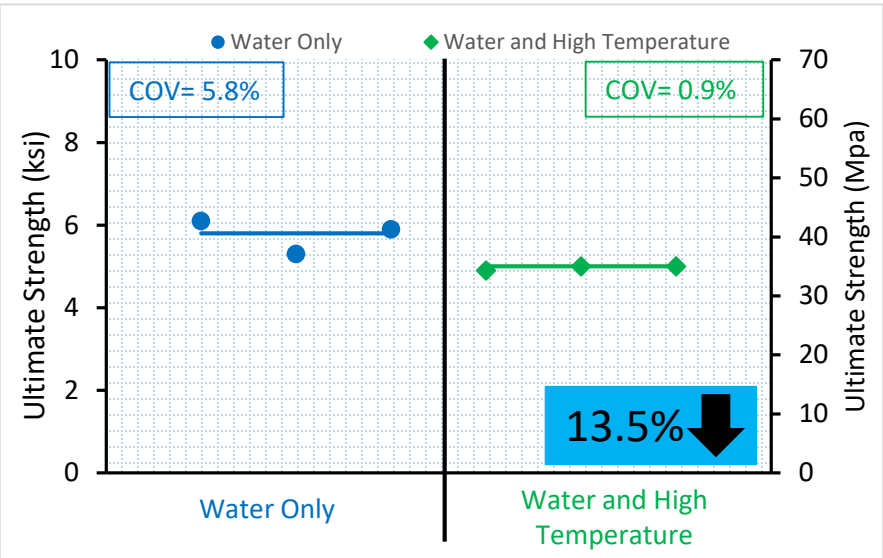


CFRP Strand – Epoxy durability





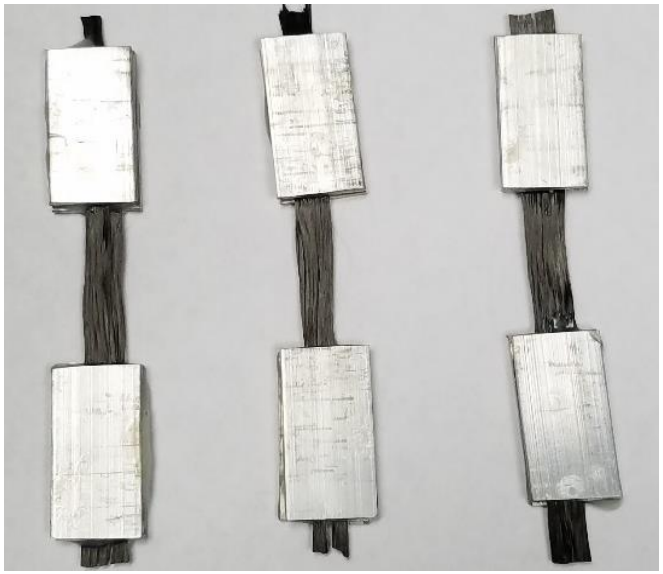




Results after exposure

cov=coefficient of variance

CFRP Strand – Carbon fiber durability



Carbon fiber tow specimens prepared to be tested after exposure

CFRP Strand – Continuing Work

- Evaluate CFRP pre-stressed beams after 18 months exposure
- In-depth analysis of findings
- Propose durability models and test protocols based on degradation mechanism(s)
- Propose updates to FDOT Specifications (Section 933) as necessary

THANKS