Advancing Small Bridges (Florida-Down Under)

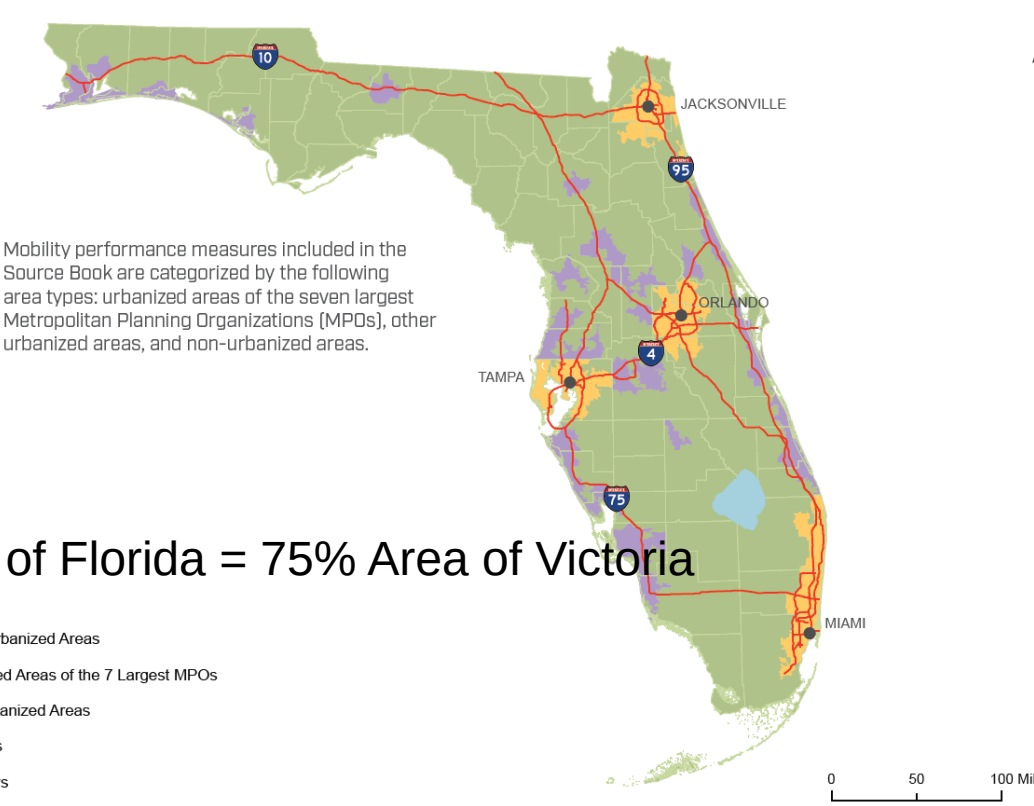
By: Steven Nolan, Christina Freeman, Ananda Kelly, Marco Rossini

FDOT Cardno UNIVERSITY OF MIAMI

Outline

1. Overview of FDOT
2. History of Prestressed Slab-Beams in Florida
3. FSB's Development
4. Implementation
5. Looking Ahead – Enhancements

Overview of the FDOT



Area of Florida = 75% Area of Victoria

GENERAL

20.5 M people

112 M visitors

53,625 square miles of land

TRANSPORTATION SYSTEM

HIGHWAY AND BRIDGE

122,736 centerline miles of public roads

12,106 centerline miles of State Highway System (SHS)

4,300 centerline miles of Strategic Intermodal System (SIS)

12,267 bridges, **6,858** maintained by FDOT

MOBILITY PERFORMANCE MEASURES

HIGHWAY AND BRIDGE

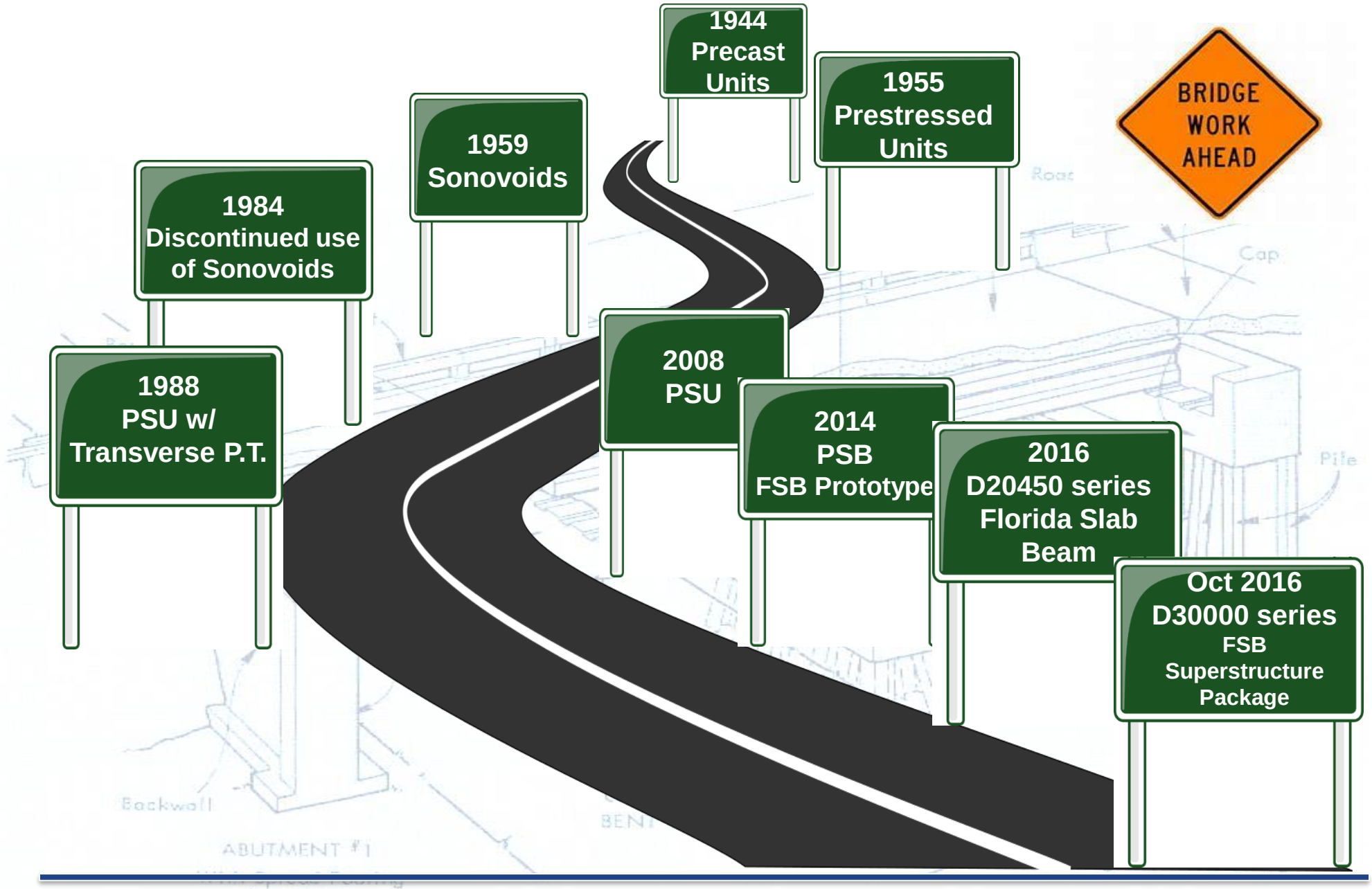
322.1 M daily vehicle miles traveled on the SHS

77% reliable peak hour/peak period travel on freeways

5% of the SHS centerline miles are heavily congested during peak hour

637 M truck tons transported in Florida

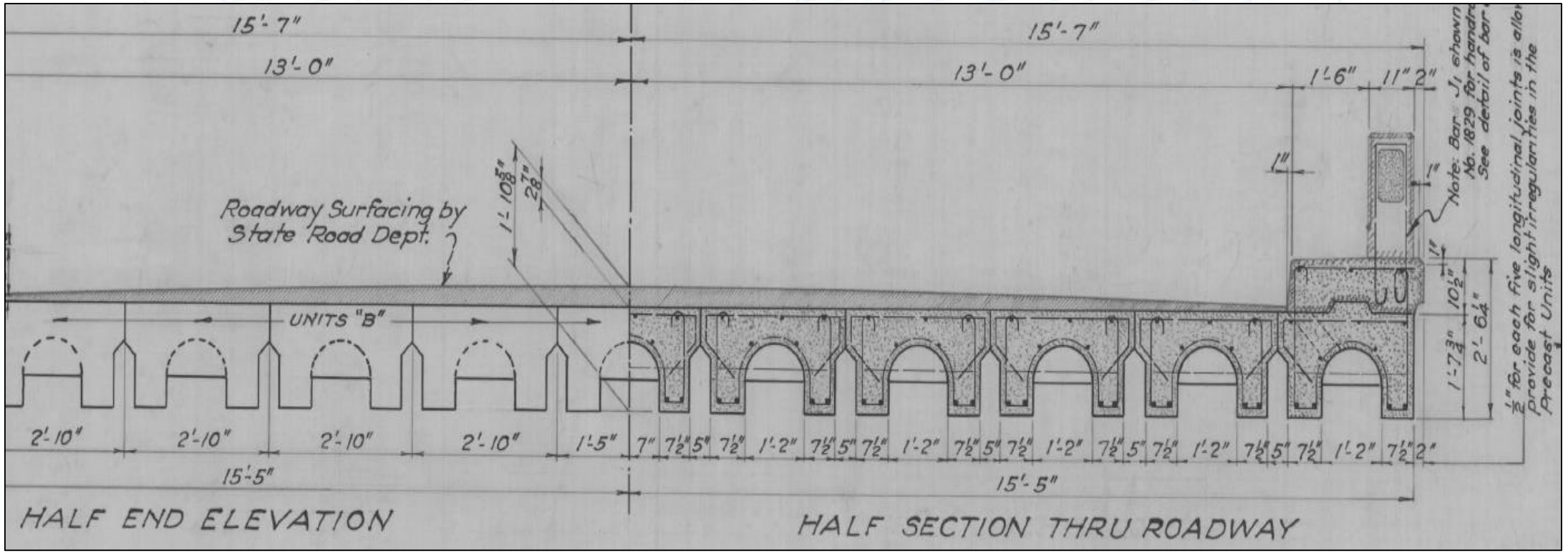
Source: http://www.fdot.gov/planning/FTO/mobility/2017sourcebook.pdf



The Road to the Florida Slab-Beams (FSB's)

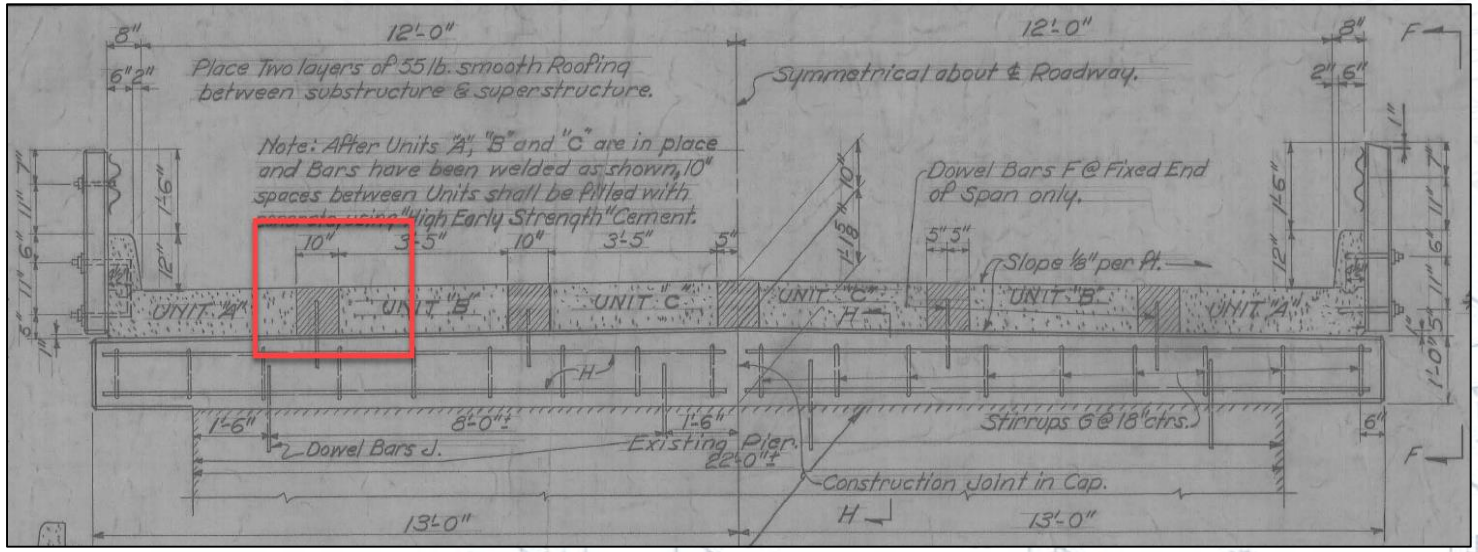
Precast Slab-Beams (1940's)

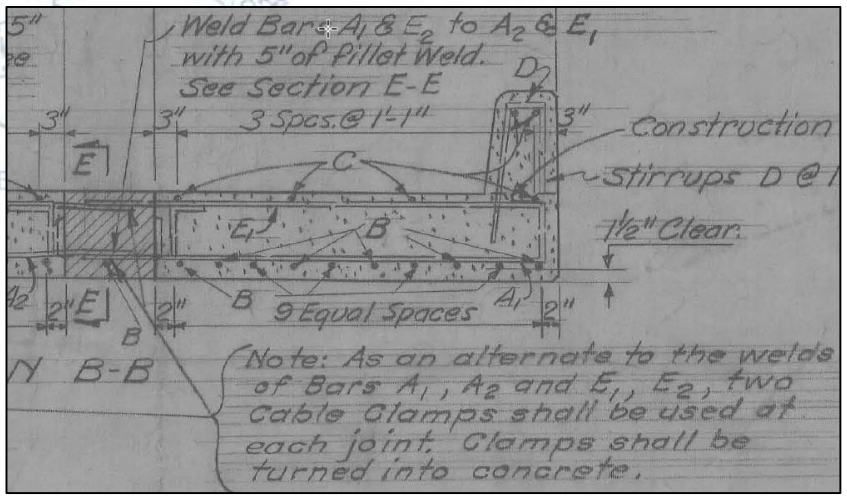
- ***Index 1889:*** *Precast Arched Bottom Beams (1944)*
  - ✓ 15' (4.6m) spans, 34" (865mm) wide, Grade 33 (225 MPa) rebar;
  - ✓ Asphalt overlay.



Precast Slab-Beams (1940's)

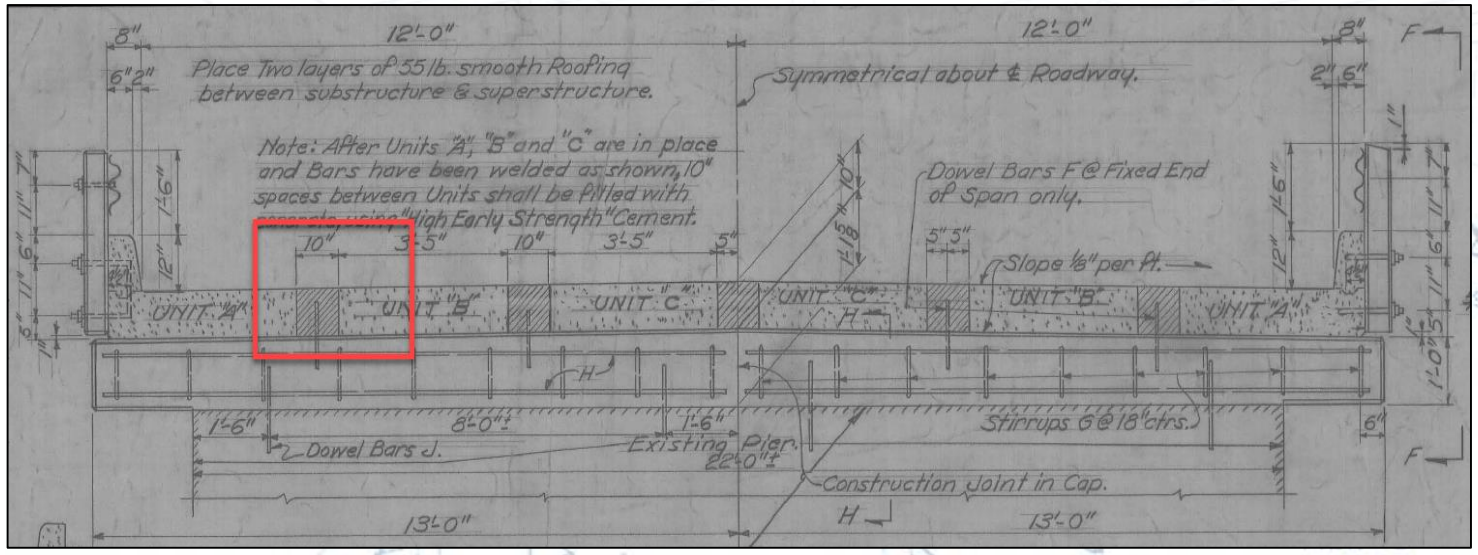
- ***Index 2366:*** *Precast Rectangular Slab Beams (1949)*
  - ✓ 15' (4.6m) spans, 39" (990mm) wide, Grade 33 (225 MPa) rebar;
  - ✓ 10" (250mm) C-I-P closure pour, with lap welded rebar splices.

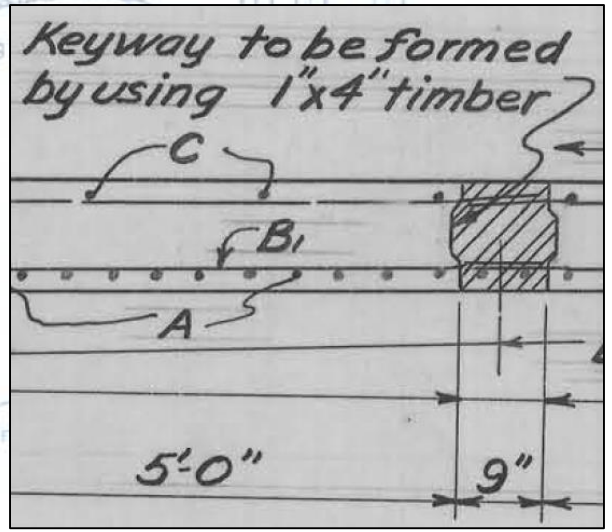




Precast Slab-Beams (1950's)

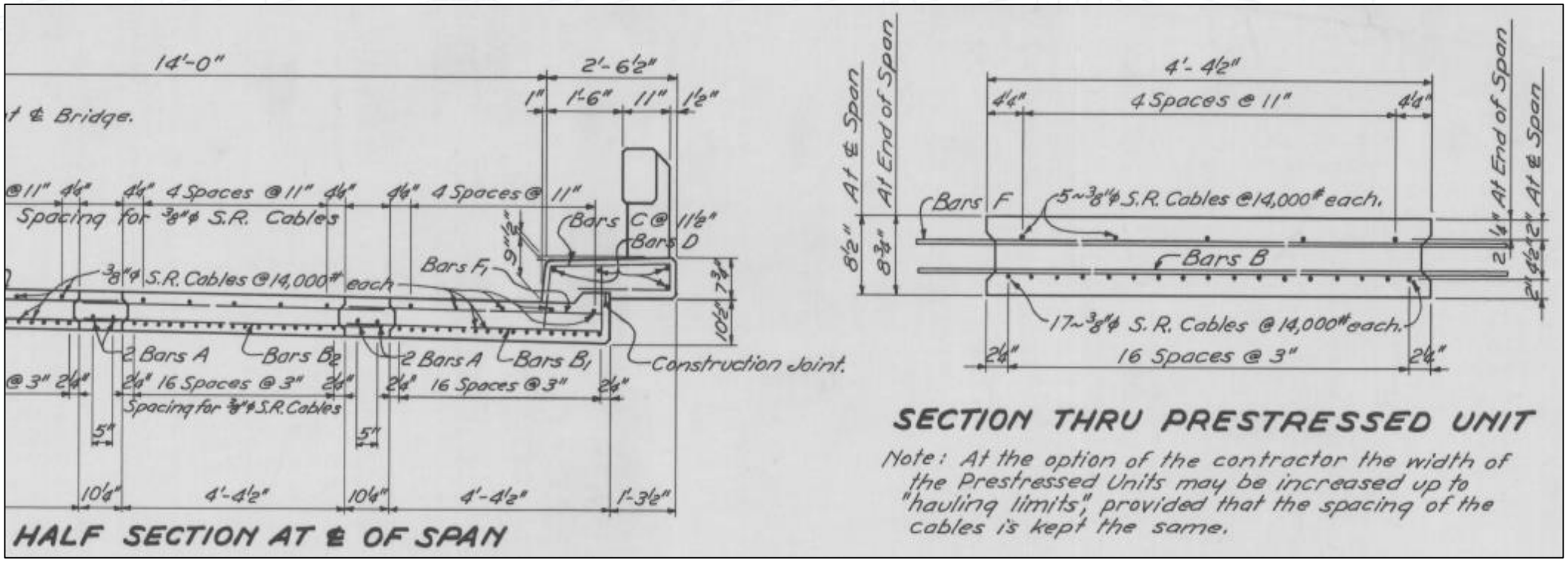
- ***Index 2569:*** *Precast Rectangular Slab Beams (1950)*
  - ✓ 15' (4.6m) spans, 39" (990mm) wide, Grade 33 (225 Mpa) rebar;
  - ✓ 10" (250mm) C-I-P closure pour with keyways and lap welded splices.





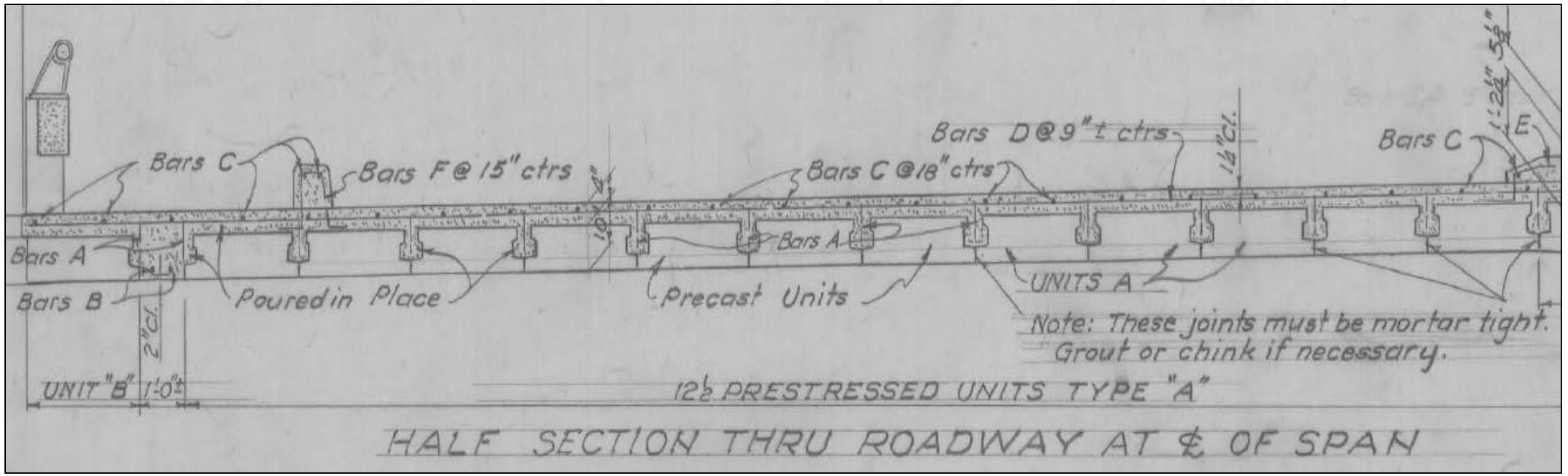
Precast/Prestressed Slab-Beams (1950's)

- ***Index 3457:*** *Prestressed Rectangular Slab Units (1955)*
  - ✓ 15' (4.6m) spans, 4' to 5' wide (1.2m to 1.5m), Grade 250-SR 3/8" dia. (1700 Mpa 10mm dia.) 7-wire strand;
  - ✓ 10" (250mm) C-I-P closure pour with keyways and lap welded splices.



Precast/Prestressed Slab-Beams (1950's)

- ***Index 3684:*** *Prestressed Keyed Slab Units (1956)*
  - ✓ 30' (9.1m) spans, 2.5' wide (760mm), two rows of Grade 250-SR (1700 MPa) strand;
  - ✓ 4" (100mm) C-I-P structural concrete topping with integral closure pour;
  - ✓ 12" (300mm) ± C-I-P makeup width/joint.

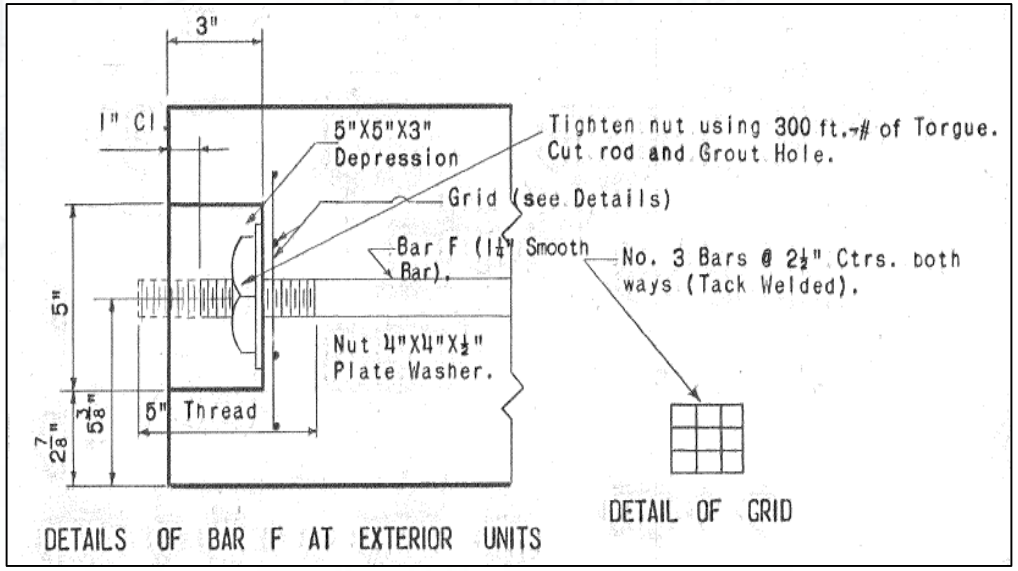


Precast/Prestressed Slab-Beams (1950's)

- ***Index 3684-mod:*** *Prestressed Keyed Slab Units (1958)*
  - ✓ 30' (9.1m) spans, 2.5' (760mm) wide, two rows of Grade 250 (1700 Mpa) strand;
  - ✓ 4" (100mm) C-I-P concrete overlay with integral closure pour;
  - ✓ 12" (300mm) ± C-I-P makeup width/joint.
  - ✓ 2~Transverse Post-Tensioned

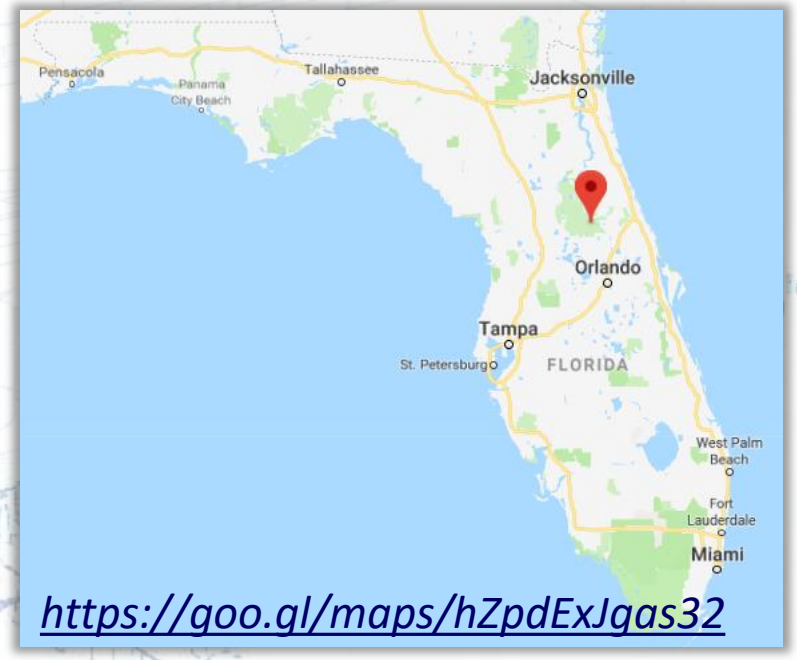
    Bars at third-points,

    300 ft-lbs tightening torqued.



Precast/Prestressed Slab-Beams (1950's)

- ***Index 3684-mod:*** *Prestressed Keyed Slab Units (1958)*

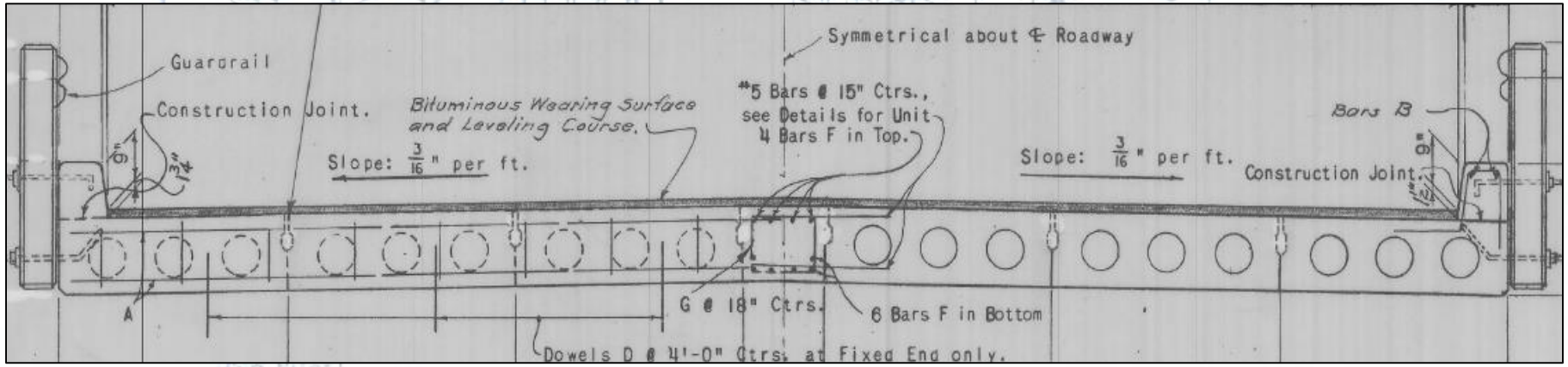


There is still at least one example of this type of superstructure under traffic in Florida, **CR 445 over Alexander Springs Creek**. An engineer from the FDOT State Bridge Maintenance office recently stated, *"…my favorite prestressed slab [is], CR-445 over Alexander Springs Creek. Altogether neglected, and nonetheless in excellent condition"* *(4)*.

4. Devault, A., personal communication (email) with Nolan, S. and Freeman, C. April 10, 2015.

Precast/Prestressed Slab-Beams (1950's)

- ***Index "various":*** *Prestressed Voided Slab Units (1959)*
  - ✓ 30' (9.1m) spans, 2.5' (760mm) wide, two rows of Grade 250-SR (1700 MPa) strand;
  - ✓ 12" (300mm) ± C-I-P makeup width/joint.
  - ✓ Asphalt overlay;
  - ✓ Transverse Post-Tensioned Bars at mid- or third-points (500 ft-lbs tightening torque).



Precast/Prestressed Slab-Beams (1960's - 1984)

- ***Index "various":*** *Prestressed Voided Slab Units (1959)*
  - ✓ 30 to 40 foot (9.1 to 12.1m) spans;
  - ✓ Asphalt overlay;
  - ✓ Transverse Post-Tensioned Bars at mid- or third-points (500 ft-lbs tightening torque);
  - ✓ Reflective cracking due to loss of transverse prestress and grout degradation.

Precast/Prestressed Slab-Beams (1960's - 1984)

- ***Index "various":*** *Prestressed Voided Slab Units (1959)*

  - ✓ Reflective cracking due to loss of transverse prestress and grout degradation… ***Potential Corrosion Concern!***

Precast/Prestressed Slab-Beams (1960's - 1984)

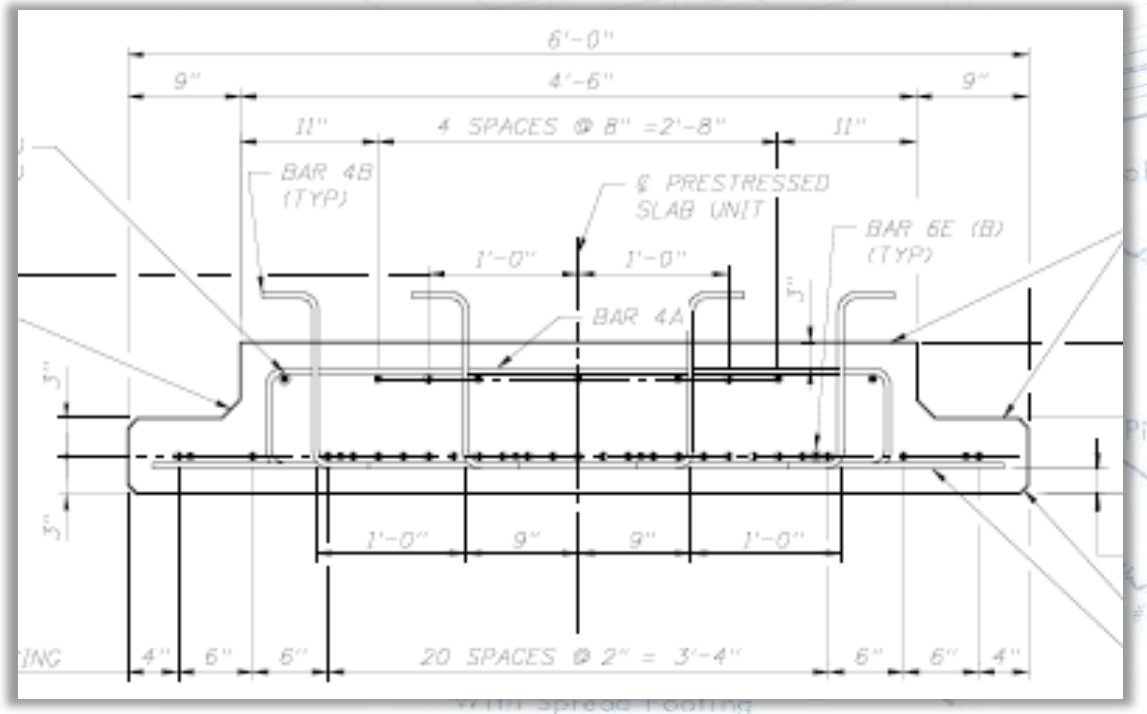
- ***Index "various":*** *Prestressed Voided Slab Units (1959)*

  - ✓ ***Potential Corrosion Concerns***

    … also from the underside…

Precast/Prestressed Slab-Beams (1990 – 2000's)

- ***Index (none):*** *Prestressed Slab Beams*
  - ✓ District 7 (Tampa) PSB = "Z-Beams"
  - ✓ Integral 6" (150mm) structural concrete topping and RC keyway;



Precast/Prestressed Slab-Beams (1990 – 2000's)

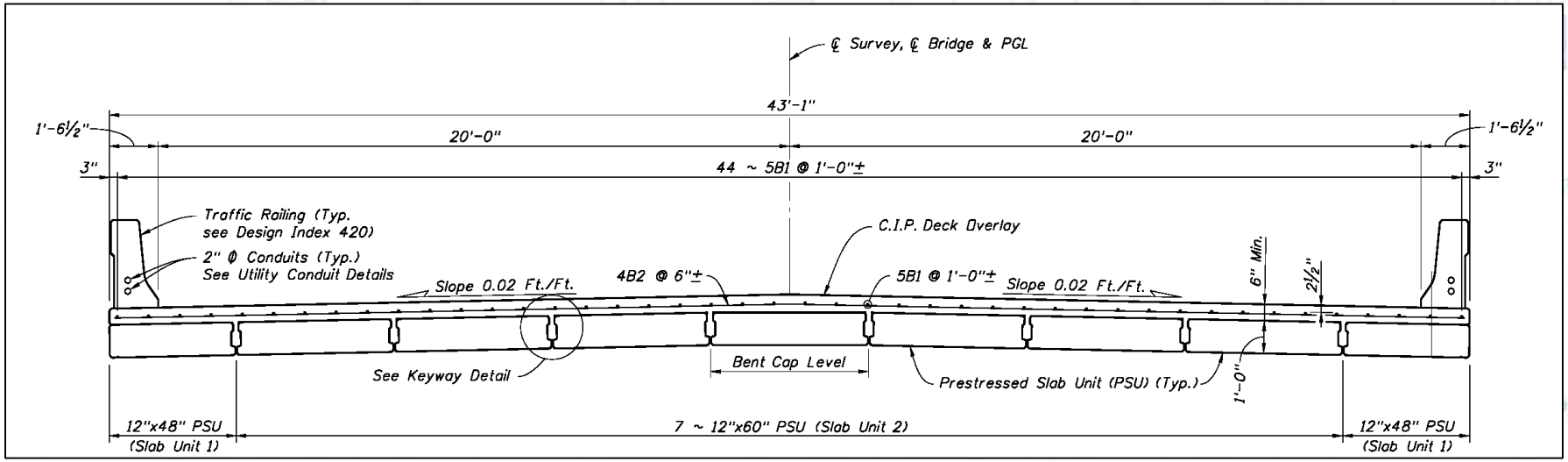
- ***Poutre-Dalle®:***
  - ✓ Poutre-Dalle® System was a proprietary design originally developed in France
  - ✓ Adopted by ***MnDOT*** in 2005 after a joint ***AASHTO***, ***NCHRP*** and ***FHWA*** sponsored Scan Tour of Europe in April 2004.
  - ✓ The system was promoted by ***FHWA*** under their Prefabricated Bridge Element Systems (PBES) initiative for use by other states with ***MnDOT*** initially holding a workshop showcasing two demonstration projects [7] [8].

(7) MnDOT/FHWA Precast Slab System Workshop Summary Report, FHWA, September 8, 2005.

(8) Piccin, R. and Schultz, A. E. (2012). "The Minnesota inverted-tee system: Parametric studies for preliminary design." PCI Journal, Spring, 162–179. http://www.pci.org/pci_journal-2012-spring-15/

Precast/Prestressed Slab-Beams (2000's)

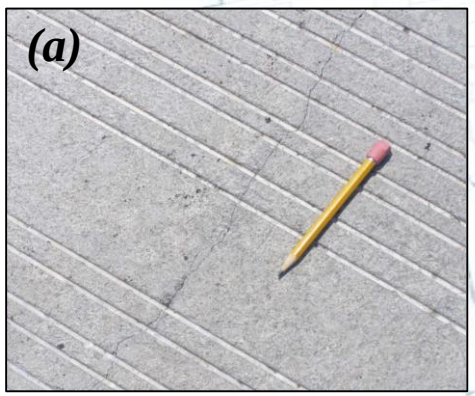
- ***Index 20350* series:** *Prestressed Slab Units (2008)*
  - ✓ Pilot project began 2008 – *SR30 (Gulf County);*
  - ✓ Statewide Standard published in 2010;
  - ✓ 2.5' to 5' (760 to 1520mm) wide, 12 & 15" thick (300 & 380mm), CIP 6"(150mm) RC/FRC structural topping;
  - ✓ FRC based on recommendations from FDOT ***Research Project BD545-9*** [9];

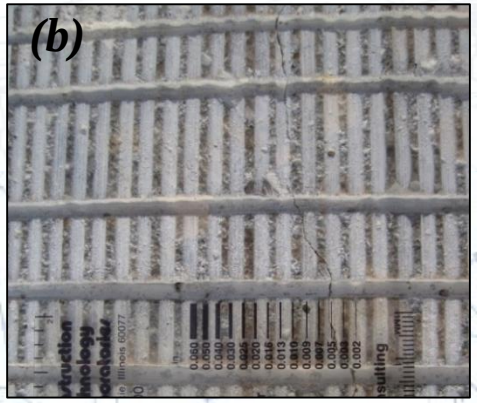


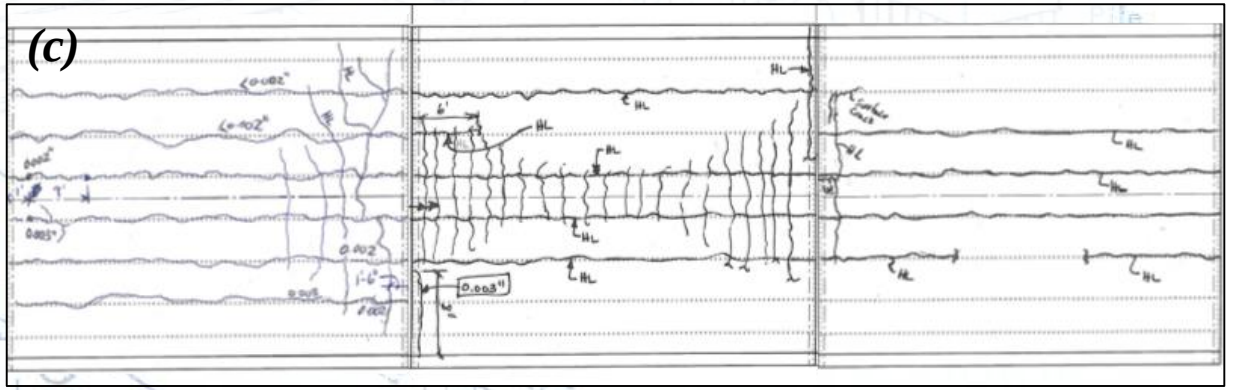
(9) Hamilton, H., Cook, R., Alfonso, L., "Crack Control in Toppings for Precast Flat Slab Bridge Deck Construction", FDOT Research Project BD545-9, March 2006.

Precast/Prestressed Slab-Beams (2000's)

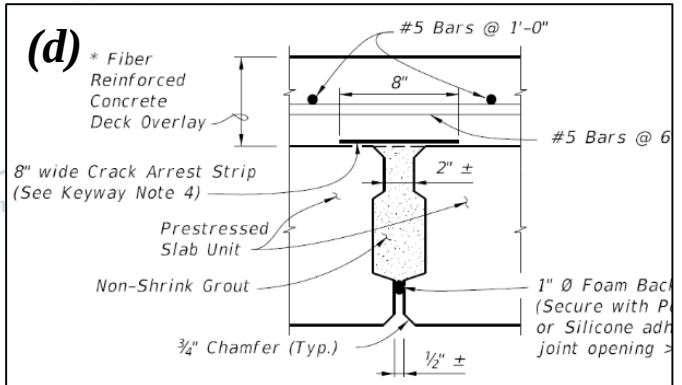
- ***Index 20350* series:** *Prestressed Slab Units (2008 - 2014)*
  - ✓ Shrinkage/Reflective longitudinal cracking issue;
  - ✓ Transverse cracking on continuous "jointless-bridge" span details
  - ✓ Reverted to ***"Developmental"*** status in 2012;







FIGURES: Typical longitudinal deck cracking in PSU system (a) SR30A using polypropylene FRC, 2011; (b) & (c) CR12A using basalt FRC, 2013; (d) Addition of Mitigation "Crack Arrest Strip", 2014.



Precast/Prestressed Slab-Beams (2010's)

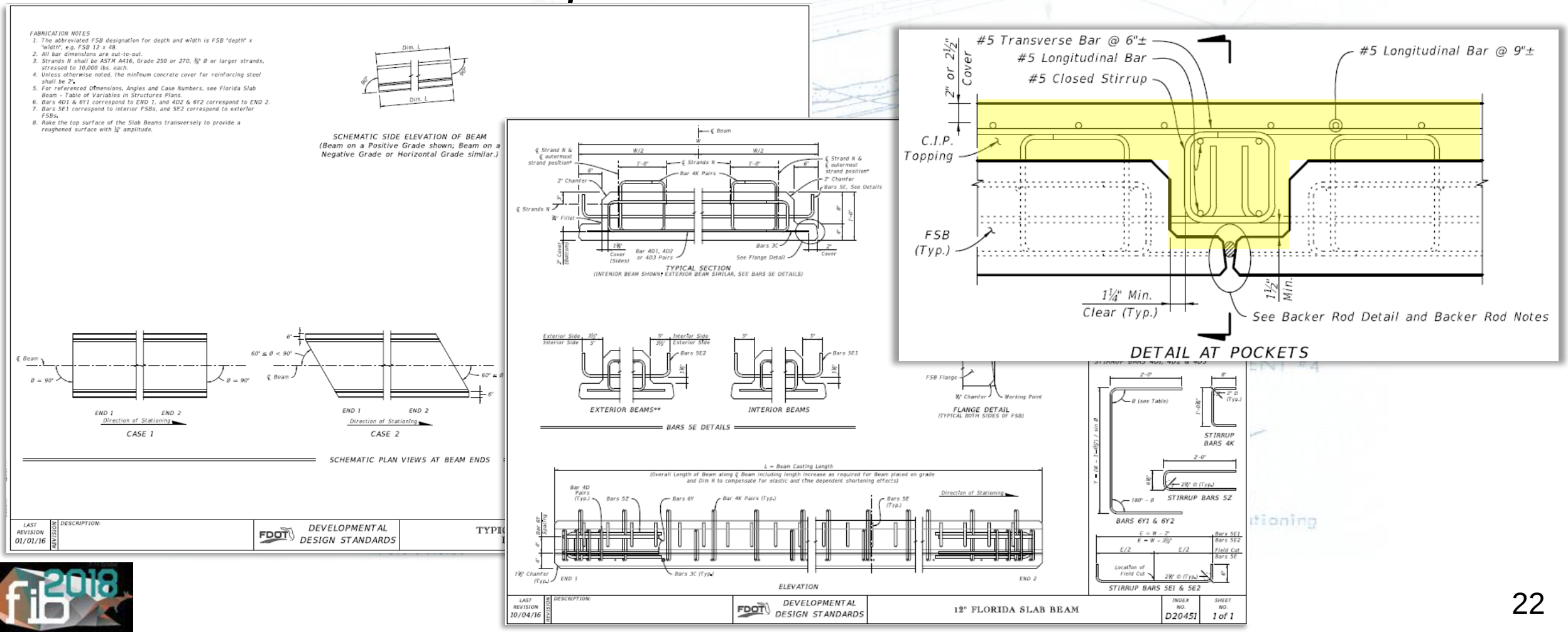
- ***Index D20450* series:** *Florida Slab Beams (2014)*
  - ✓ Pilot project began 2014 – *SR373/Orange Ave (Tallahassee);*
  - ✓ ***Developmental Standard*** published in 2016;
  - ✓ 3' to 5' (1 to 1.5m) wide, 12",15", & 18" (300, 380, & 460mm) thick, CIP 6" (150mm) structural concrete topping;

Precast/Prestressed Slab-Beams (2010's)

- ***Index D20450 series:*** *Florida Slab Beams (2014)*
  - ✓ Pilot project – *SR373/Orange Ave over St. Marks Trail;*

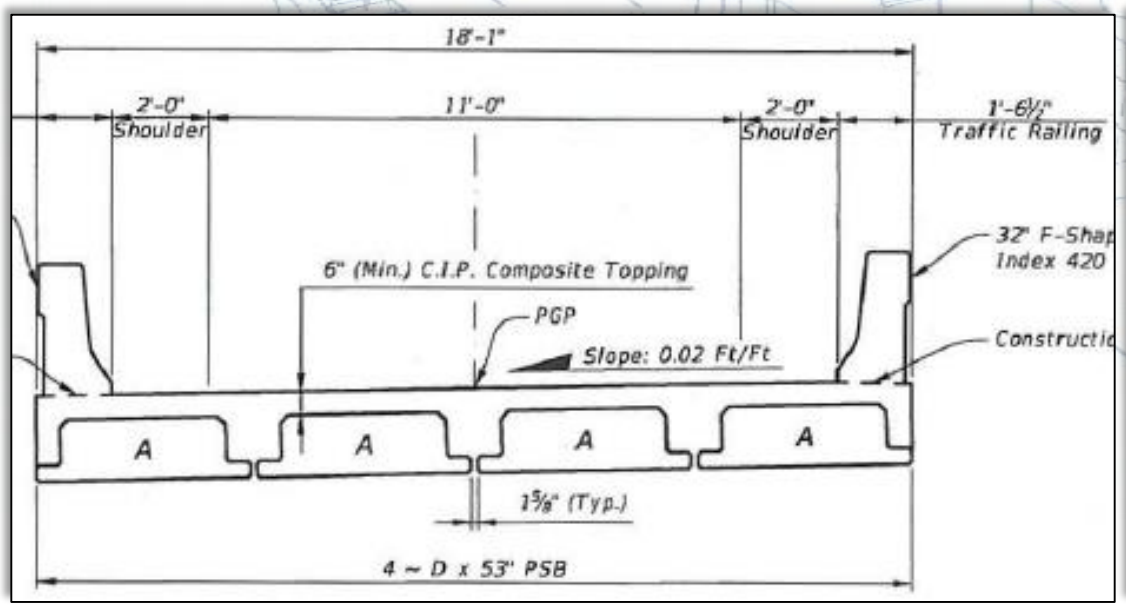
Precast/Prestressed Slab-Beams (2010's)

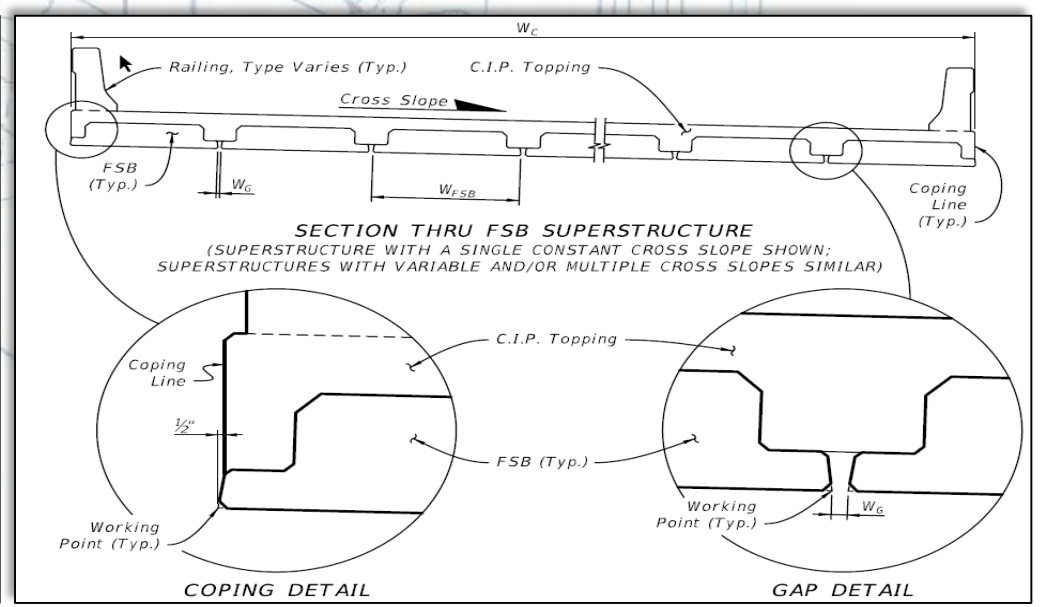
- ***Index D20450 series:*** *Florida Slab Beams (2016)*
  - ✓ Published ***Developmental Standard*** and ***Instructions***:



Precast/Prestressed Slab-Beams (2010's)

- ***Index D30000 series:*** *Bridge Superstructure Packages (2017)*
  - ✓ Intended initially for Off-System (Local) Bridges;
    - 30, 40, 50 ft. span lengths (FSB-12 & FSB-15);
    - 4~bridge clear widths – 18', 27', 35' and 40';
    - Saves approx. 14 plans sheets and includes load rating sheet.





Why FSB's ?

- ***Index D30000* series:** *Bridge Superstructure Packages (2017)*
  - ✓ Based on stakeholder surveys;

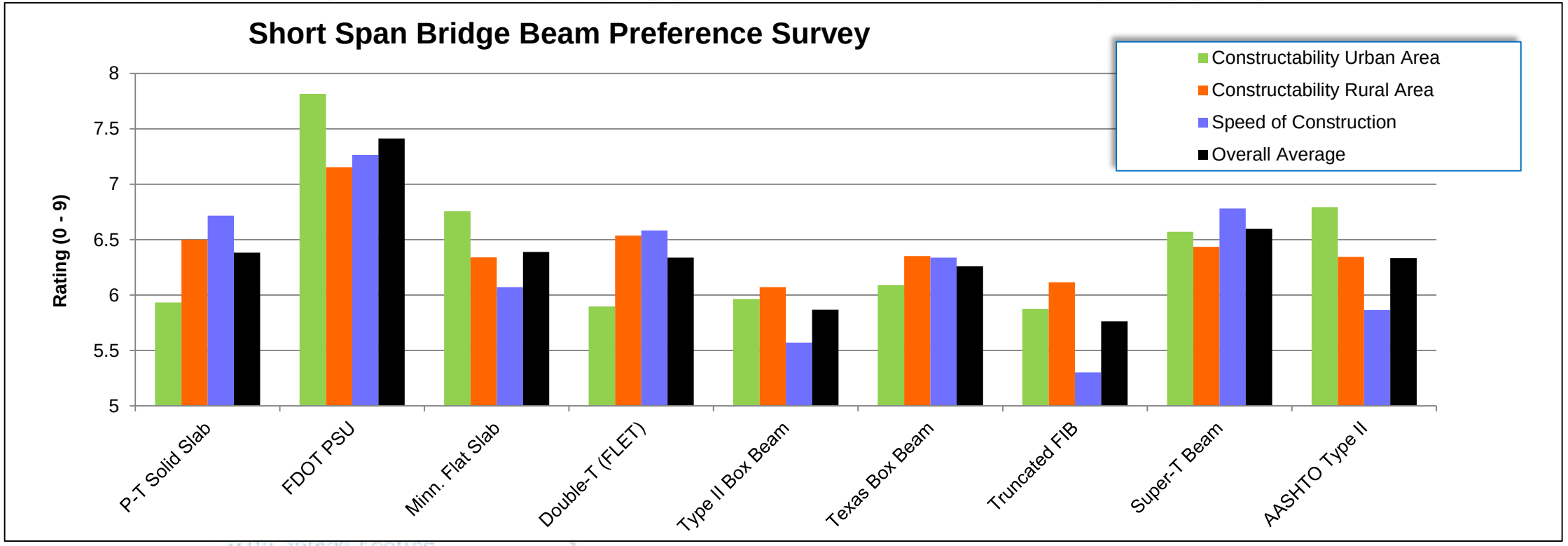


Chart: 2012 preference survey results for off-system bridge superstructure package

Why FSB's ?

- ***Index D30000* series:** *FSB Superstructure Packages (2017)*

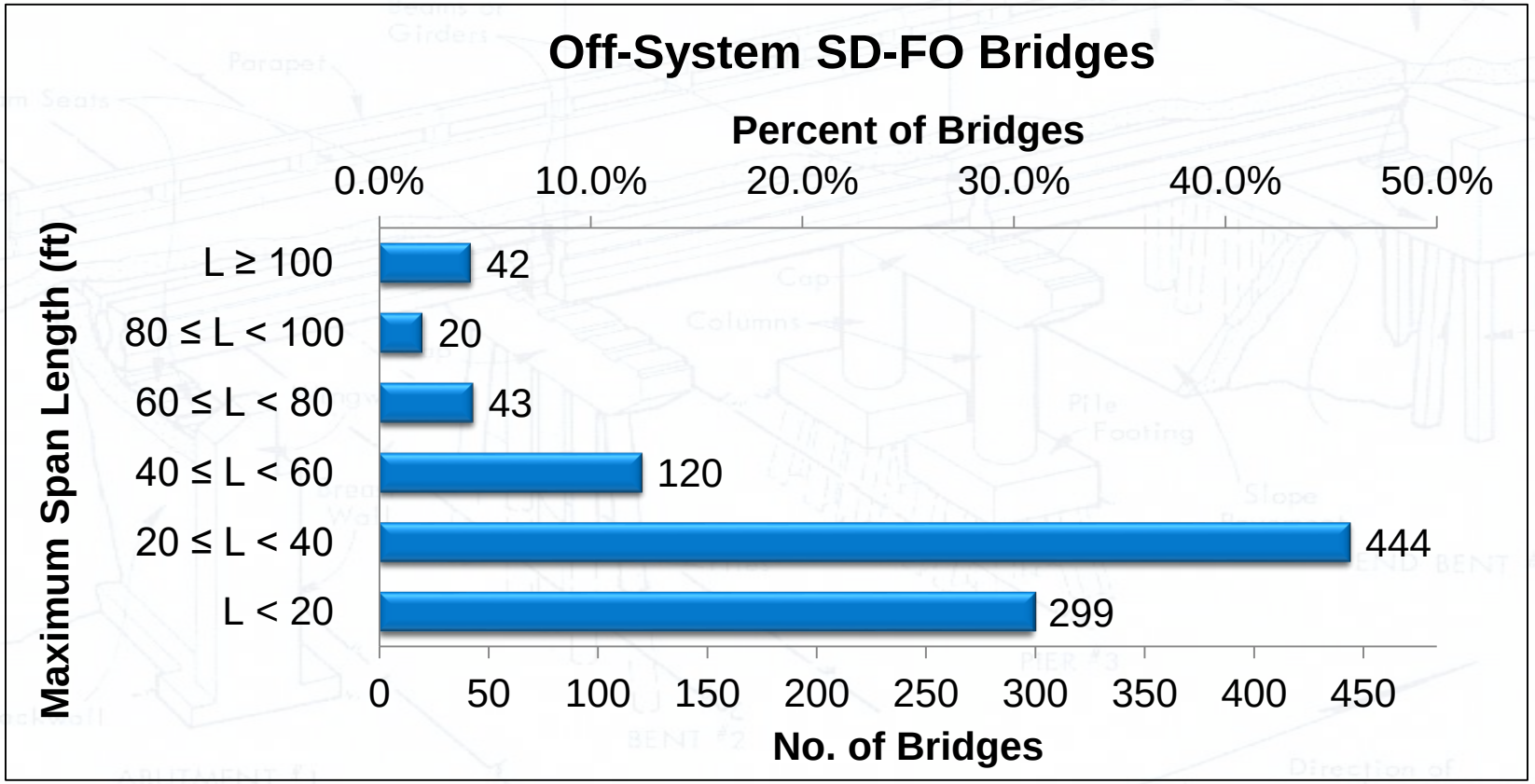
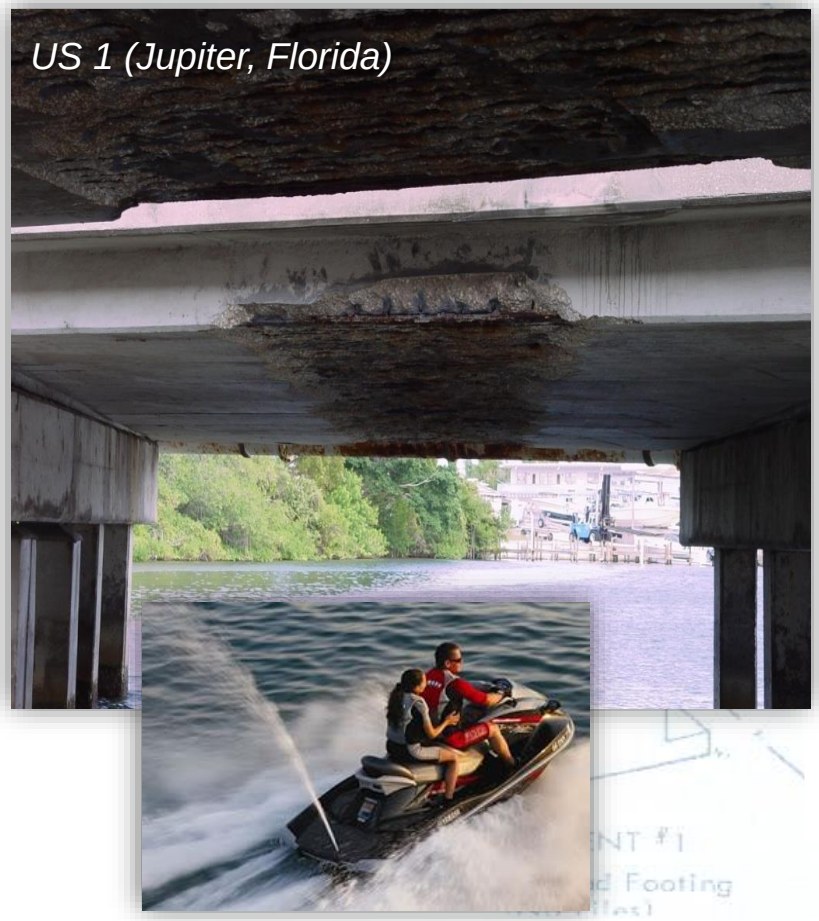


Chart: Florida Off-System bridge span length histogram showing total number of bridges by span length (2011).

25

Why Structurally Deficient (SD) ?

- ***Mostly Corrosion induced!***



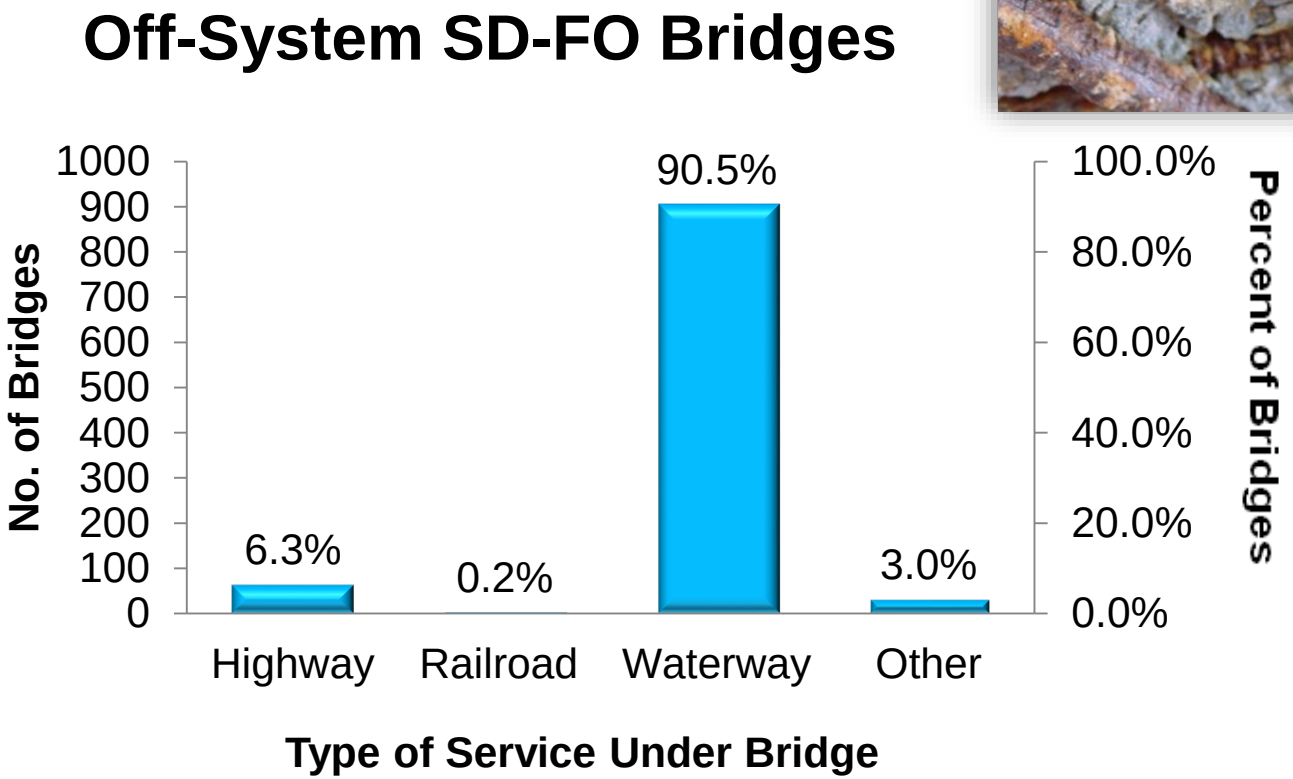
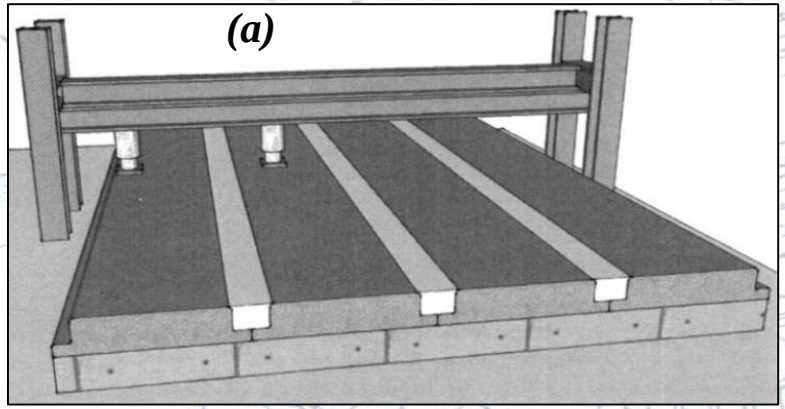


Chart: Florida Off-System bridge crossing type for Structurally Deficient or Functionally Obsolete (2011).

Enhancement - UHPC

- ***Florida Slab-Beams*** *(2017-18)*
  - ✓ Project ***BDV29 977-28*** – Develop and Evaluate Alternative FSB and UHPFRC Connection Details, and Testing Protocol



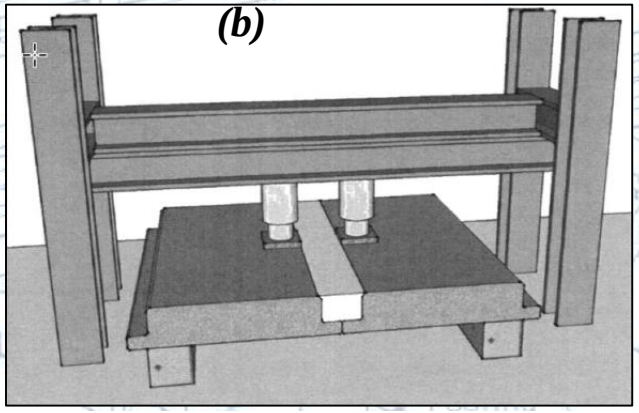


FIGURE: Proposed testing for FSB with UHPFRC joints currently under research development (a) full scale fatigue and strength testing; (b) small scale joint mockup.

Enhancement - UHPC

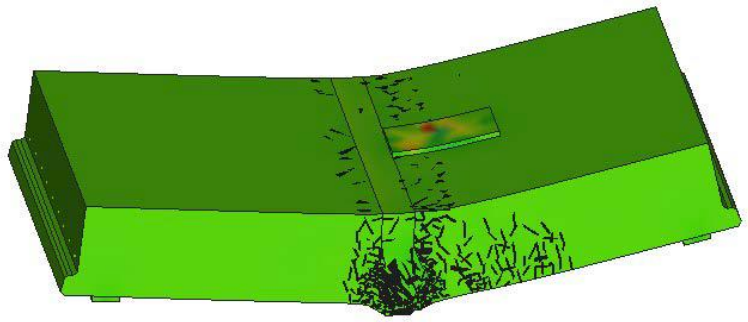
- ***Florida Slab-Beams*** *(2017-18)*
  - ✓ Project ***BDV29 977-28*** – Develop and Evaluate Alternative FSB and UHPFRC Connection Details, and Testing Protocol

(a)

(b)

(c)

(d)



FIGURES: FDOT research facility, (a) & (b) UHPC high shear grout mixture; (c) UHPC dry mix bags & steel fibers; (d) FEA Modeling.

Enhancement - HSSS

- ***Florida Slab-Beams*** *(2018)*
  - ✓ HSSS strand testing (initially using AASHTO Type II Beams);

Stainless-Steel Strands and Lightweight Concrete for Pre-tensioned Concrete Girders (*Project* ***BDV30 977-22****)**

"The objectives of this project are to determine the use of stainless steel strands in pre-tensioned girders and to verify the strand and girder behavior through testing."

FIGURE: FDOT research facility coil of HSSS-alloy 2205, 0.6" dia. strand.

29

Enhancement - FRC

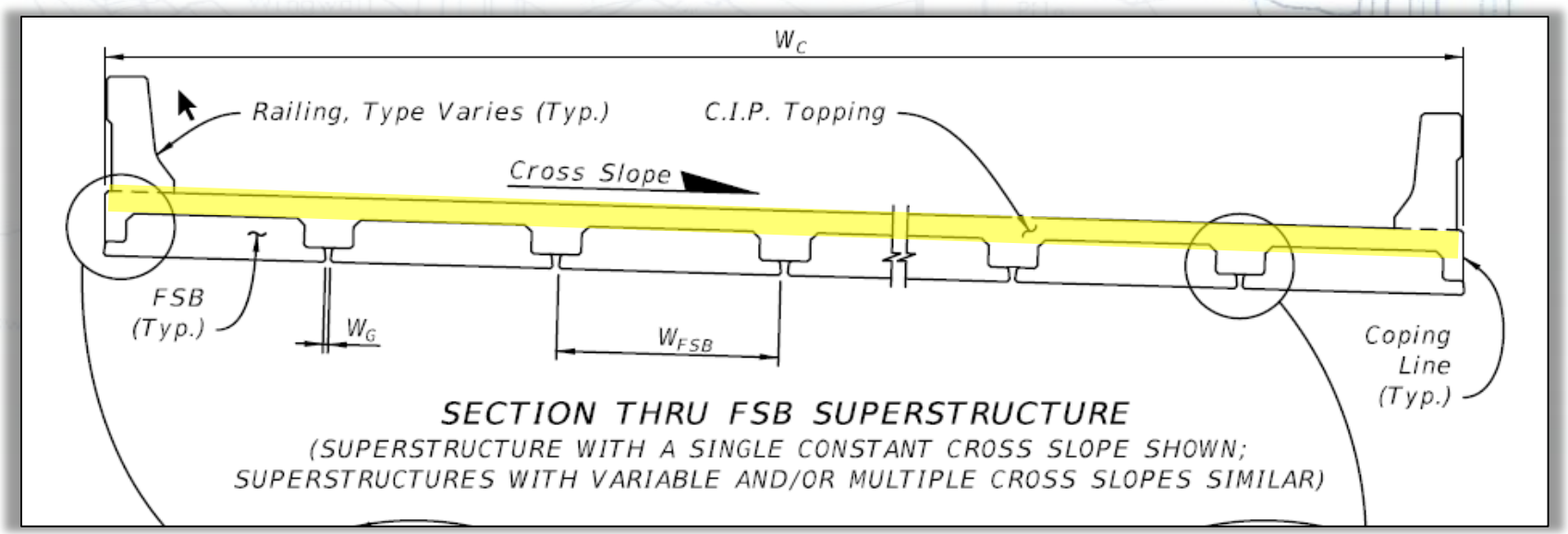
- ***Florida Slab-Beams*** *(2018)*
  - ✓ Developing design criteria for ***FRC*** in prestressed beams -

    BDV31 977-41 *Macro Synthetic Fiber Reinforcement for Improved Structural Performance of Concrete Bridge Girders (complete Nov. 2018)*

Photo: ACI 544.1R

UF UNIVERSITY of FLORIDA

  - ✓ Use in Structural Topping in lieu of Shrinkage Reducing Admixtures (SRA) and could reduced reinforcing?



SECTION THRU FSB SUPERSTRUCTURE
(SUPERSTRUCTURE WITH A SINGLE CONSTANT CROSS SLOPE SHOWN;
SUPERSTRUCTURES WITH VARIABLE AND/OR MULTIPLE CROSS SLOPES SIMILAR)

Enhancement - FRP

- ***Florida Slab-Beams*** *(2018-19)*

✓ Developing design criteria for:

i. ***Glass-FRP*** prestressing

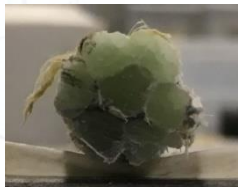
ii. ***Basalt-FRP*** reinforcing

✓ FHWA's *Innovations Deserving of Exploratory Analysis* ***(IDEA)***

- GFRP Prestressing - ***MILDGLASS*** *(University of Miami);*

UNIVERSITY OF MIAMI

IDEA
Innovations Deserving Exploratory Analysis Programs



✓ FHWA's ***S****tate* ***T****ransportation* ***I****nnovation* ***C****ouncils* ***(STIC)*** Incentive Program

- BFRP Reinforcing Standards Development ***(FDOT)***

FDOT

STIC
State Transportation Innovation Councils

Contact Information:

Steve Nolan, P.E.

State Structures Design Office

Steven.nolan@dot.state.fl.us

(850) 414-4272