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HALLS RIVER BRIDGE BULKHEAD-SEAWALL REPLACEMENT CHALLENGES, AND A WAY FORWARD

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MIAMI

FDOT

Paper 75: Bridge Bulkhead-Seawall Replacement Challenges, and a Way Forward

Abstract:
The Halls River Bridge project included the replacement and widening of the existing bulkhead-seawall system. The existing 1954 system utilized shallow tipped concrete sheet piles with deadman pile anchors, presumably due to the shallow subsurface limestone rock strata. With the 2016 bridge replacement it was desired to utilize a cantilevered bulkhead system and eliminate the tieback anchors due to both constructability and long-term maintenance concerns. Soil borings at the site indicated near surface difficult driving conditions through weathered limestone, which typically preclude the use of a conventional jetting installation method for precast concrete sheet piling. Plan notes were added to the contract documents making the contractor aware that trenching for the installation of the precast concrete sheet piles may be necessary. Additionally, the precast concrete sheet piles where to be prestressed and reinforced with innovative materials, CFRP and GFRP respectively, for enhanced durability. The bid prices received on the project were significantly higher than the historical cost average, indicating that bidders were aware of the installation risks and additional cost of the FRP materials. During construction operations, the contractor attempted several installation alternatives, including: dynamic and vibratory driving; pre-punching; and pre-auguring, before reverting to the suggested trenching installation method. This paper explores the additional costs incurred due to trench installation methods for the cantilevered bulkhead, the versatility of the FRP-PC components that were eventually modified, and the potential mitigation strategies for owners with similar challenges on future projects. A modified FRP-RC/PC soldier pile wall system will be presented with an emphasis on highlighting improvements that have become possible with the refinement of design parameters for FRP materials under sustained loading in both the first edition of AASHTO Guide Specification for the Design of Concrete Bridge Beams with CFRP Systems, and the AASHTO Bridge Design Guide Specification for GFRP Reinforced Concrete (2nd Edition).

Introduction

- Halls River Bridge included the replacement and widening of the existing bulkhead-seawalls.
- Existing 1954 system utilized shallow tipped thin concrete sheet piles with deadman pile anchors.
- Shallow subsurface limestone rock strata and unrestricted access for tie-back and deadmen installation for the first bridge at the site.
- The 2016 bridge replacement it was desired to utilize a cantilevered bulkhead system and eliminate the tieback anchors due to both constructability and long-term maintenance concerns.
- Similar anchored wall systems experience severe distress at the anchor connection due to corrosion of the precast tie-beams

Courtney Campbell Causeway, seawall (Tampa Bay)

Gandy Blvd. seawall, (Tampa Bay)

Introduction – Why is this important?

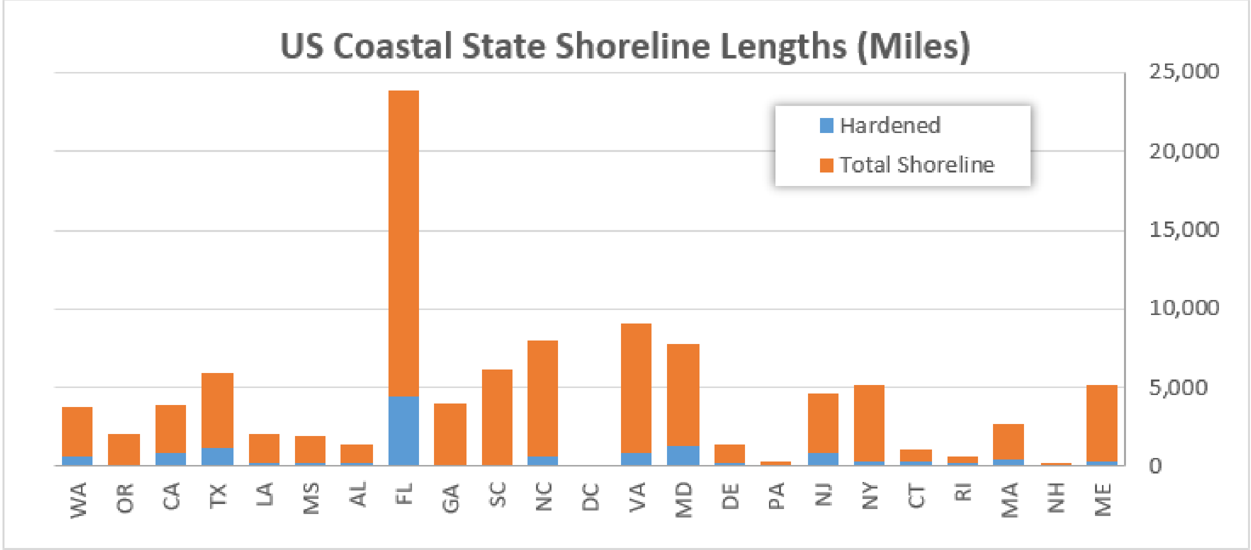
- Florida at the longest hardened "sheltered" shoreline in the USA

WebTable 3. Shoreline hardening and population statistics by state

	Hard sheltered shore (km)	Sheltered shore (km)	Hard sheltered shore (%)	Hard open shore (km)	Open shore (km)	Hard open shore (km)	Hard shore (km)	Total shore (km)	Hard shore (%)
Atlantic									
Connecticut	477	1907	25	0	0		477	1907	25
Delaware	287	2163	13	5	45	11	292	2208	13
DC	29	54	53	0	0		29	54	53
Florida*	2694	11 365	24	58	628	9	2752	11 992	23
Georgia	92	6340	1	14	158	9	106	6498	2

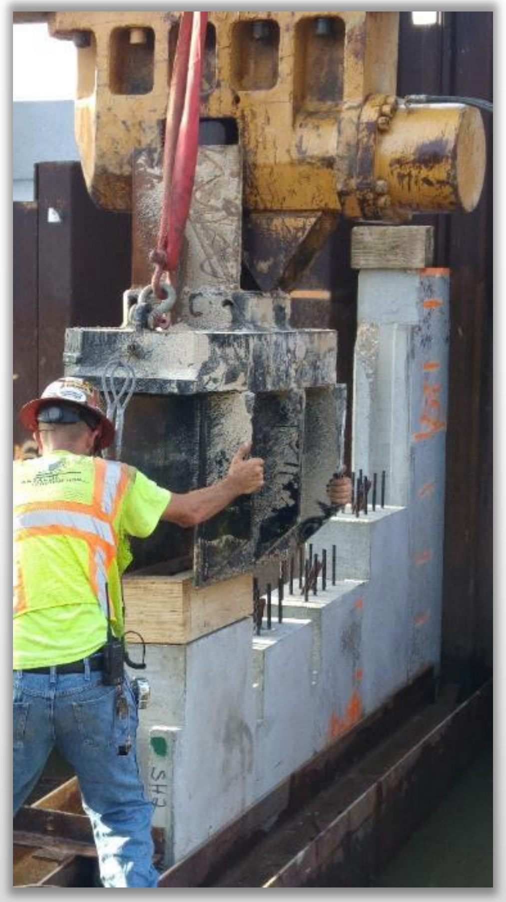
	Hard shore (km)	Total shore (km)	Hard shore (%)
Gulf			
Alabama	356	2606	14
Florida*	4427	26 383	17
Louisiana‡	353	3305	11
Mississippi	367	3033	12
Texas	1886	9612	20
Pacific			

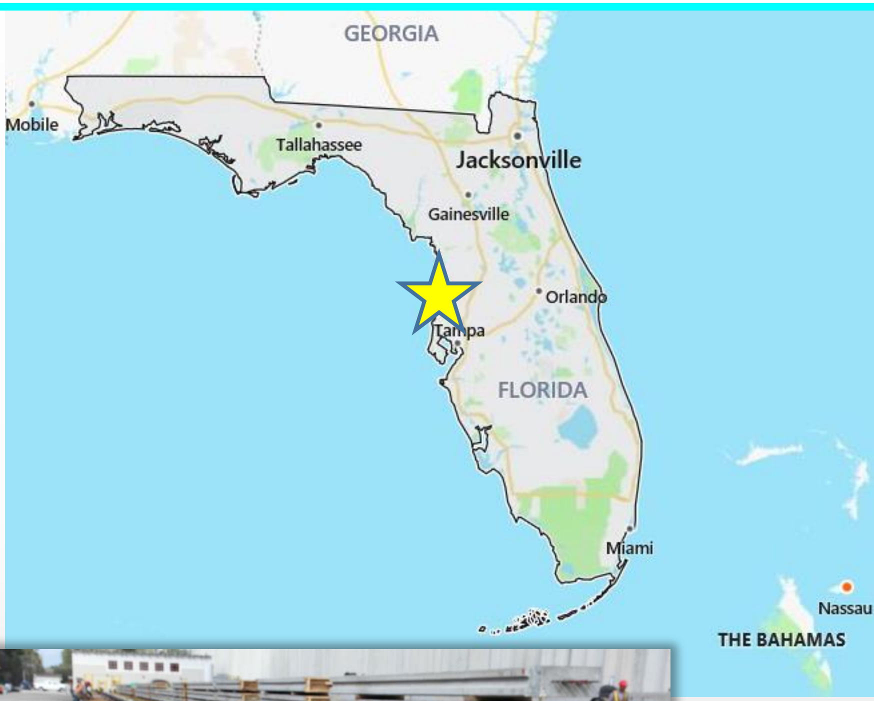
(Gittman & al. 2015).



FRP-RC/PC Demonstration Bridge

Halls River Bridge, Homosassa (2017-19)



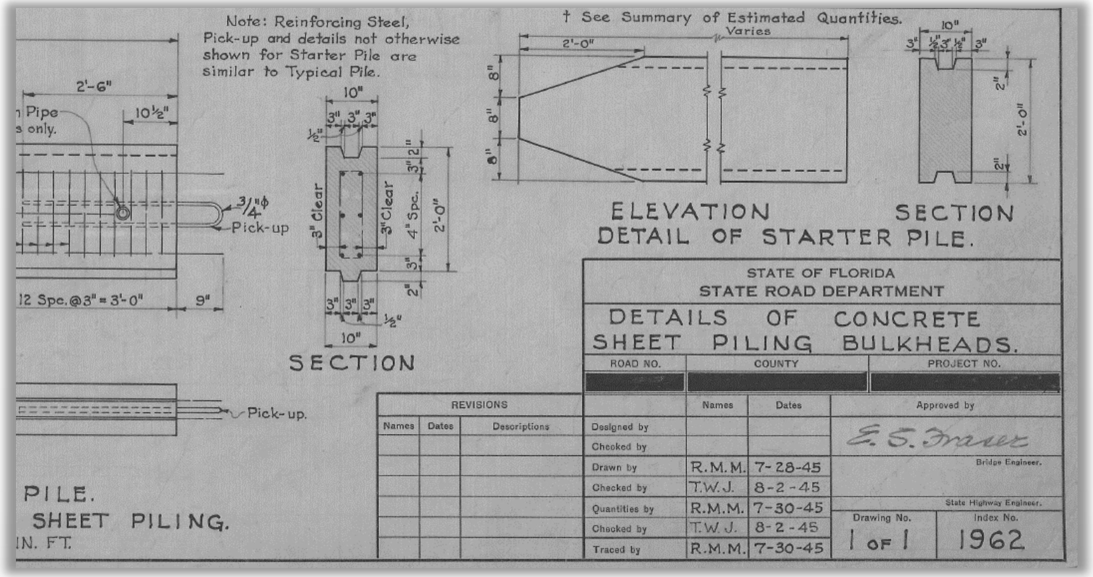


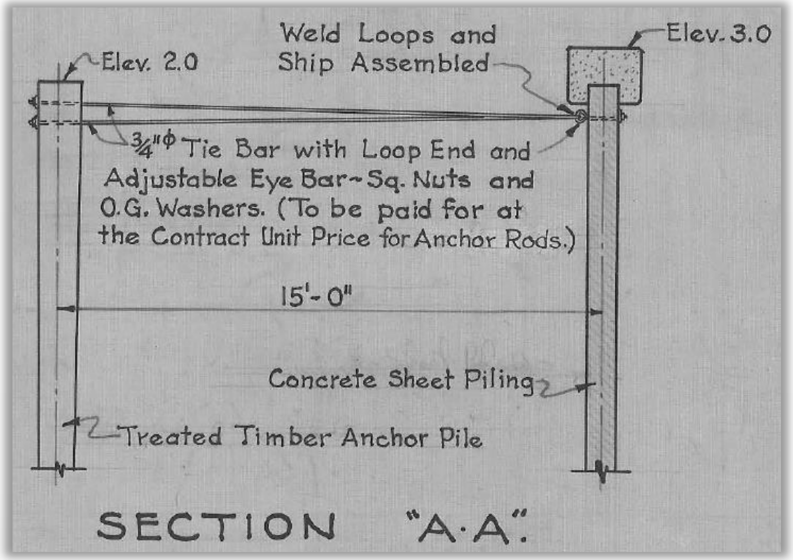
Halls River Bridge Fast-Facts:
https://www.fdot.gov/structures/innovation/FRP.shtm#link9

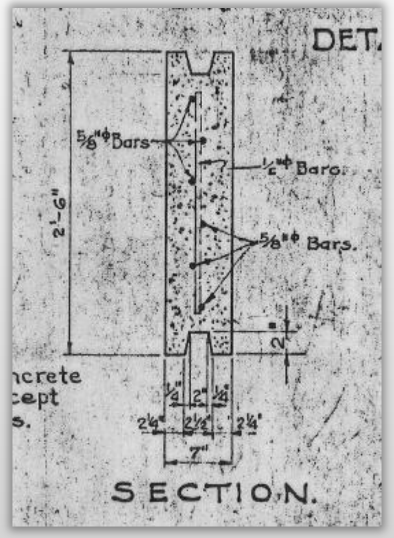
Original HRB Bulkhead-Seawall System

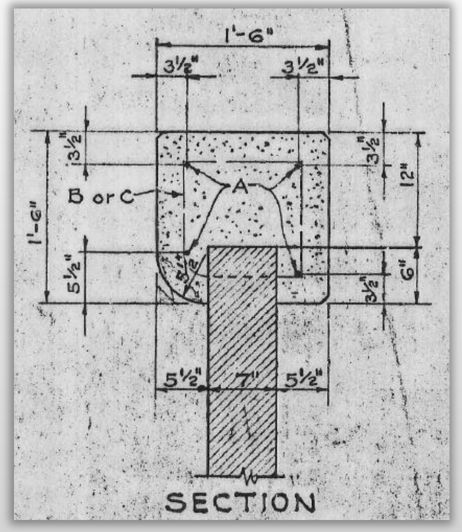
- Coastal Bulkheads in Florida, typically consist of cantilevered or anchored concrete sheet pile walls with cast-in-place caps.
- Anchored wall systems typically use precast RC tie-beams with isolated sheet piles as deadman.
- Concrete cover on sheet pile wall systems provides a temporary barrier against salt water in uncracked concrete, it is not impermeable so eventually the reinforcing and prestressing steel will corrode.
- The proposed bridge had a wider footprint.
- A cantilever-wall design was preferred to avoid conflicts with the existing 1954 anchored-walls which used deadman and precast beam tie-backs to support the anchored wall, and other constructability concerns
- The cantilever-wall design provided many benefits, but the soil borings revealed a potential disadvantage – with a relatively high limestone layer

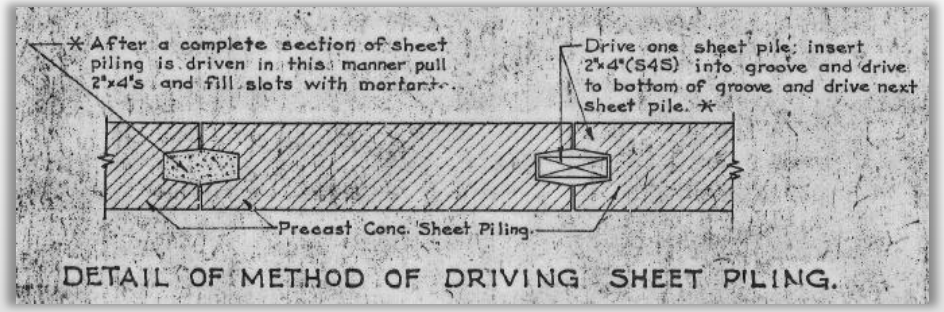
Historical Concrete Sheet Pile Systems in Florida





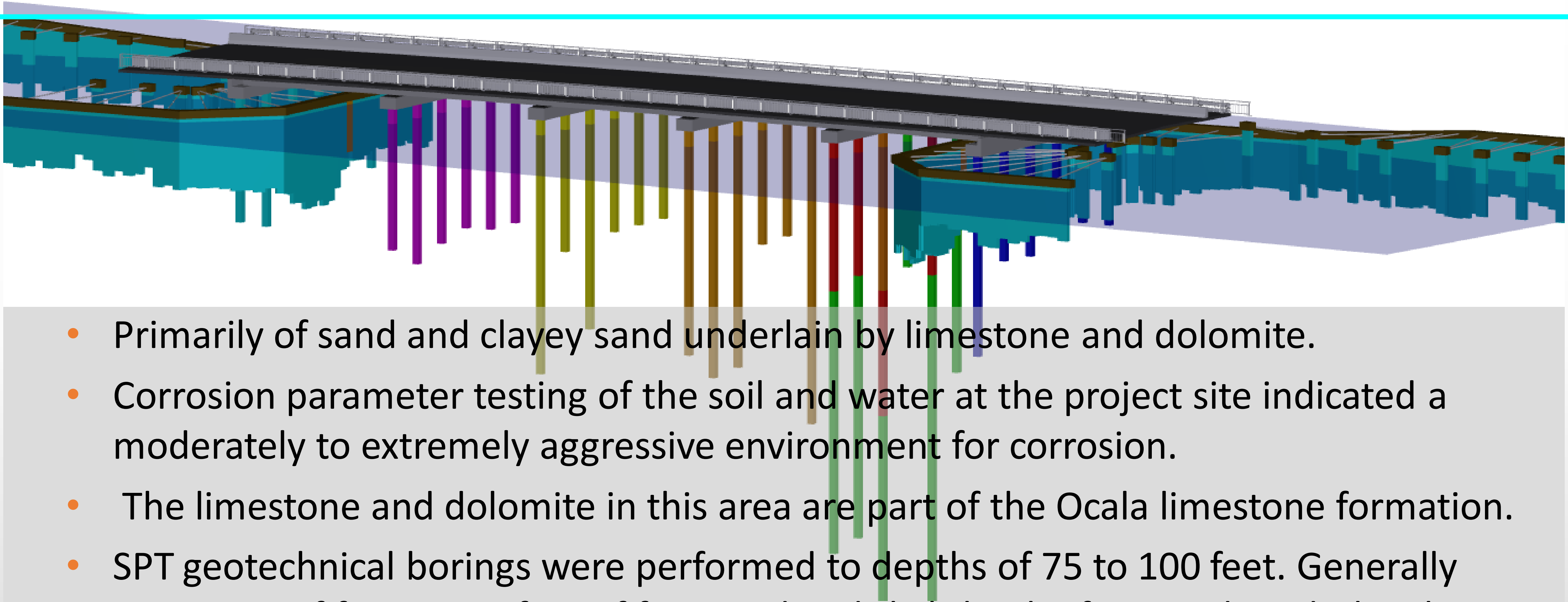






Images from 1945 (Index 1962) & 1946 (Index 2039) Standards. Florida State Road Dept. (FDOT)

Geotechnical and Environmental Conditions



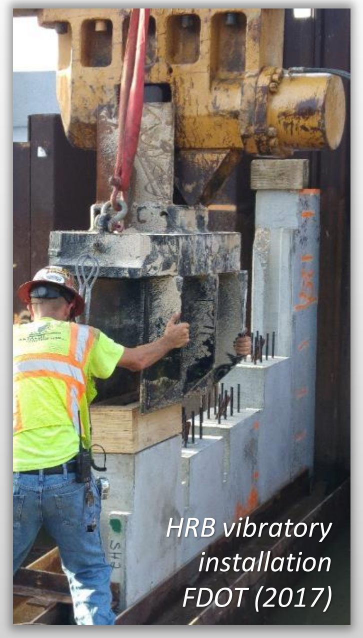
- Primarily of sand and clayey sand underlain by limestone and dolomite.
- Corrosion parameter testing of the soil and water at the project site indicated a moderately to extremely aggressive environment for corrosion.
- The limestone and dolomite in this area are part of the Ocala limestone formation.
- SPT geotechnical borings were performed to depths of 75 to 100 feet. Generally consisting of five to ten feet of fine sand and slightly silty fine sand, underlain by highly weathered limestone (SPT N-Values varied 2 to 30) interbedded with layers of competent weathered limestone (SPT N-Values of 60+)

Modifying the HRB Bulkhead-Seawall Design

- During the bulkhead-seawall construction, the contractor encountered had difficulty with the installation from the first day.
- Variety of methods were tried attempted (pre-punching, grinding, and trenching but the construction rate was resulted in significant delays.
- Additional borings were taken to determine, but only confirmed the soil parameters found with the earlier previous borings.

Table of Initial Sheet Pile Installation Progress:

Month	Installed	Cumulative Wall Length
Feb 2017	0 feet	0 feet
Mar 2017	0 feet	0 feet
Apr 2017	0 feet	0 feet
May 2017	140 feet	140 feet (2.24%)
June 2017	80 feet	220 feet (3.52%)
July 2017	130 feet	350 feet (5.60%)
Aug 2017	116 feet	466 feet (7.50%)


HRB vibratory installation FDOT (2017)


Pre-forming at Courtney Campbell Causeway, FDOT (2011)

Lessons Learned

- While installing sheet piling using preformed pile holes, punching, trenching and/or other methods is possible, it is very difficult and time consuming.
- Contractors have difficulty in correctly estimating the effort, in both costs and time, needed to complete this work.
- Serious consideration should be given in lengthening bridges in order to eliminate these walls when at all possible.
- Using alternative wall types, such as pile or shaft supported or secant pile walls, should also be considered to minimize the constructability issues.

Alternative Corrosion-Resistant system

Soldier Pile and Panel

- Popular bulkhead configuration in southeast Florida where there is a shallow subsurface layer of moderately hard rock (Miami Limestone/Oolite).
- The soldier (or king) pile system allows preformed or bored pilot holes to assist driving vertical prestressed piles to a minimum tip elevation to secure the toe of the wall.
- These soldier piles support vertical precast concrete panels via. direct bearing on the back face of the pile.
- The durability of these systems can be enhanced with the simple substitution of FRP reinforcing and prestressing. This approach is currently being utilized on two projects in south Florida for the FDOT
    - **NE 23rd Ave over Ibis Waterway bridge replacement;**
    - **SR-5 (US 41) over North Creek bridge replacement.**

Alternative Corrosion-Resistant system

Soldier Pile and Panel

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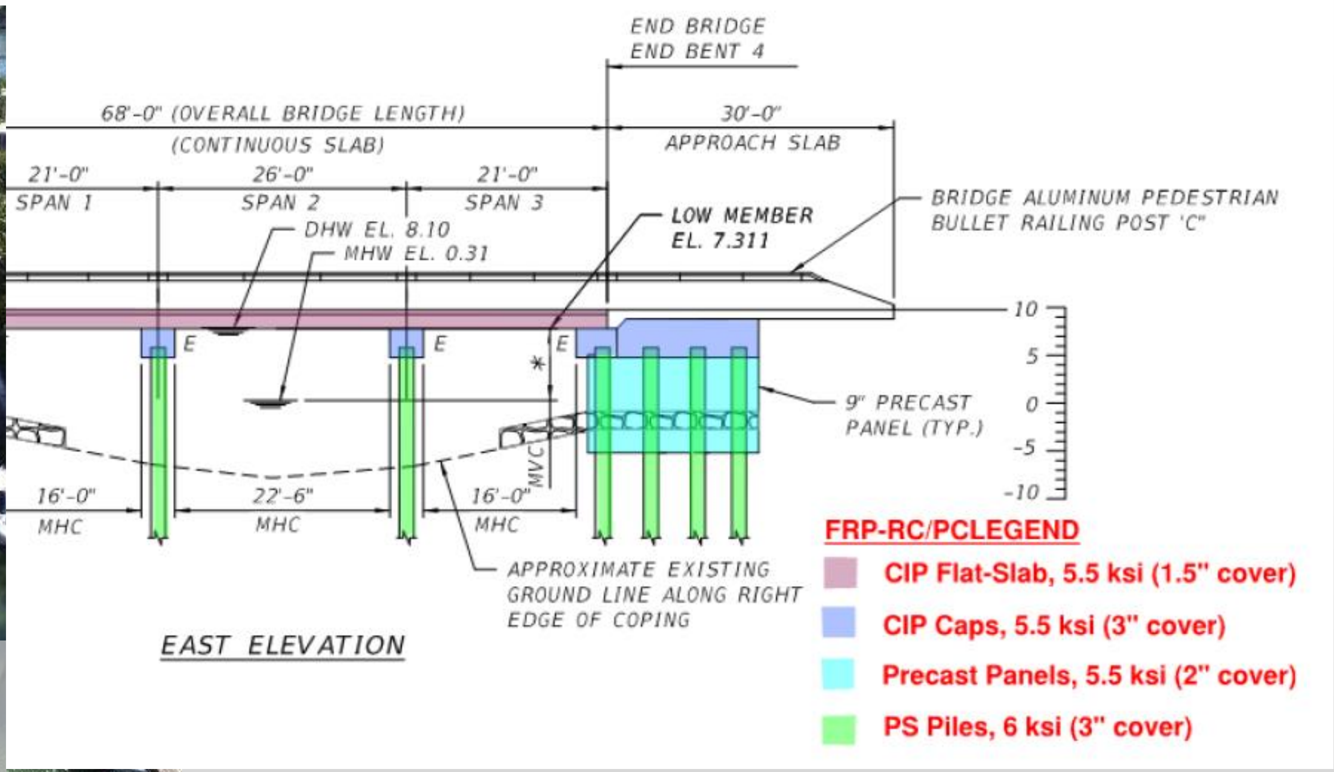
Miami Beach seawall-bulkhead and road raising project.
(Photo / Bruce Mowry, city engineer / courtesy http://gatehouseprojects.com/risingseas/home/site/news-jrnl.com)



Alternative Corrosion-Resistant system

Fiberglass sheet piles and GFRP-PC Flat or Corrugated panels

- Fiberglass panels are typically pultruded panels interlocked with each other through a pin-eye connection on both ends to form a continuous wall;
- This type of wall system is a unique waterfront structure: as the fiberglass composite sheet pile ages in an aggressive environment, the tensile strength loss is minimal;
- These material properties prove the long-term high performance of the material and are estimated to be at least four times higher than that of alternative panels made of vinyl materials;
- However, GFRP pultruded sheet piling present a major controlling factor in design: because of their low modulus compared to steel, composite-piling materials may exhibit large deformations in excess of design limits.

Alternative Corrosion-Resistant system

"MILDGLASS" – NCHRP IDEA Project #207

- GFRP strand prototype is currently investigated;
- GFRP may be an efficient alternative since it does not require high levels of concrete prestressing, as CFRP strands do, addressing some of the main constructability issues and safety issues during tensioning CFRP strands;
- reduced cost compared to the CFCC counterpart, making the GFRP strand a competitive and durable alternative;
- Same stressing procedures and techniques currently applied to steel prestressed concrete tensioning and construction;
- The construction and installation methods remain the same currently used for CFRP-PC elements.

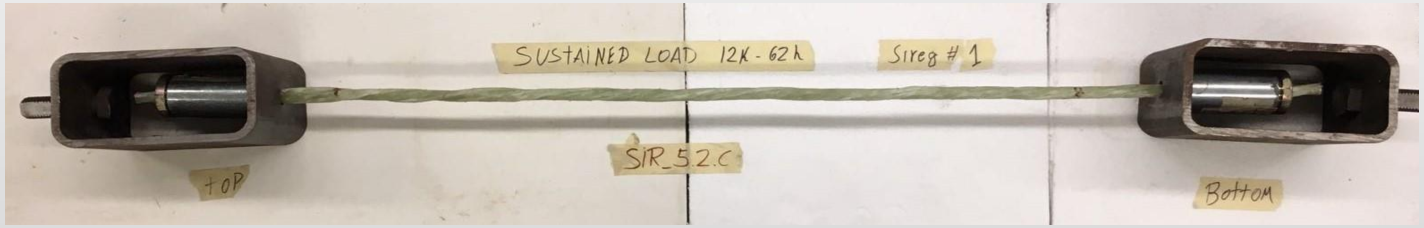
Alternative Corrosion-Resistant system

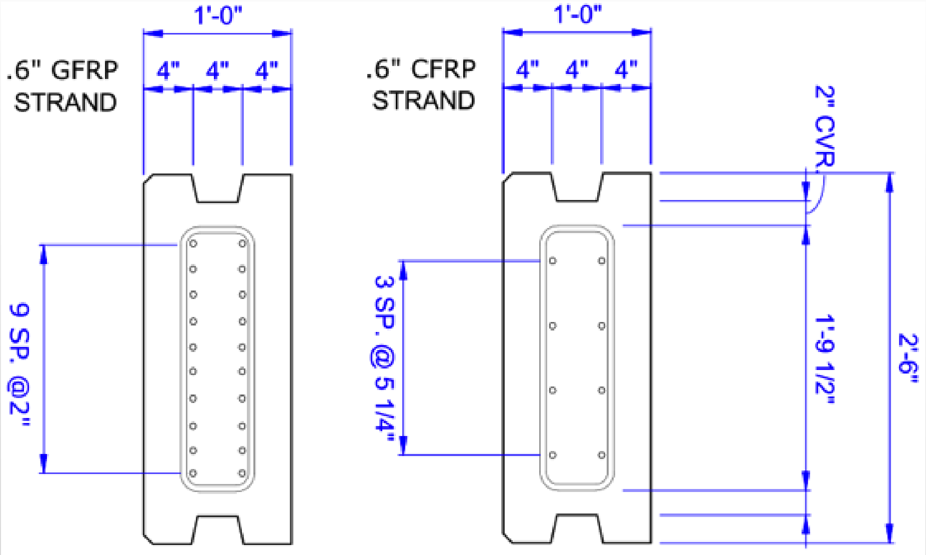
"MILDGLASS" – NCHRP IDEA Project #207

- Developing design criteria for prestressing:
  - *i.* ***Glass-FRP*** solid bars;
  - *ii.* ***Glass-FRP*** twisted strands;
- FHWA's *Innovations **D**eserving of **E**xploratory **A**nalysis **(IDEA)***
  - GFRP Prestressing - ***MILDGLASS*** *(University of Miami);*

First prototype GFRP-VE system

IDEA
Innovations Deserving Exploratory Analysis Programs



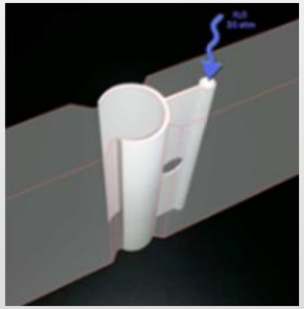


(Left) Future GFRP-PC sheet pile concept;
(Right) Current CFRP-PC sheet pile design used for Halls River Bridge project.

Alternative Corrosion-Resistant system

"PRECOPAL" **Corrugated GFRP-PC Sheet Piles:**

- Precopal is a innovative project part of the European Union's **Horizon 2020** research and innovation programme;
- Aims to provide a new sustainable type of pre-stressed, steel-free sheet piles, along with its enhanced mechanical characteristics given by the full corrosion resistant GFRP, in combination with a minimum of 90MPa compression resistance concrete (C80/95);
- Prestressed 0.55-inch diameter GFRP bars that replace the traditional steel;
- Each sheet pile is connected with the next one with an innovative hollow cylindrical joint system, made of PVC, which minimizes water permeability;
- Easily driven into the ground with the typical and conventional construction methods currently deployed.



Alternative Corrosion-Resistant system

“PRECOPAL”– HORIZON 2020

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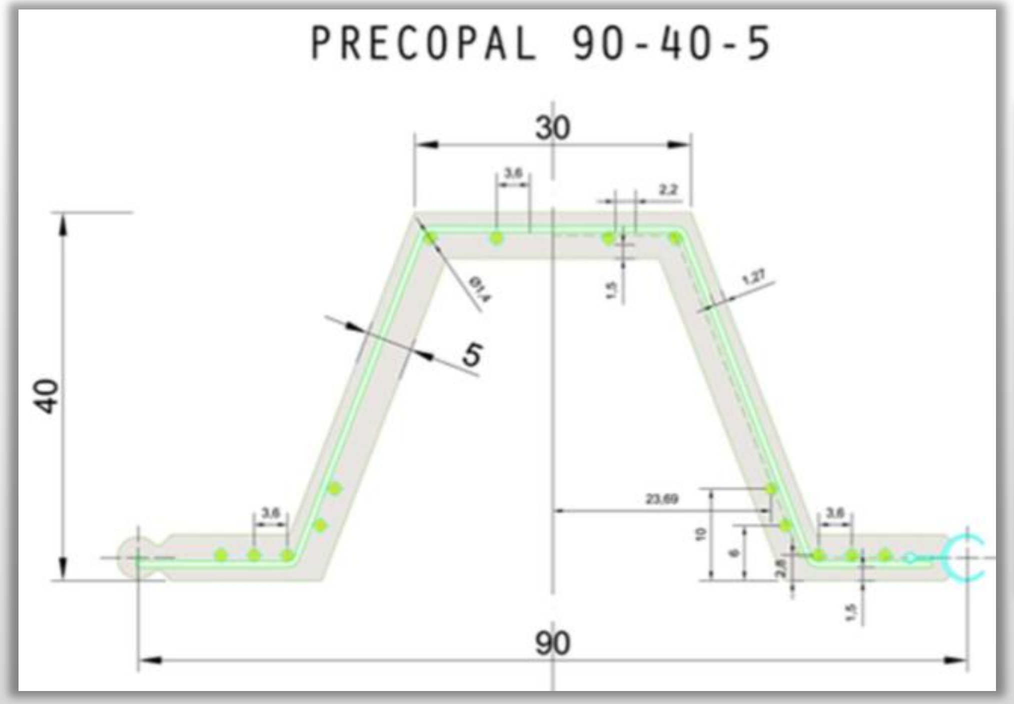
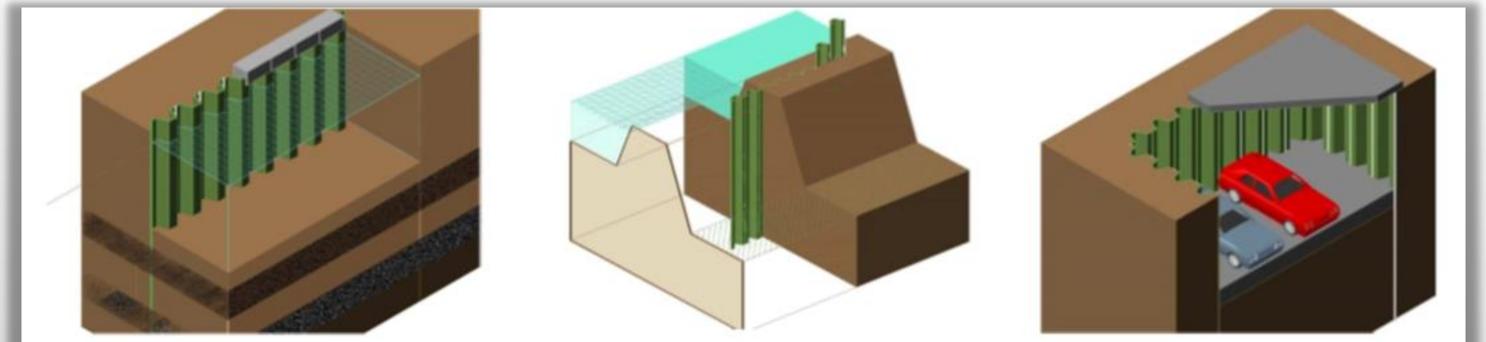


PRECOPAL
SUSTAINING YOUR LAND



Usage 1:
marina’s docks and marine, lacustrine and fluvial banks

Usage 2:
securing river embankments

Usage 3:
basement parking lots and buildings

Conclusion

- Valuable insight was gained during the demonstration project for the **Halls River Bridge** replacement.
- FRP-PC/RC solutions are expanding and provide viable and adaptable applications with less concerns regarding the further durability that arises due to unanticipated construction challenges, damage, and mistakes.
- The increased initial acquisition costs should be easily offset with future maintenance cost savings and extended design life.
- Continued development of FRP-PC/RC solutions, refinement of design guidance, and full adoption of FRP design codes will continue to improve cost efficiency in the near future.

Questions

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