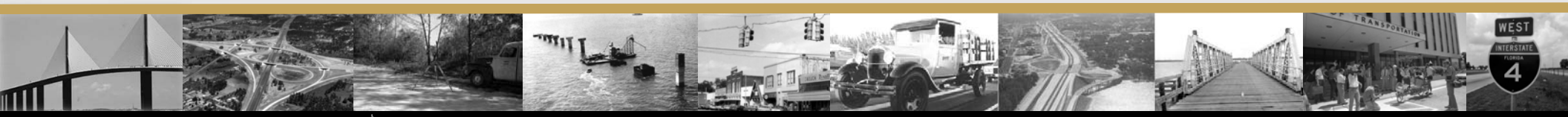
2015 Design Training Expo

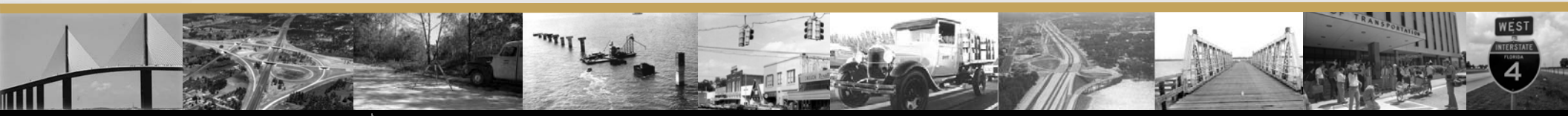
Florida Slab Beam (FSB) Development and Implementation

Ben Goldsberry, P.E.
Florida Department of Transportation
Structures Design Office

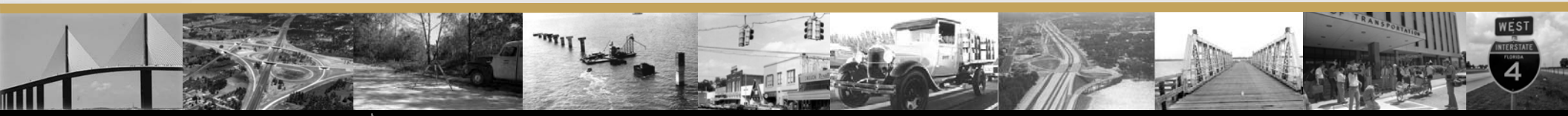


Presentation Outline

- History of Slab Beam Superstructures in Florida
- Florida Slab Beam (FSB) Superstructure
- Pilot Project – Orange Avenue over St. Marks Trail
- Lessons Learned
- Implementation – Developmental Design Standards

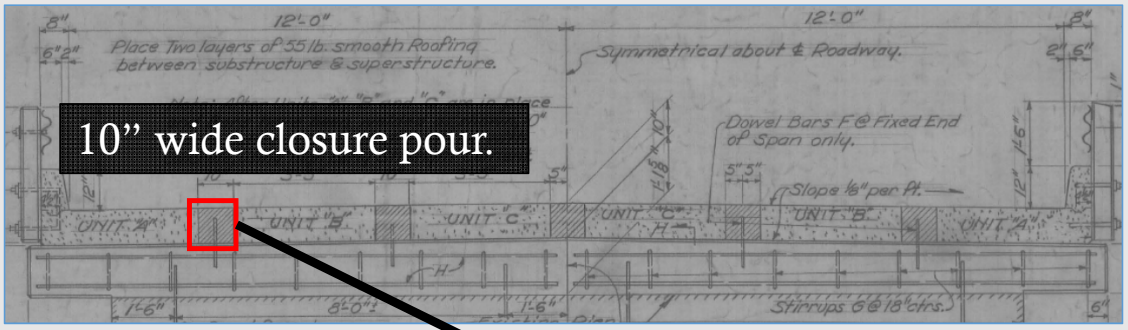


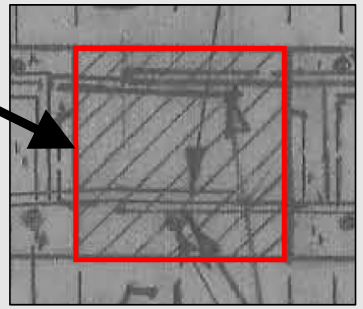
History of Slab Beam Superstructures in Florida

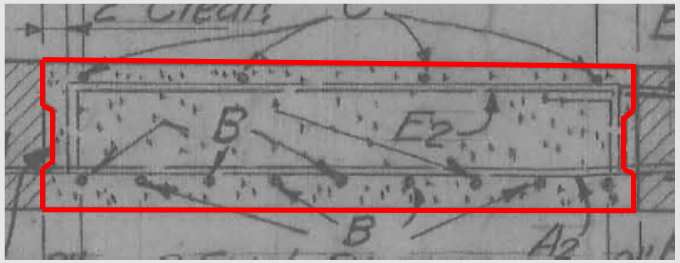


1949 Precast Units

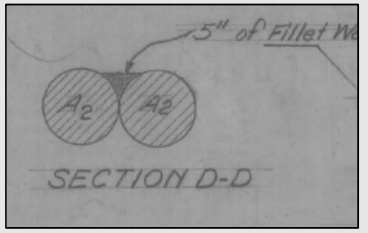
- 15’ Span
- Precast (not prestressed)
- Top of beam is riding surface (no topping)
- Closure pours required forming below

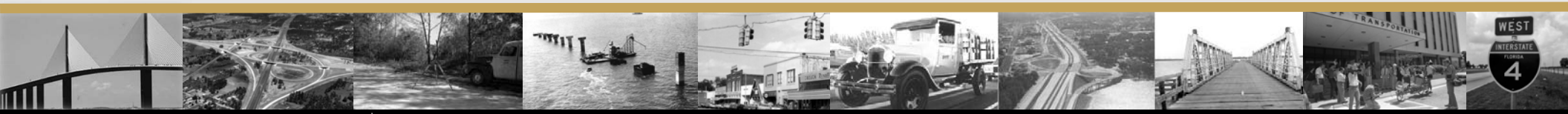






Transverse top & bottom rebar connected in closure pour by welding or by cable clamps





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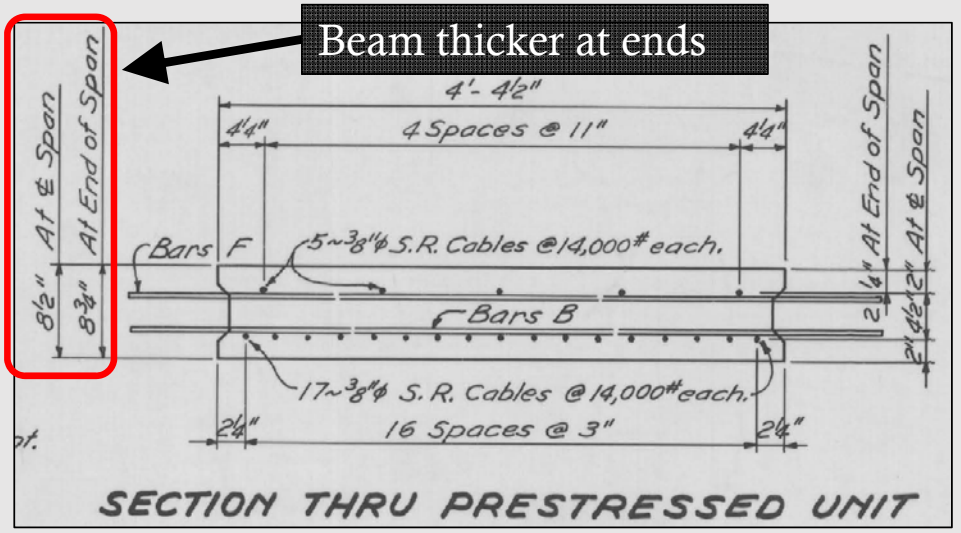
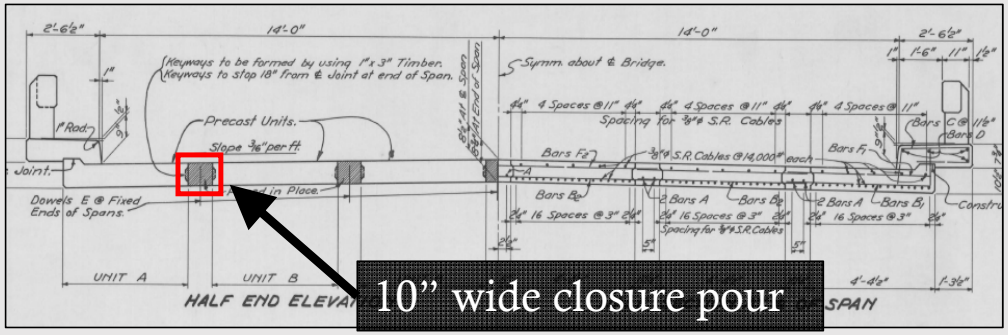
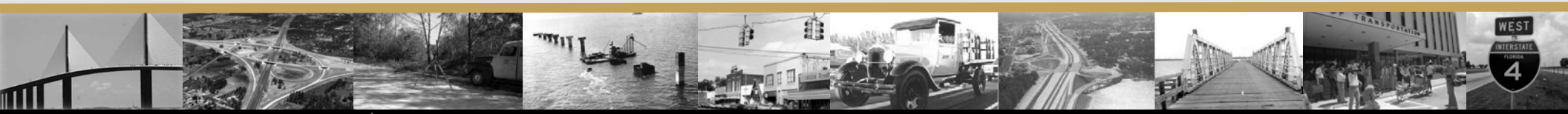
1955 Prestressed Units

- Changed to Prestressed
- Same 15’ Span and cross section from 1949 drawings
- Still no topping
- Still have closure pours that required forming from below
- No detail for connecting top & bottom rebar in closure pour
- Beams thicker at ends to account for camber (rideability)

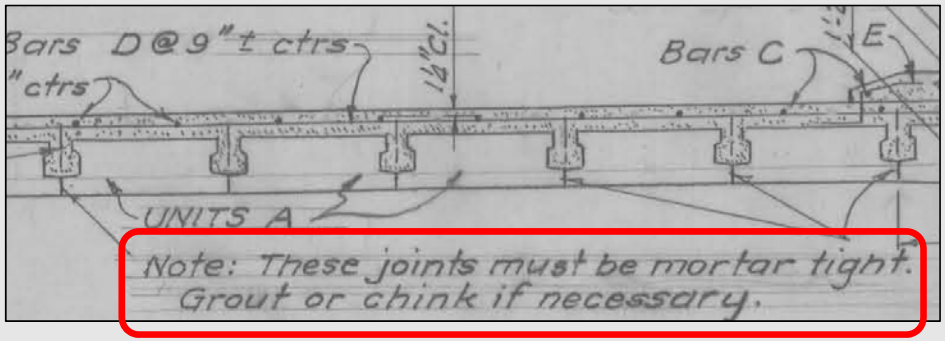


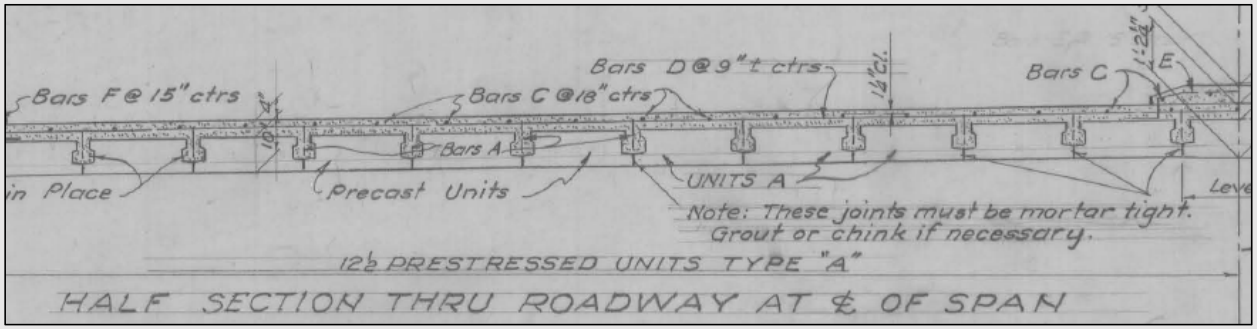


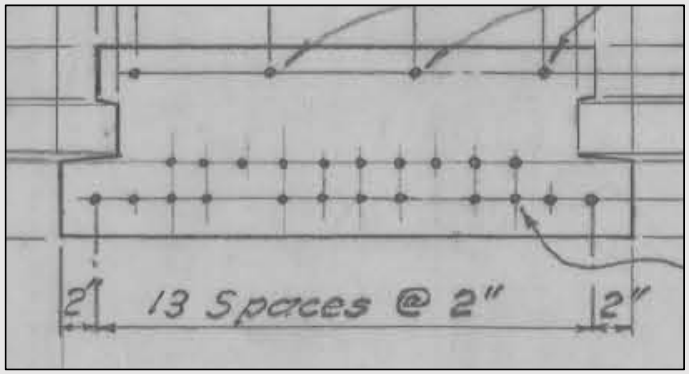


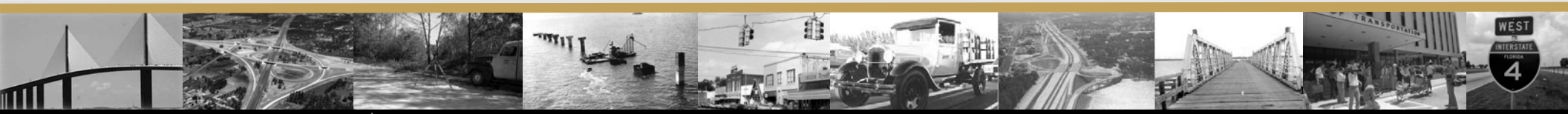
1956 Prestressed Units with C.I.P. Topping

- Eliminated closure pour and bottom transverse rebar
- Added 4” thick reinforced concrete composite topping
- Units erected with side-by-side contact
- Longitudinal joints grouted tight
- 30’ Span





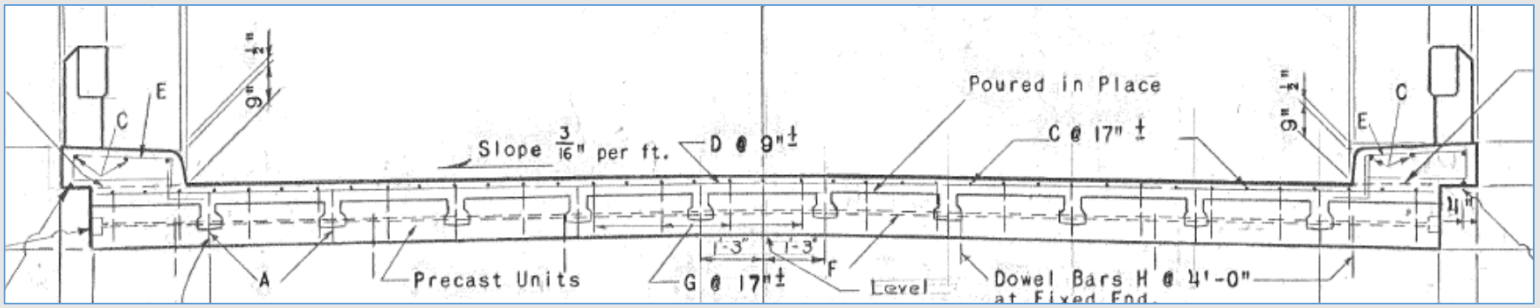


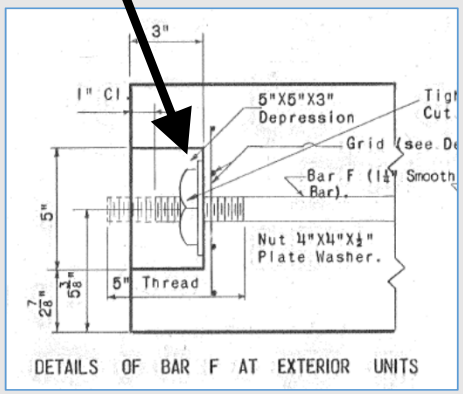


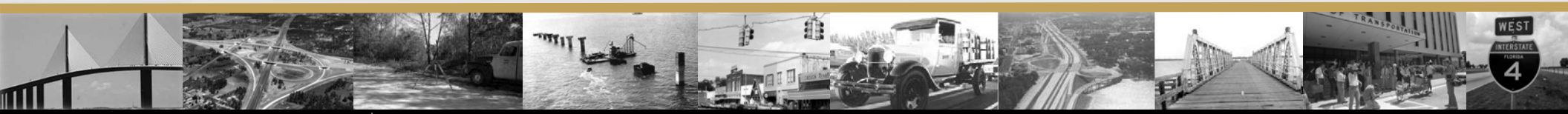
1958 Prestressed Units with C.I.P. Topping

- Added transverse tie bars through sleeves (not post-tensioned)
- Still have 4” thick reinforced concrete composite topping
- Units still erected side-by-side with grouted longitudinal joints

Tighten nut using 300 ft.-# of Torque.
Cut rod and Grout Hole.

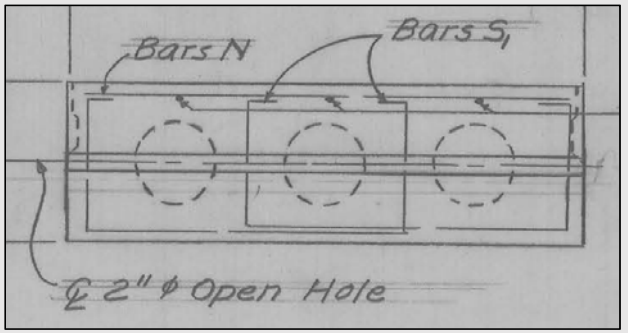


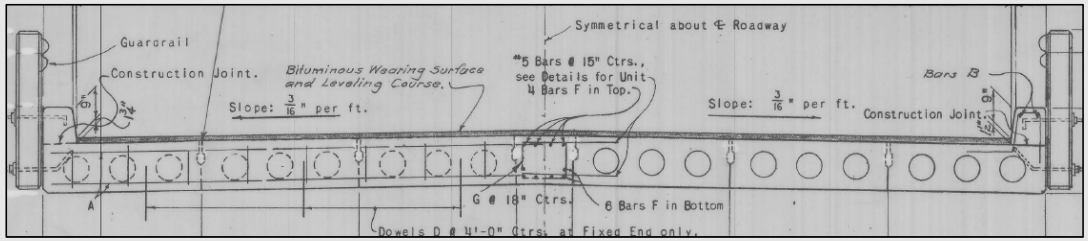


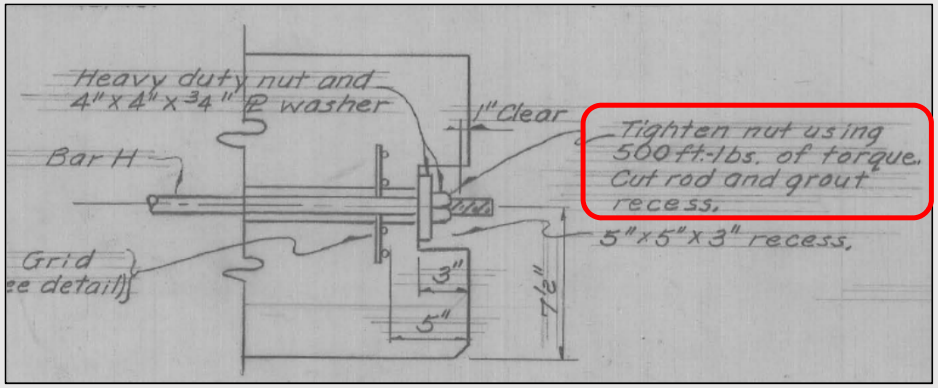


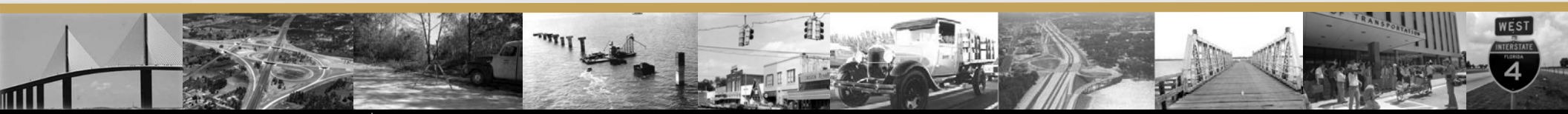
1959 Sonovoids with Asphalt Topping

- Deeper beams with voids to reduce weight
- Changed from concrete to asphalt topping (leveling course)
- Still have transverse tie bars through sleeves (not post-tensioned)
- Increased torque on tie bars from 300 to 500 ft-lbs

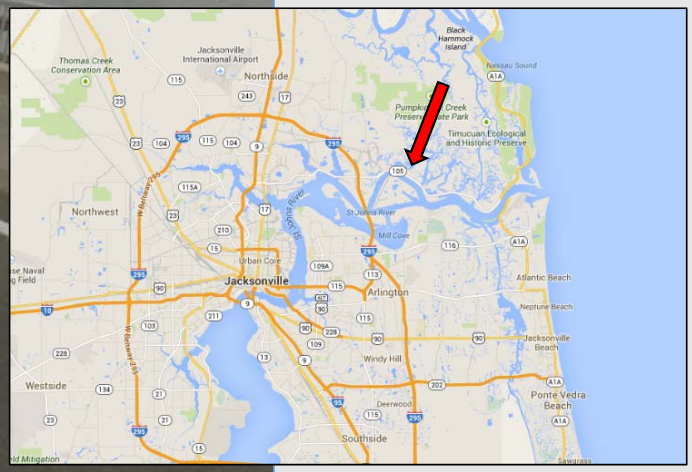








SR 105 (Heckscher Drive) over Brown's Creek (D-2) Sonovoids with Asphalt Topping



Source: Google

1984 Bulletin

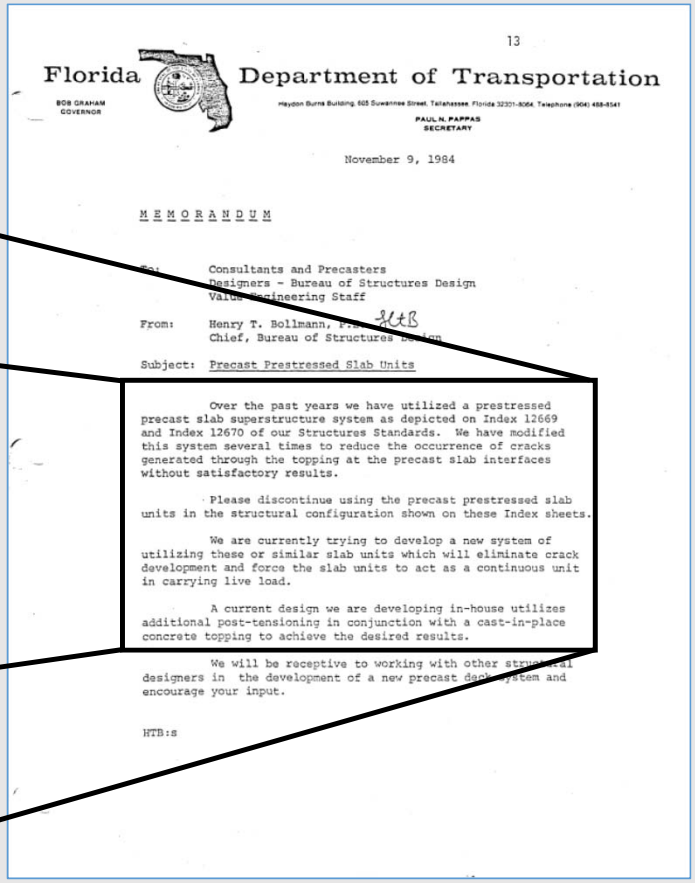
http://www.dot.state.fl.us/structures/StructuresDirectives-Pre1987HD.pdf
(see pdf page 86 of 107)

Over the past years we have utilized a prestressed precast slab superstructure system as depicted on Index 12669 and Index 12670 of our Structures Standards. We have modified this system several times to reduce the occurrence of cracks generated through the topping at the precast slab interfaces without satisfactory results.

Please discontinue using the precast prestressed slab units in the structural configuration shown on these Index sheets.

We are currently trying to develop a new system of utilizing these or similar slab units which will eliminate crack development and force the slab units to act as a continuous unit in carrying live load.

A current design we are developing in-house utilizes additional post-tensioning in conjunction with a cast-in-place concrete topping to achieve the desired results.



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Florida Department of Transportation

BOB GRAHAM
GOVERNOR

Haydon Burns Building, 605 Suwannee Street, Tallahassee, Florida 32301-8064, Telephone (904) 488-8541

PAUL N. PAPPAS
SECRETARY

November 9, 1984

MEMORANDUM

To: Consultants and Precasters
Designers - Bureau of Structures Design
Value Engineering Staff

From: Henry T. Bollmann, P.E.
Chief, Bureau of Structures Design

Subject: Precast Prestressed Slab Units

Over the past years we have utilized a prestressed precast slab superstructure system as depicted on Index 12669 and Index 12670 of our Structures Standards. We have modified this system several times to reduce the occurrence of cracks generated through the topping at the precast slab interfaces without satisfactory results.

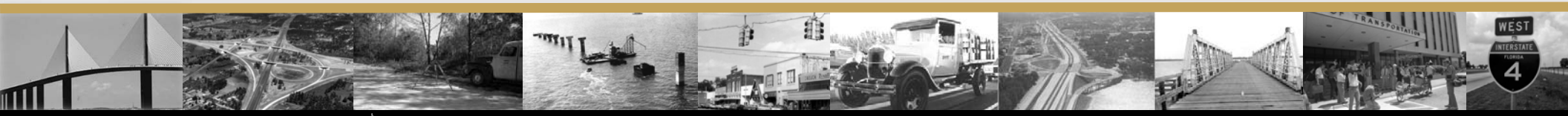
Please discontinue using the precast prestressed slab units in the structural configuration shown on these Index sheets.

We are currently trying to develop a new system of utilizing these or similar slab units which will eliminate crack development and force the slab units to act as a continuous unit in carrying live load.

A current design we are developing in-house utilizes additional post-tensioning in conjunction with a cast-in-place concrete topping to achieve the desired results.

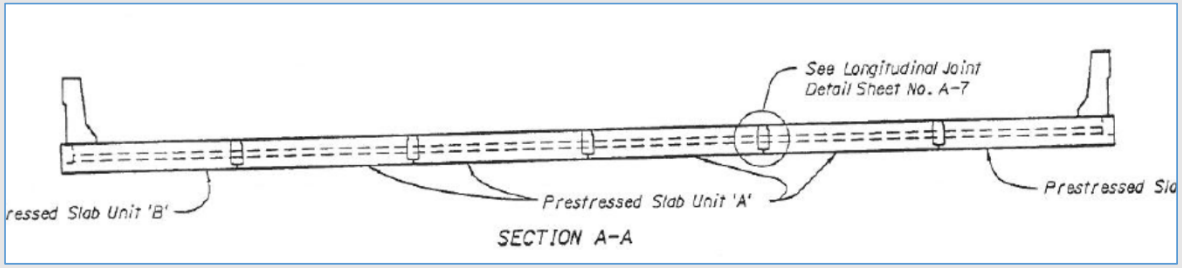
We will be receptive to working with other structural designers in the development of a new precast deck system and encourage your input.

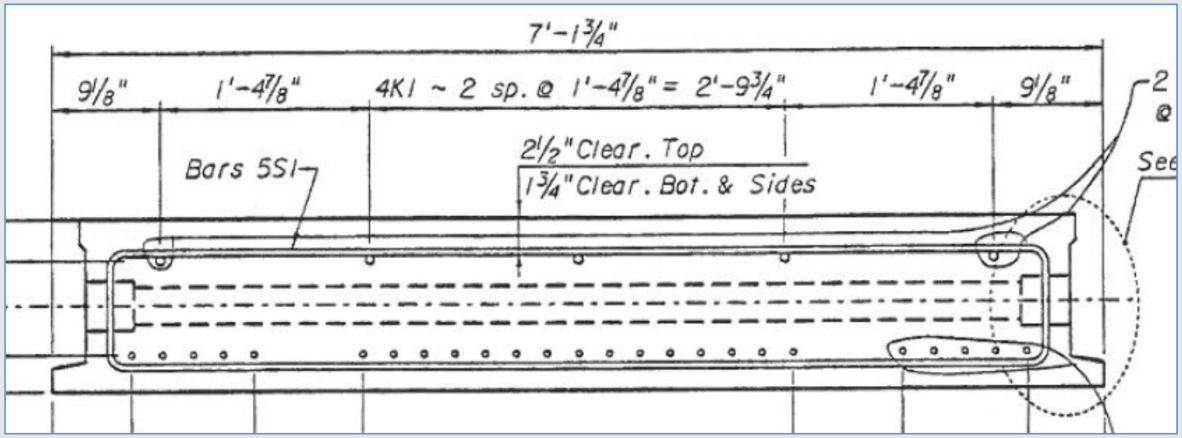
HTB:s

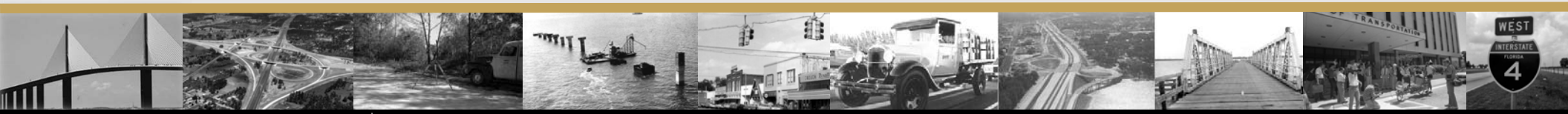


1988 Prestressed Slab Unit with Transverse Post-Tensioning

- Transversely post-tensioned
- No composite topping
- Winning bid was for the alternate design C.I.P. slab
- Post-tensioning adds cost and time to the project





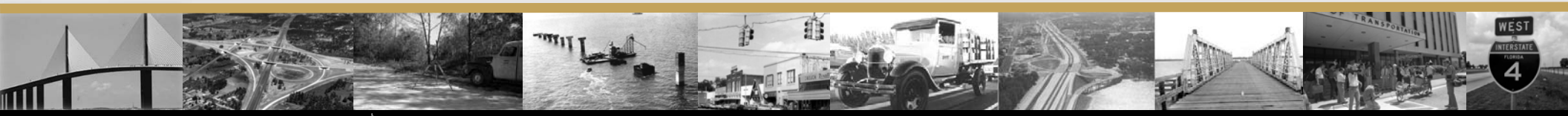


PSU with Transverse Post-Tensioning

4.4 PRECAST, PRESTRESSED SLAB UNITS [5.14.4.3]

B. In order to accommodate the enhanced post-tensioning system requirement of three levels of protection for strand, transverse post-tensioned pre-stressed slab units must incorporate a double duct system. The outer duct must be cast into the slab and sized to accommodate a differential camber of 1-inch. The inner duct must be continuous across all joints and sized based upon the number of strands or the diameter of the bar coupler. Specify that both the inner duct and the annulus between the ducts be grouted.

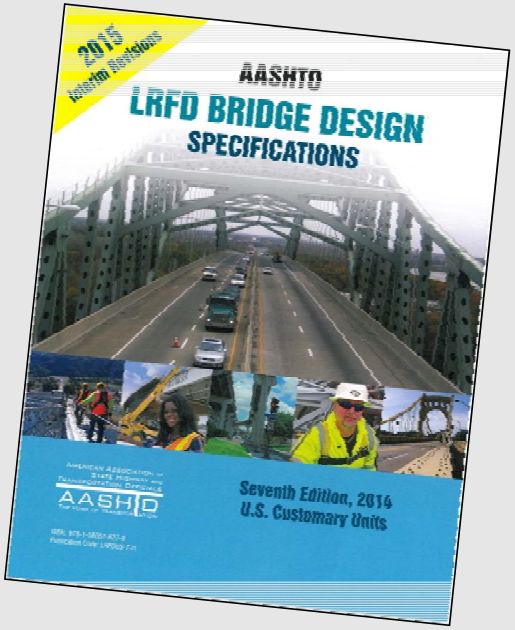
No systems currently on the Approved Post-Tensioning System Vendor Drawings



AASHTO LRFD C4.6.2.2.1 Beam-Slab Bridges

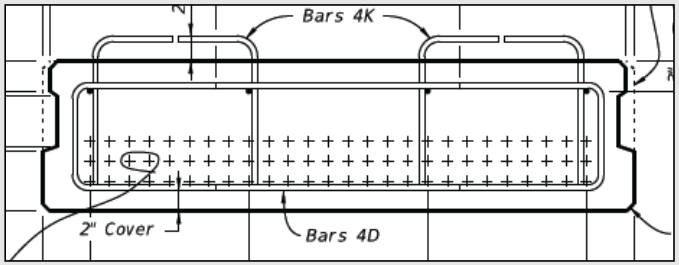
- "…this type of construction acts as a monolithic unit if sufficiently interconnected."
- What is "sufficiently interconnected"?
  - "A minimum 0.25 ksi prestress is recommended"

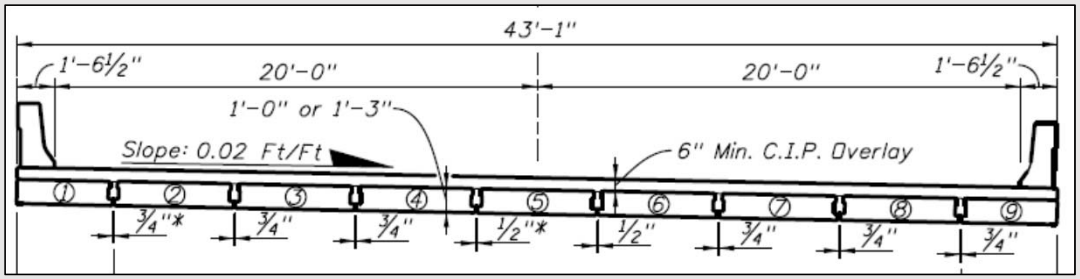
- "The use of transverse mild steel rods secured by nuts… should not be considered sufficient to achieve full transverse flexure continuity…"



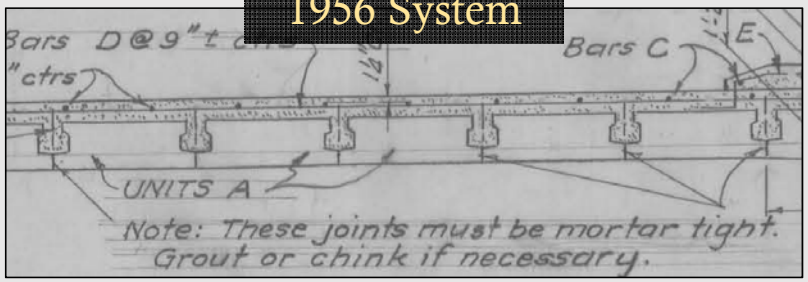
2008 Prestressed Slab Unit (PSU)

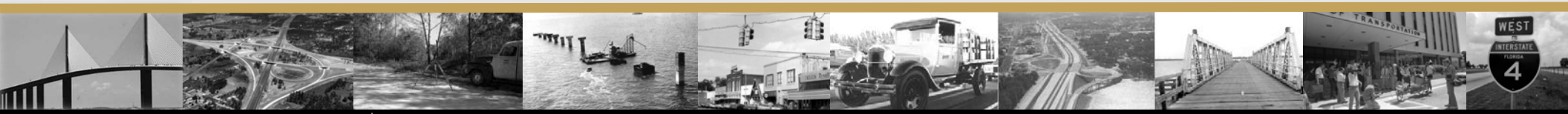
- 2008 Interim Standards
- Off-system applications only
- 6” minimum composite topping
- Single mat of reinforcing in topping
- Fiber reinforced concrete (Dev346FRC)
- No bottom transverse rebar
- Keyway filled with non-shrink grout (3 days prior to topping placement)





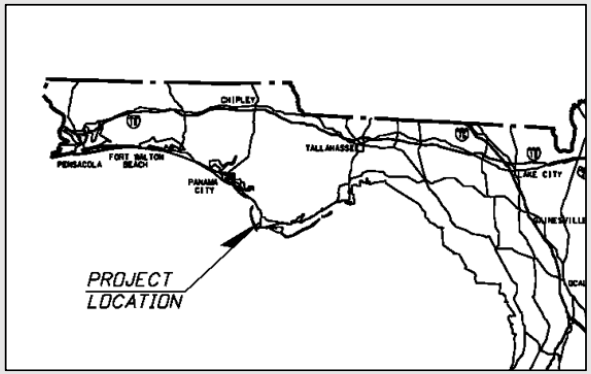
1956 System





SR 30-A (D-3)

- PSUs
- Span = 33’-2”
- Construction 2010
- Load tested Dec. 2011



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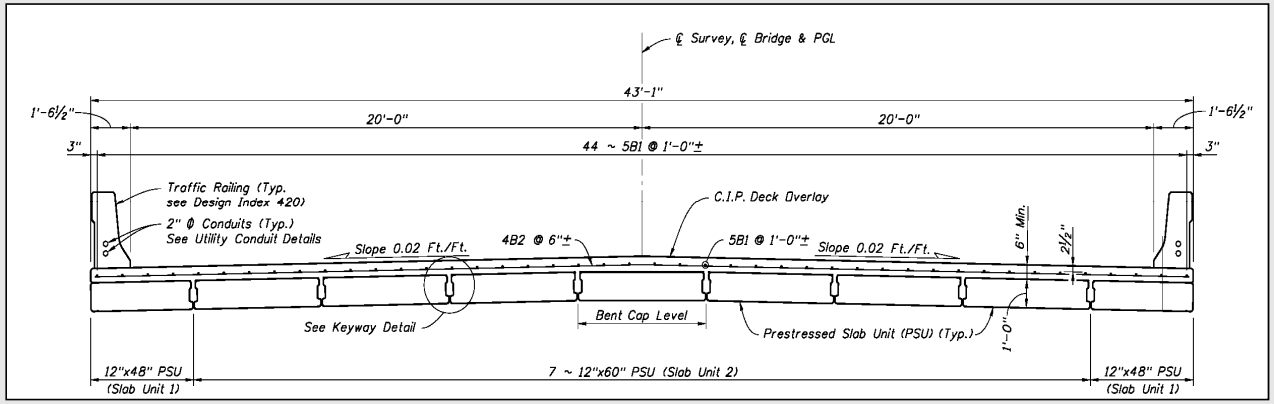
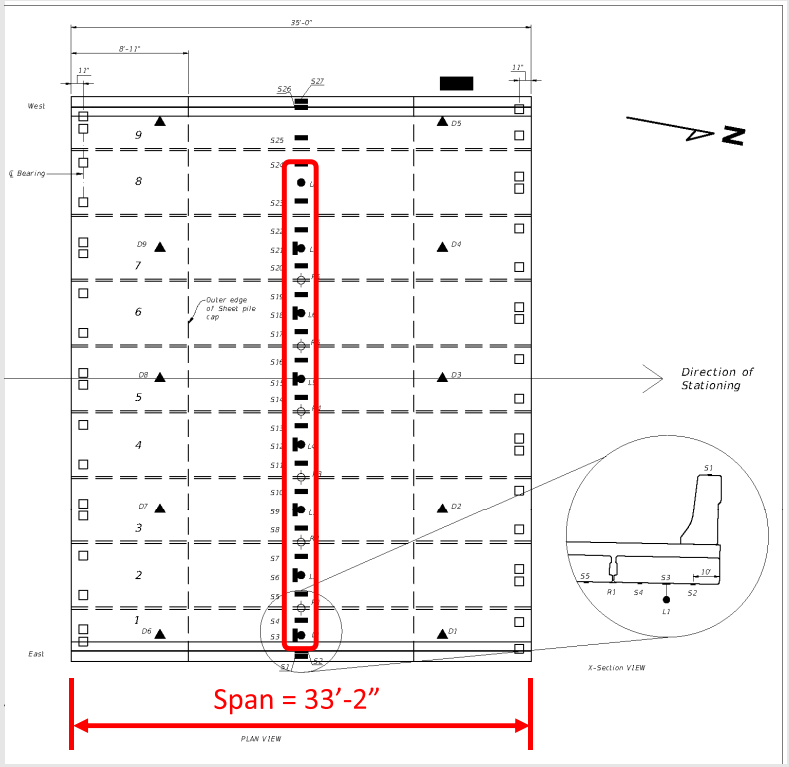
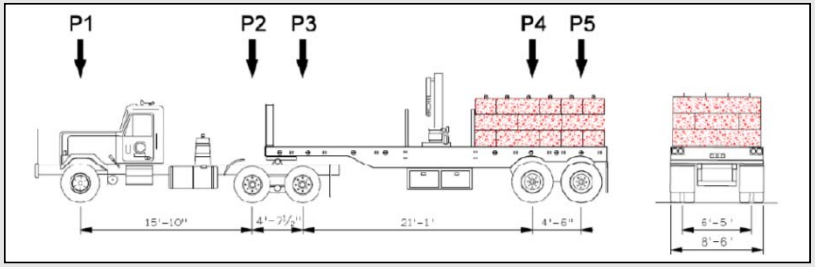
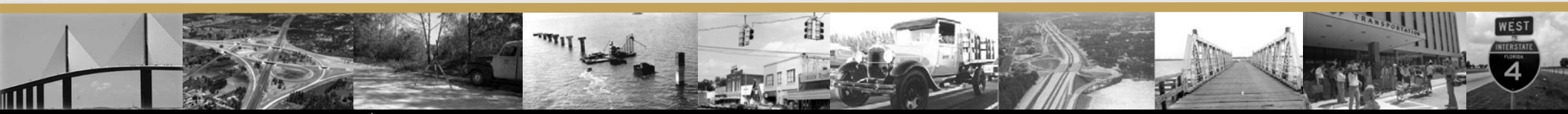


SR 30-A Load Test







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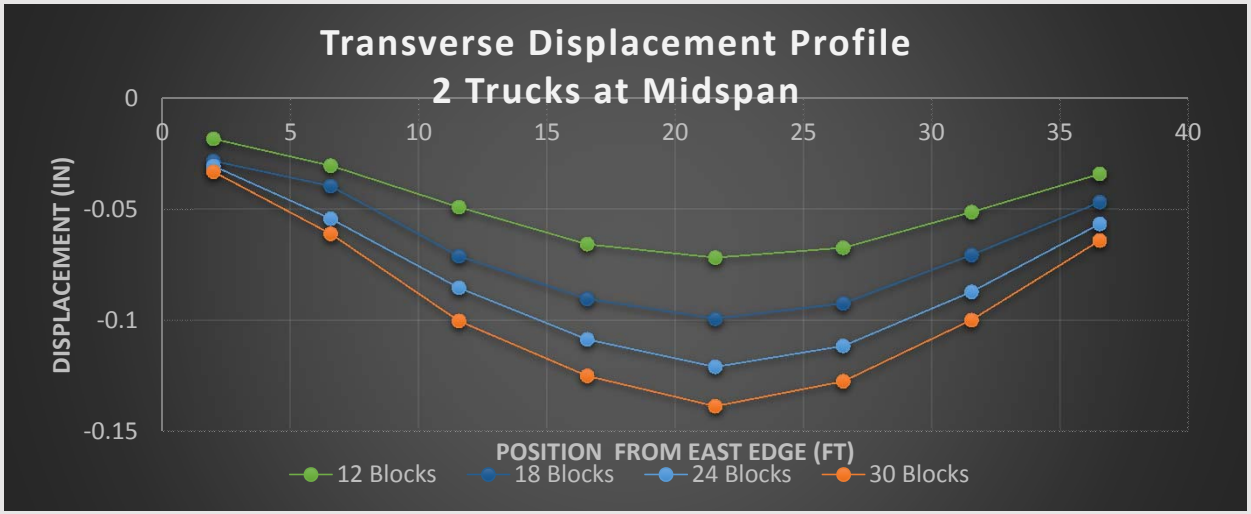
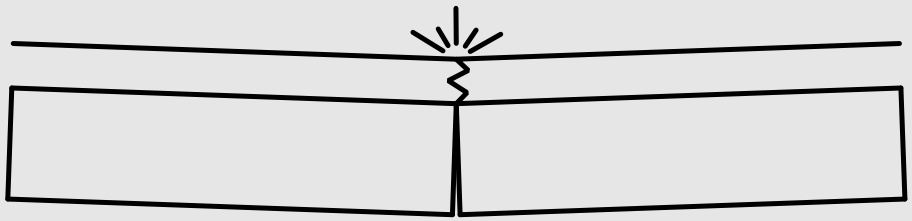
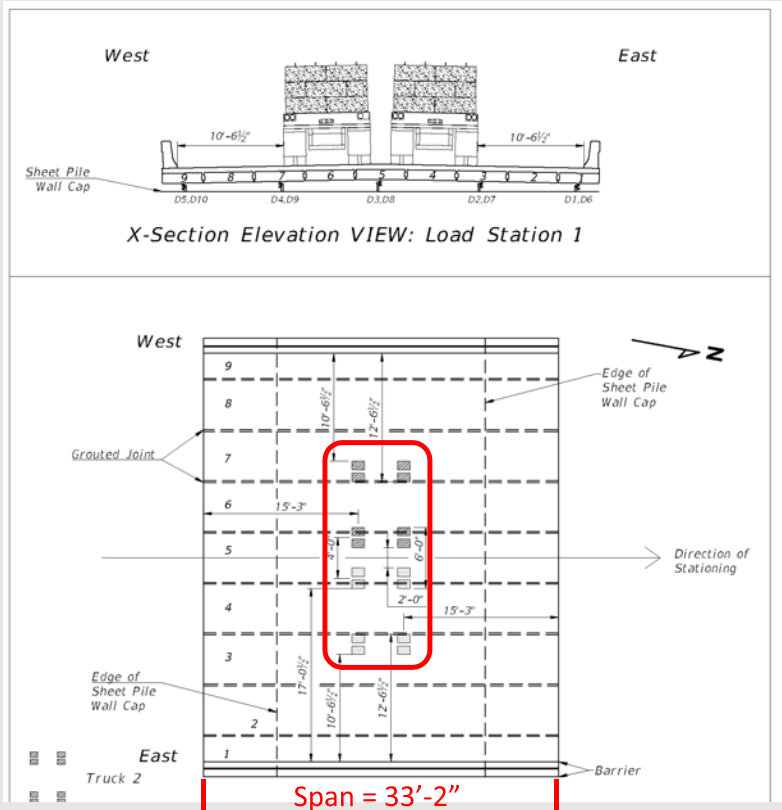
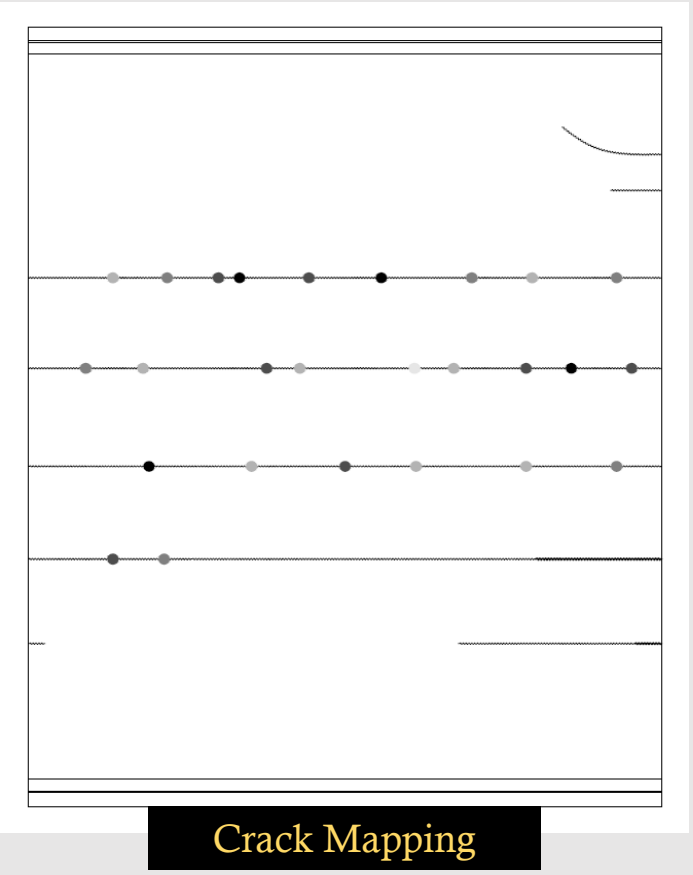
SR 30-A Load Test







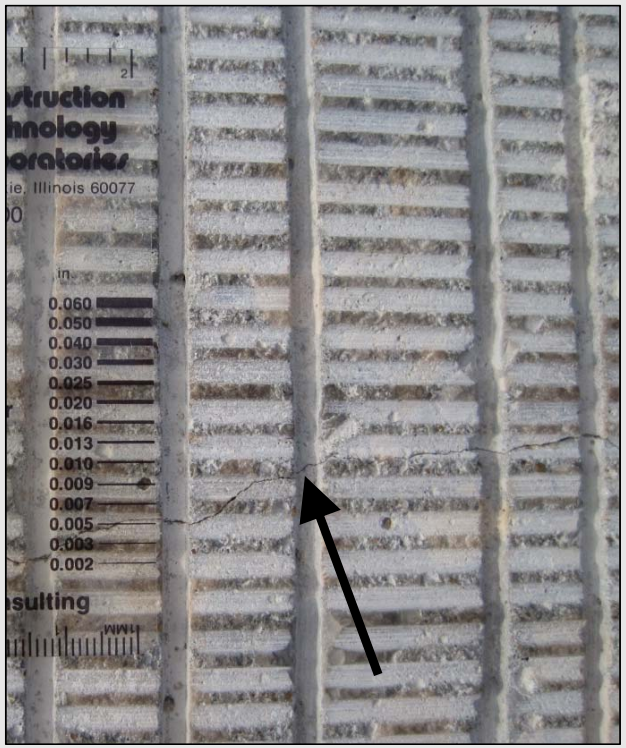
SR 30-A

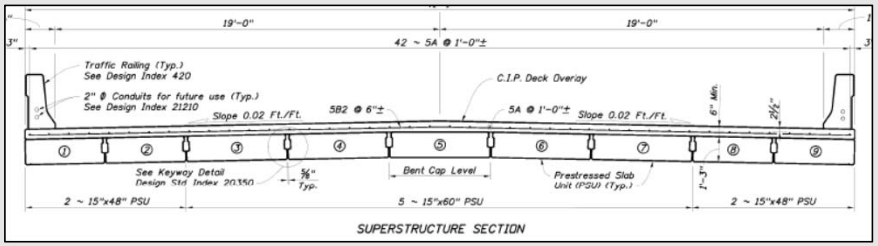


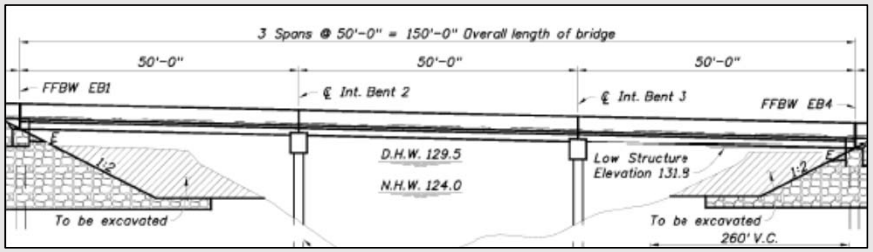
Crack Mapping

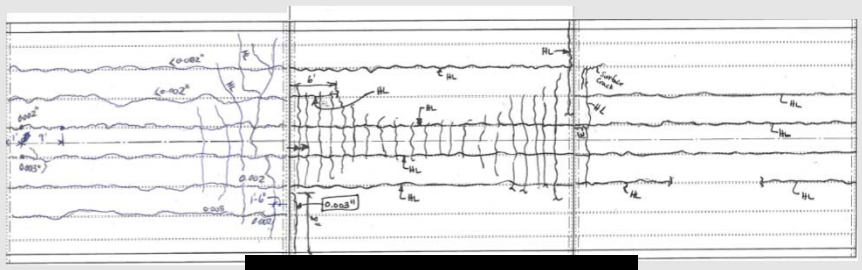
County Project in District 3

- PSUs
- 2013 crack mapping about two months after opening to traffic
- Hairline cracks at longitudinal joints



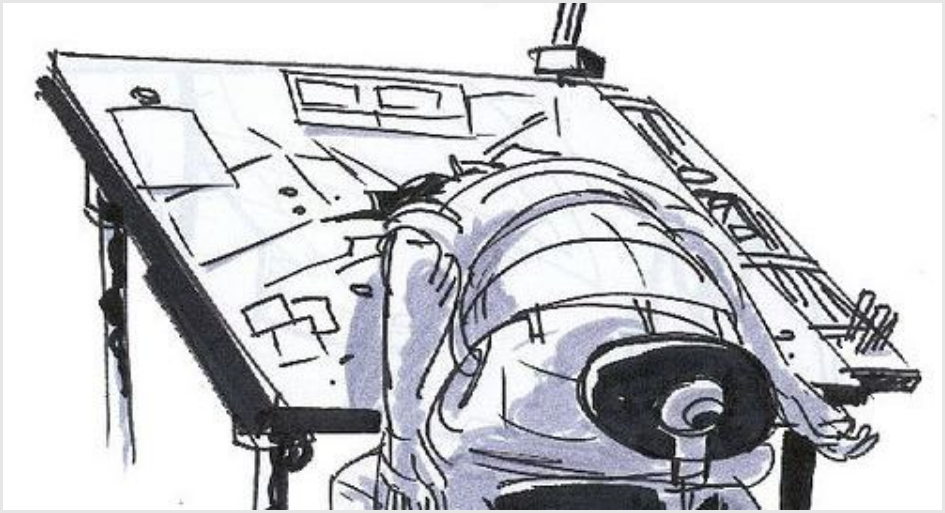






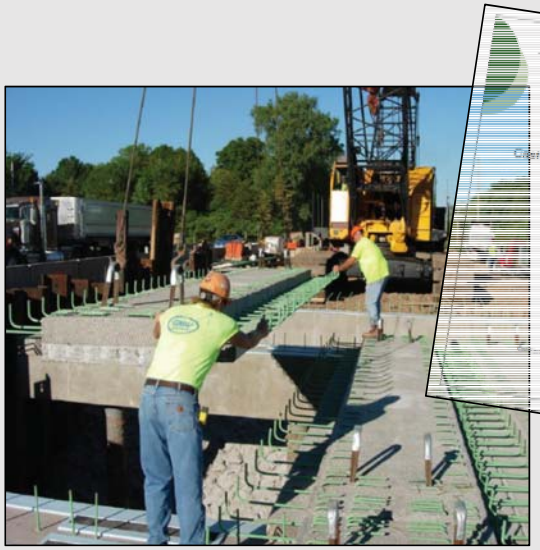
Crack Mapping

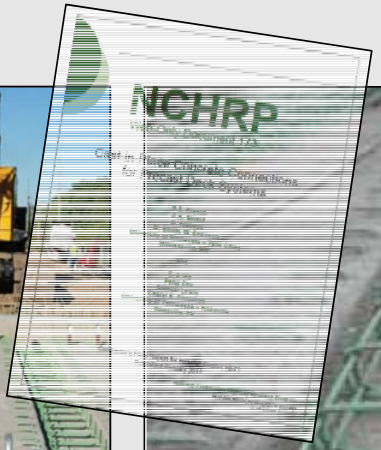
Florida Slab Beam (FSB)

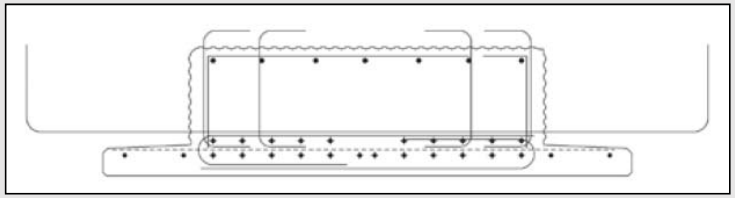


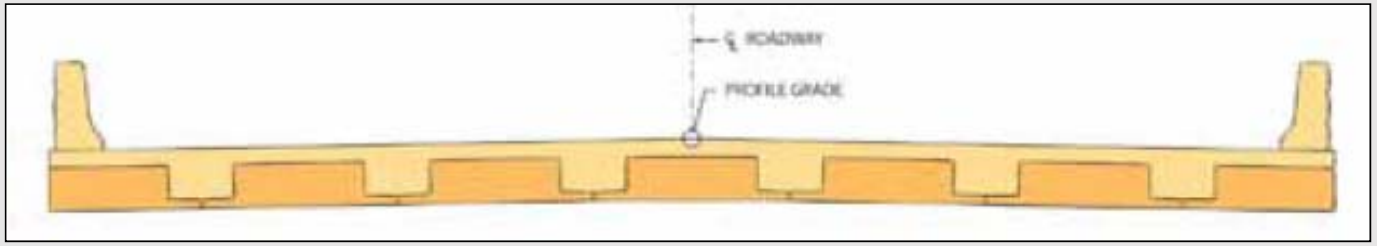
Poutre-Dalle System

- Originally developed in France
- Used in Minnesota
  - Beams erected with side-by-side contact
  - Hook bars could be a nuisance during erection



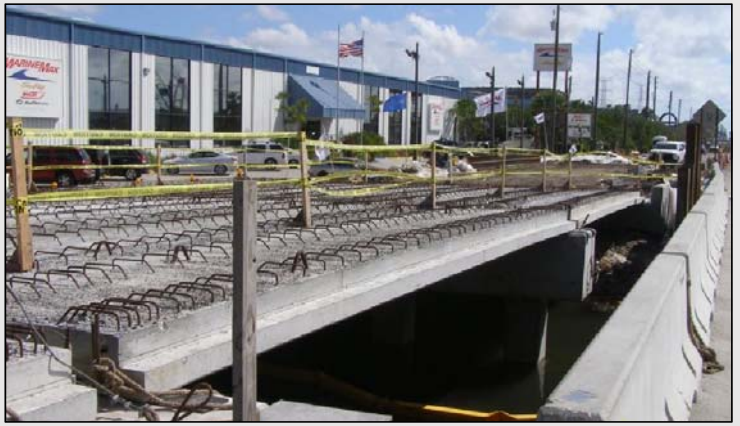


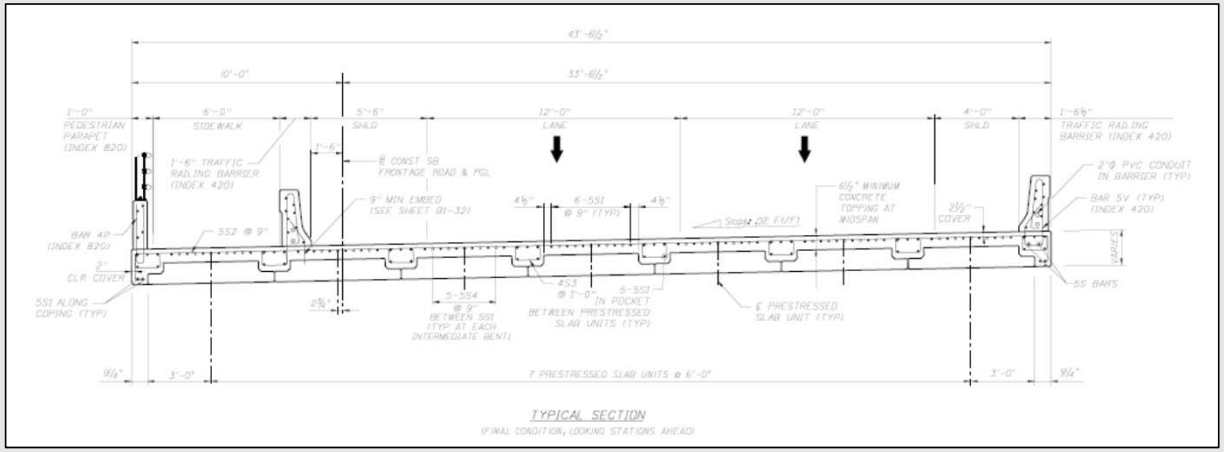




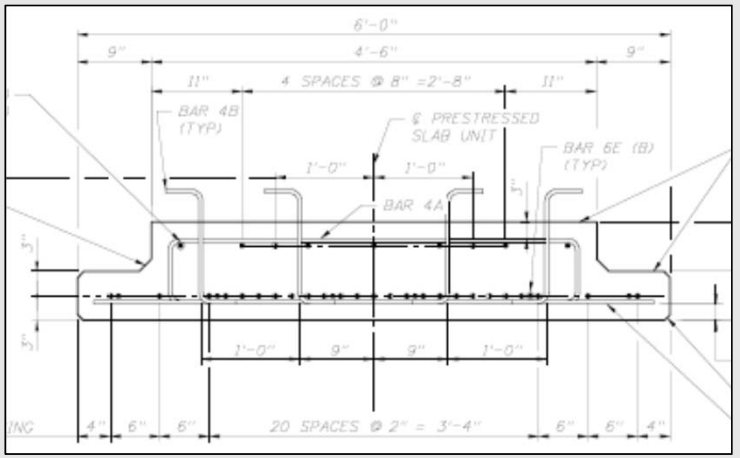
District 7 Shape

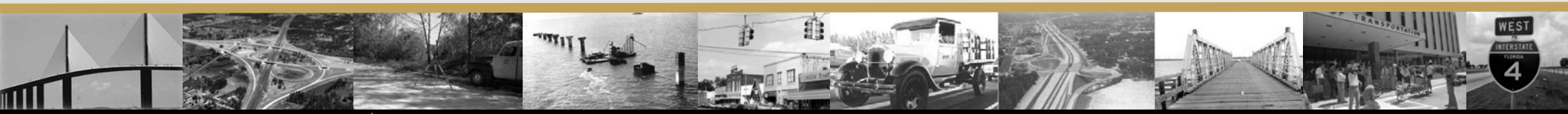
- Similar to Minnesota Shape
- No bottom transverse rebar
- Erected with side-by-side contact
- Plans required saturation of beams prior to topping pour (good)
- No significant cracking according to inspection reports – but no detailed crack mapping has been performed (to our knowledge)





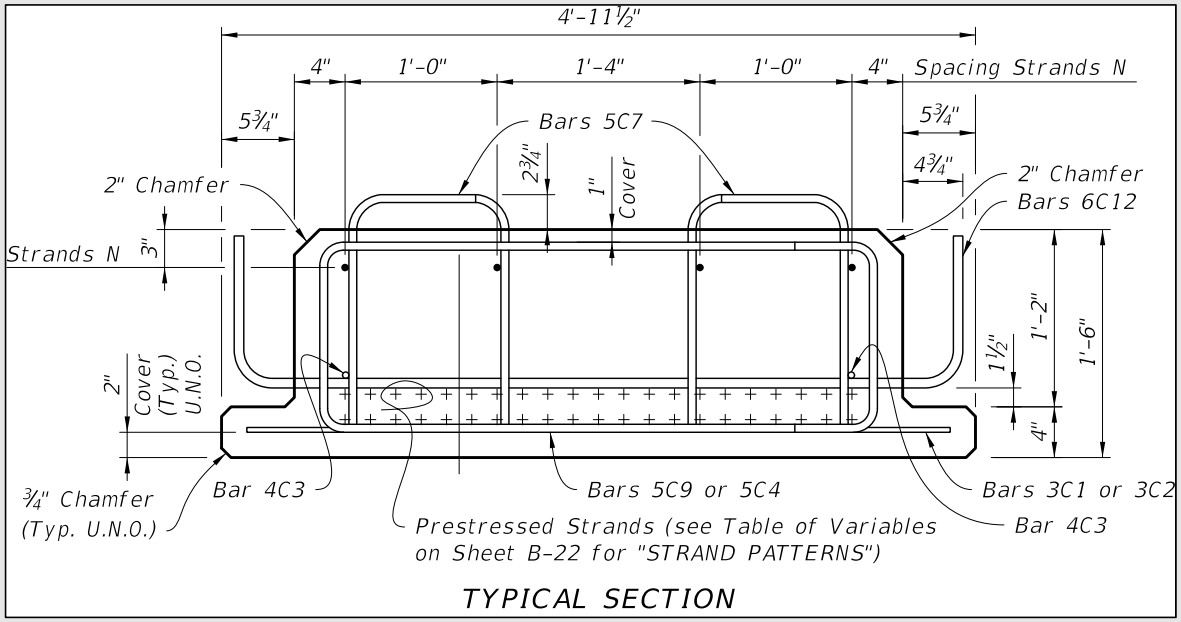
TYPICAL SECTION
(FINAL CONDITION, LOOKING STATIONS AHEAD)



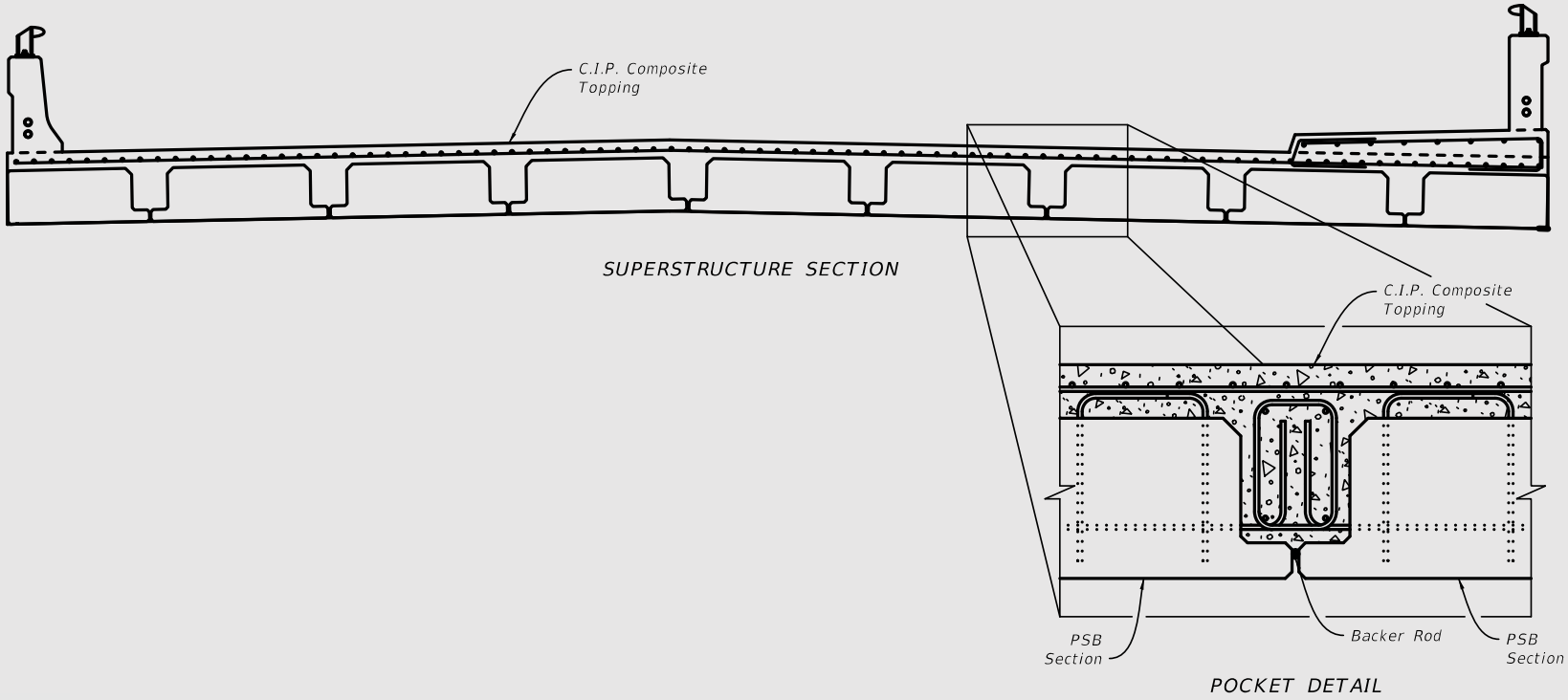


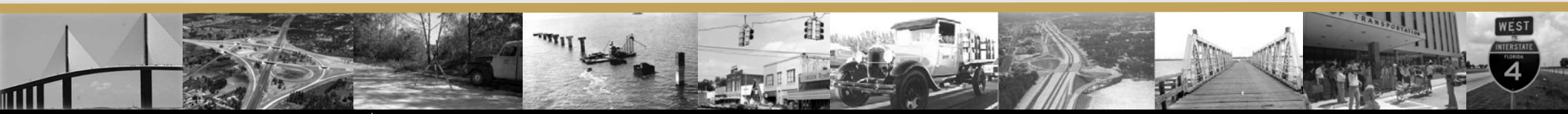
Florida Slab Beam (FSB)

- Beam shape used for pilot project
- #6 bottom transverse bars

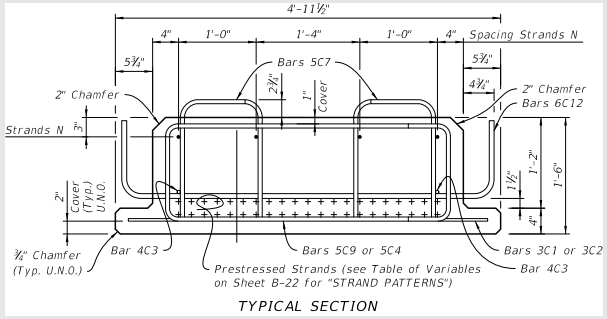


FSBs with C.I.P. Composite Topping

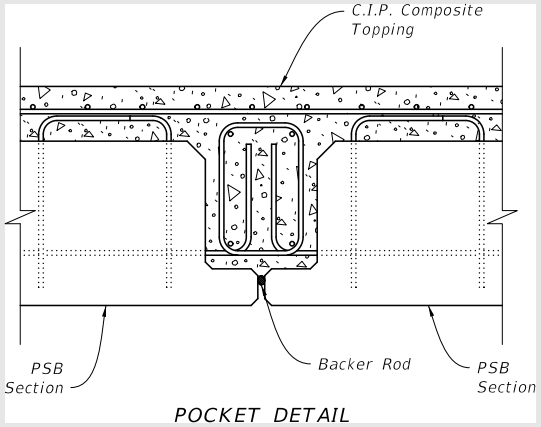




Why the FSB?

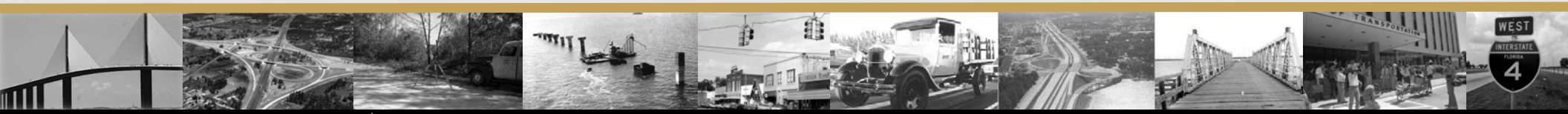


TYPICAL SECTION

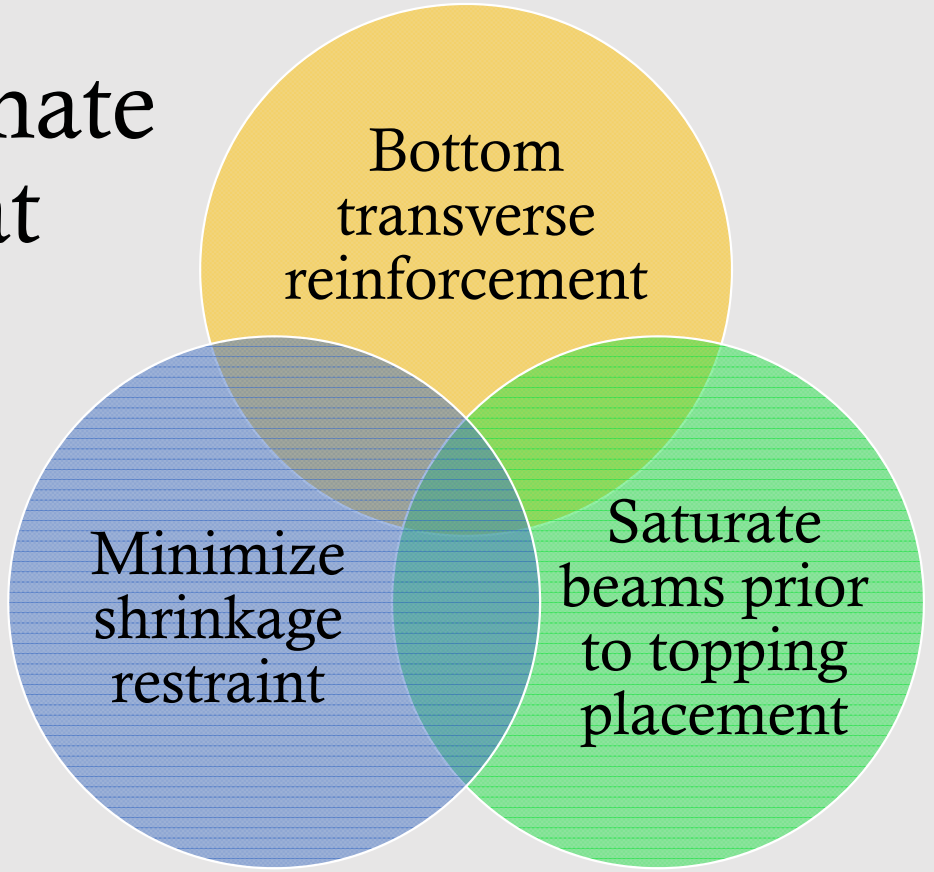


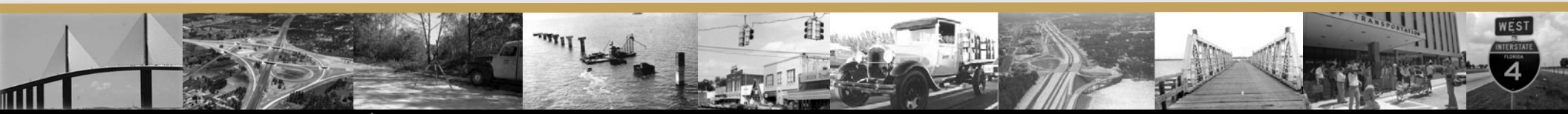
POCKET DETAIL

- Accelerated construction
  - Less forming at the site
  - Less deck steel to place and tie
  - Safe working platform with less fall protection required
- Transversely reinforced on the bottom
  - Intended to behave as a monolithic slab
  - Mild transverse reinforcement -- No post-tensioning
- FSBs fill a need
  - There is a need for beams in this span range (30 to 50-feet)
  - Lower profile
  - Potential for standardization
- Economical?
  - FSBs are relatively quick but expensive
  - FSB superstructure is over 1.5 times cost of AASHTO Type II



FSB Strategies to Eliminate or Minimize Cracking at Longitudinal Joints

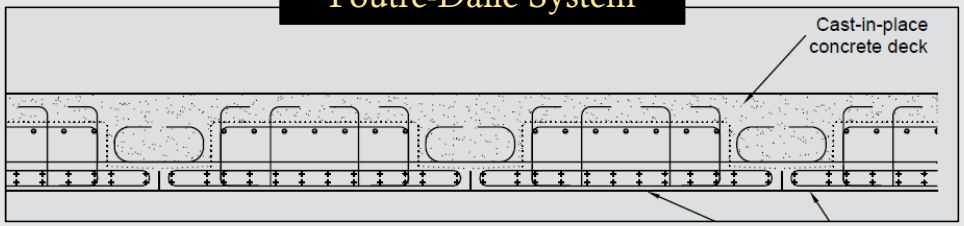




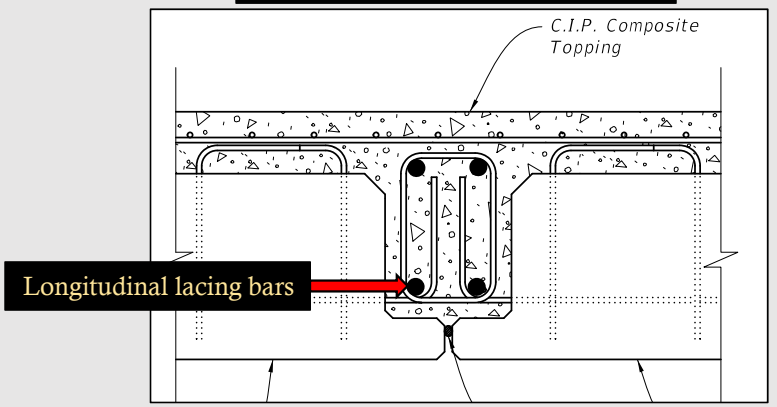
Bottom transverse reinforcement with hoop and lacing bars

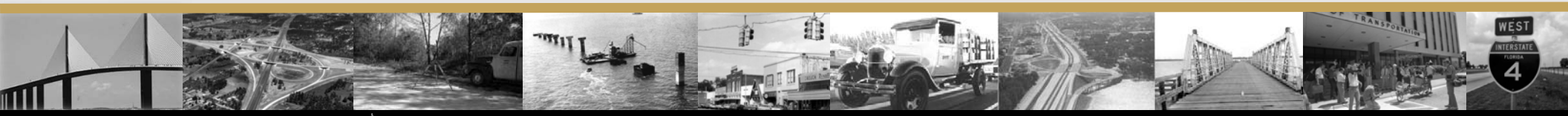
- Intended to simulate a monolithic slab without post-tensioning
- 2-way bending and live load distribution

Poutre-Dalle System



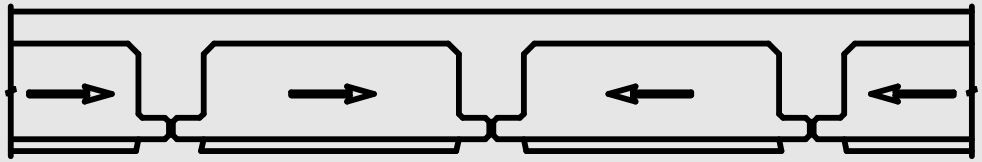
Florida Slab Beam (FSB)

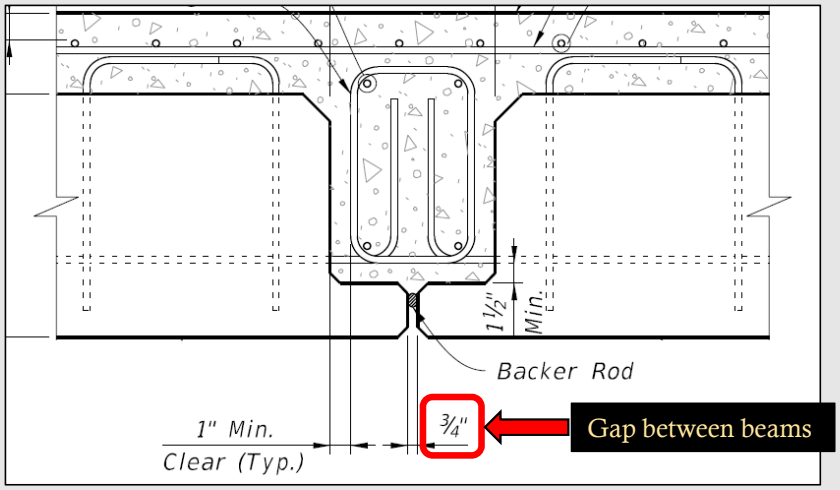


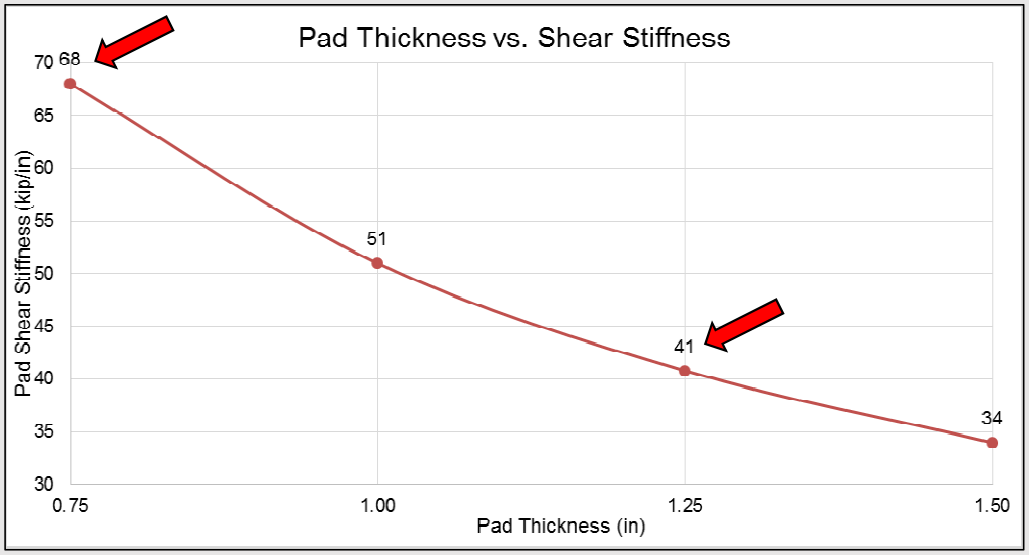


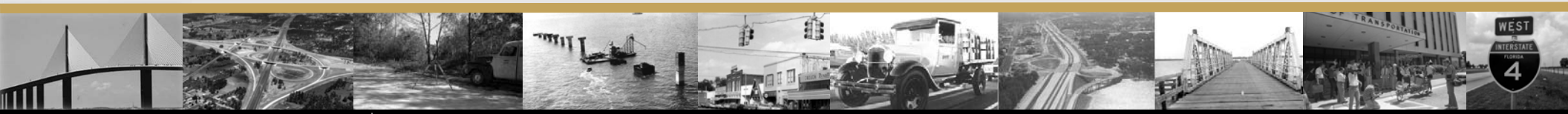
Minimize Shrinkage Restraint

- Small gap between beams
- Thicker neoprene pads
  - Minimize transverse “hard points” at supports
  - 40% reduction in transverse stiffness by increasing thickness from 0.75” to 1.25”





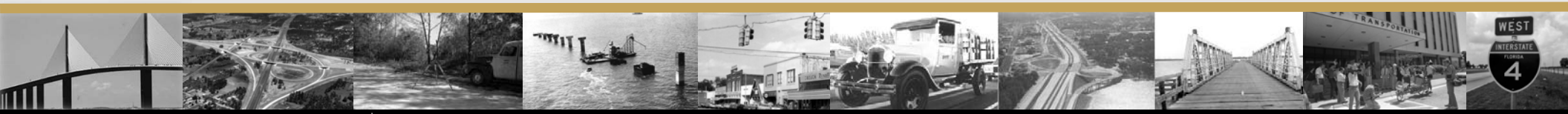




Saturate beams prior to topping placement

C.I.P. COMPOSITE TOPPING CONCRETE PLACEMENT

1. *Thoroughly clean the top surface of the PSBs of all dirt, dust and other foreign material with water or air under pressure.*
2. *Thoroughly saturate the top surface of the PSBs with water for a minimum of 12 hours before placing the C.I.P. concrete topping. Remove standing water from the surface of the PSBs just prior to placing the C.I.P. composite topping.*
3. *Cure the C.I.P. Composite Topping in accordance with Specification Section 400-16.4.*



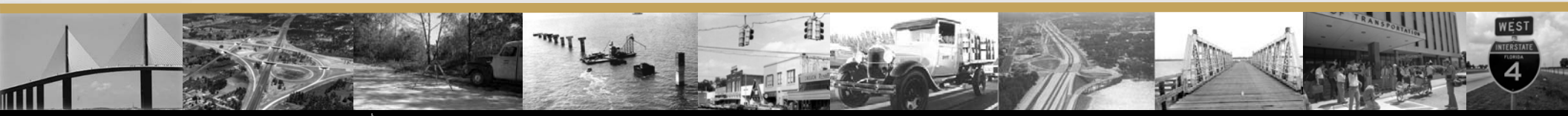
Special Provision for SRA

Shrinkage Reducing Admixture (SRA)

- Reduce material shrinkage as the concrete dries during curing

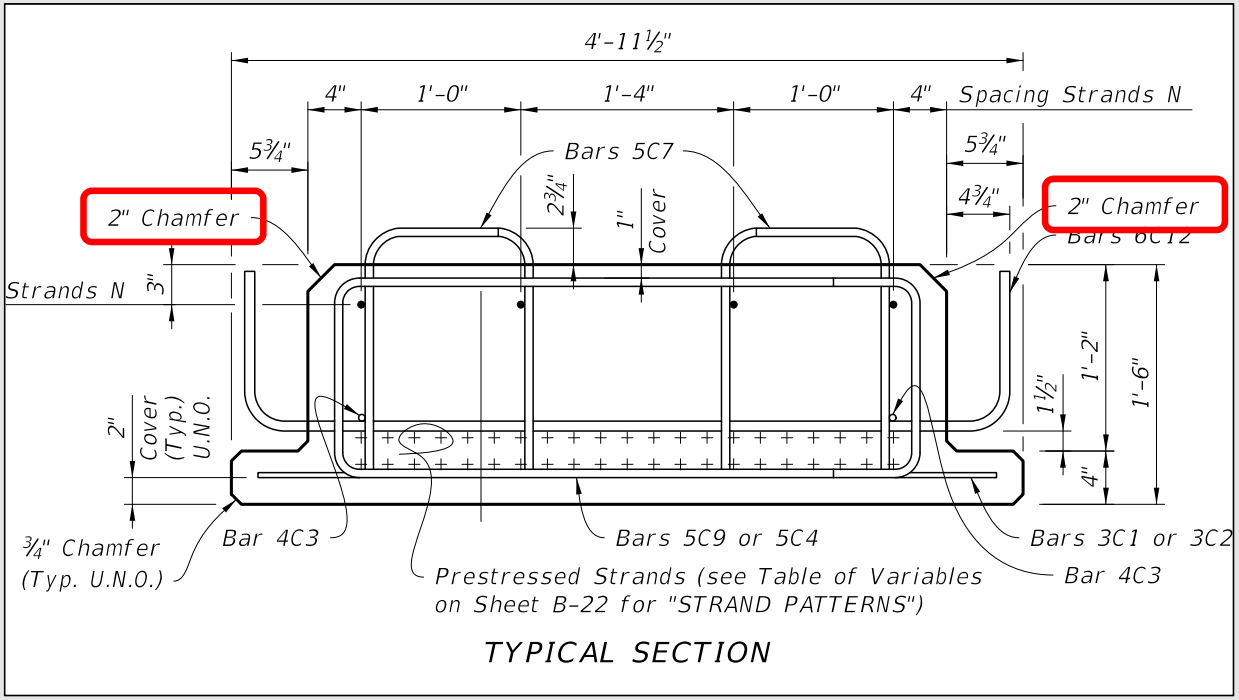
CONCRETE

Concrete Class	Min. 28-day Compressive Strength (psi)	Location of Concrete in Structure
II	3,400	Sidewalk
II	3,400	Traffic Railing
II	3,400	Traffic Railing Junction Slabs
II	3,400	C.I.P. Beam Seat and Backwall
VI	8,500	PSB
II (Bridge Deck) with SRA	4,500	C.I.P. Composite Topping



2” Chamfer on PSB

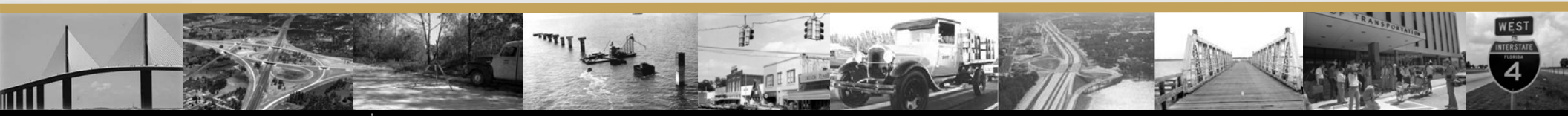
- Larger chamfer to minimize abrupt change in C.I.P. topping section (standard chamfer is ¾”)
- Reduce likelihood that reflective cracks will form at these locations



Pilot Project
Florida Slab Beams (FSBs)

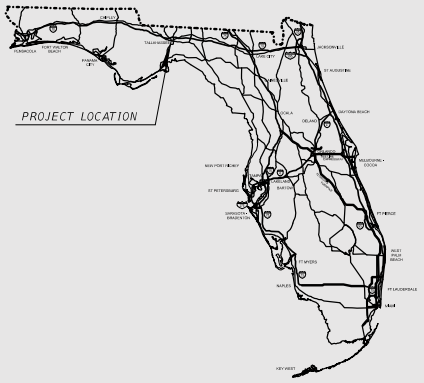
SR 373 (Orange Avenue) over St. Marks Trail

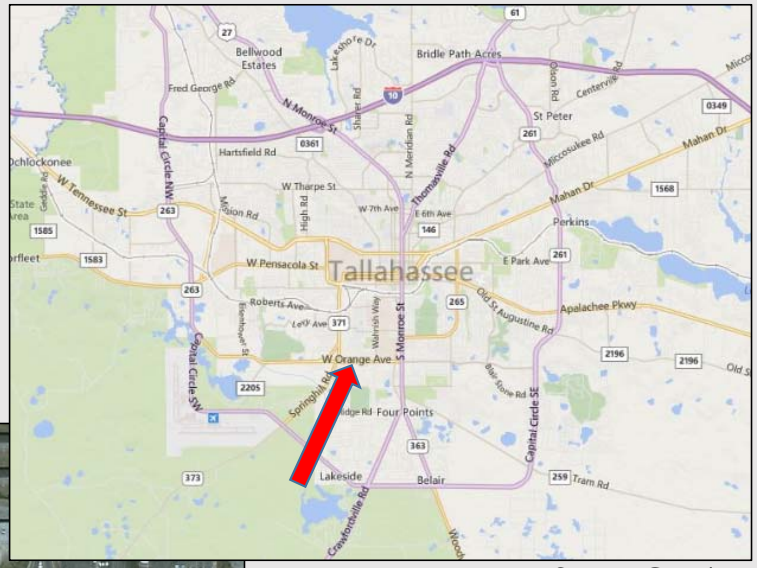
District Three, Leon County



Project Location

Tallahassee





Source: Google

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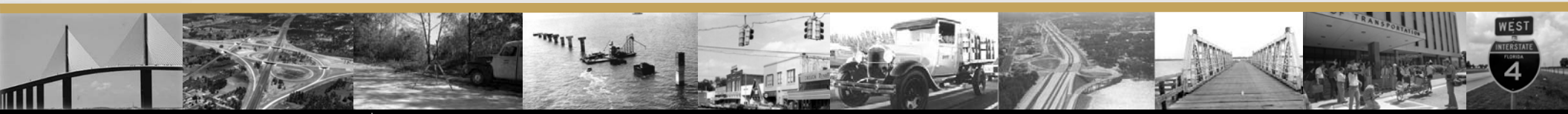
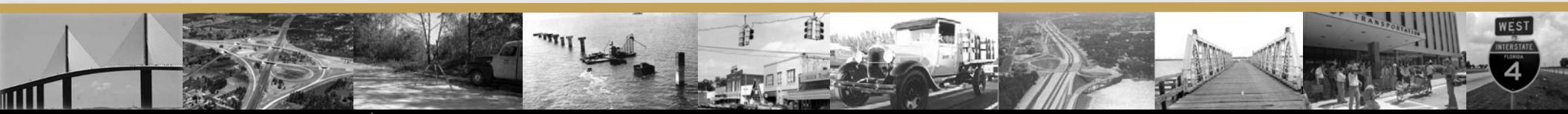


Why replace the existing bridge?

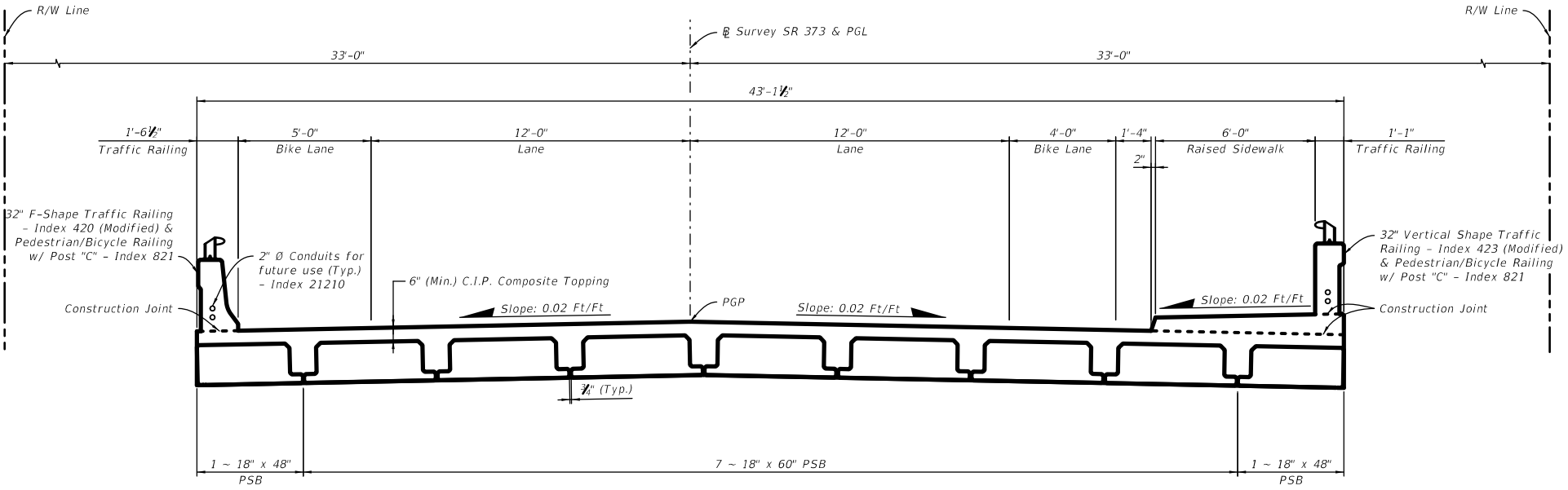


More economical or faster <u>non-bridge</u> alternatives?

At-grade crossing?

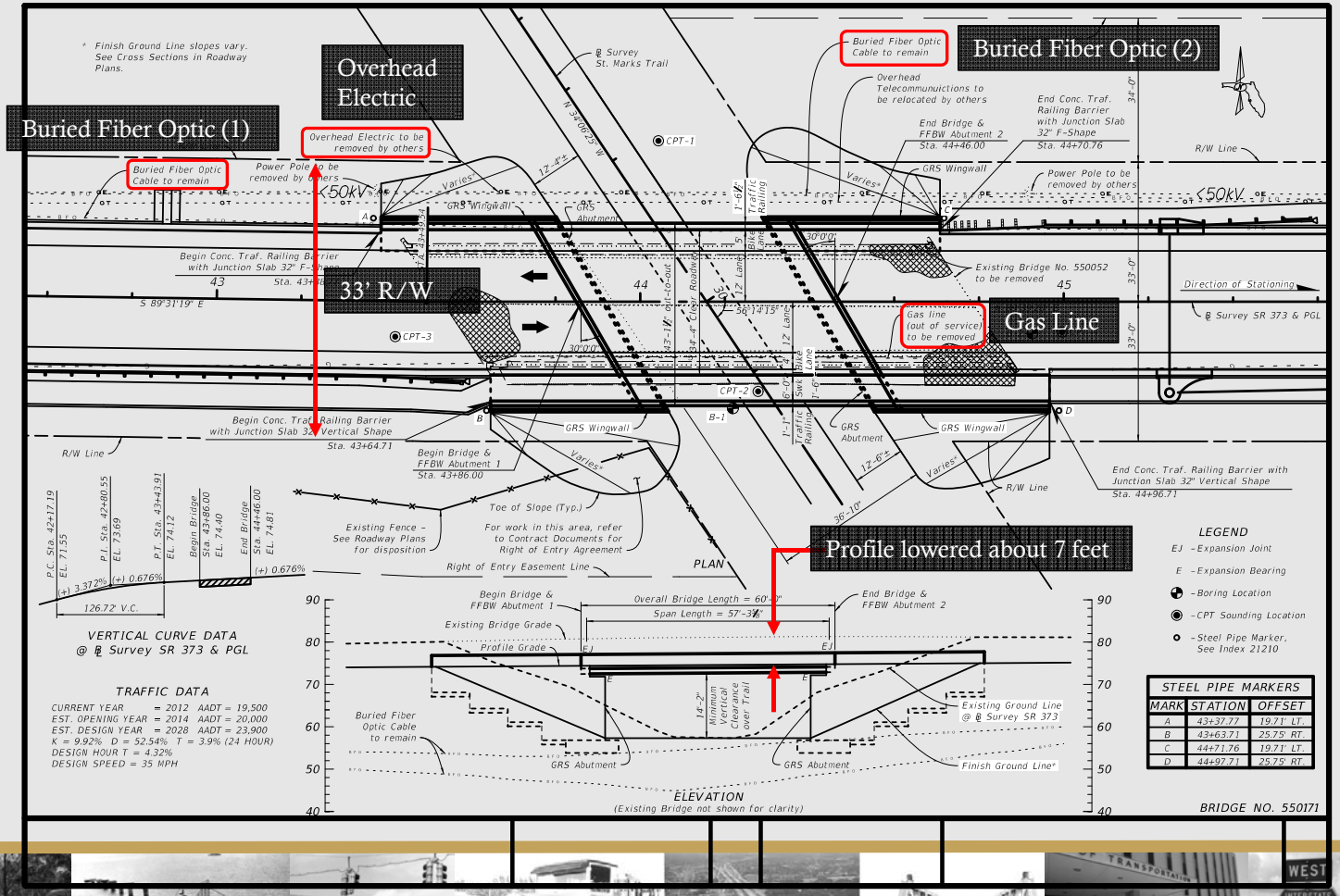
Tunnel?

Bridge Typical Section



TYPICAL SECTION

Bridge Plan and Elevation



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Project Timeline

Non-Emergency Contract

Design

May - June 2013
Bridge Weight Limit Posted for 15 Tons.
District 3 Maintenance decides to accelerate replacement.

July – Aug 2013
Preliminary design concepts.
Survey activities.
Soil borings & CPT Soundings.

Sept – Nov 2013
Final Plans and Specifications package developed for March letting.

Bid

Dec 2013 - Jan 2014
Bid package preparation.
Advertisement.
2 separate contracts for Beams and Construction.

Feb 2014
Pre-Bid Meeting.
Utility relocations.
Casting beams.

March 2014
Bids received.
Contract award.

Build

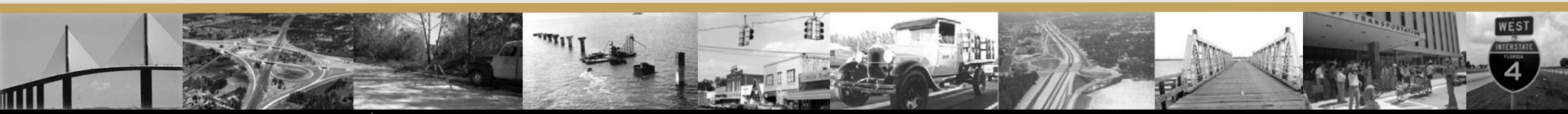
April – May 2014
Pre-con meeting.
Contractor scheduling, procuring materials, coordinating subs, etc.

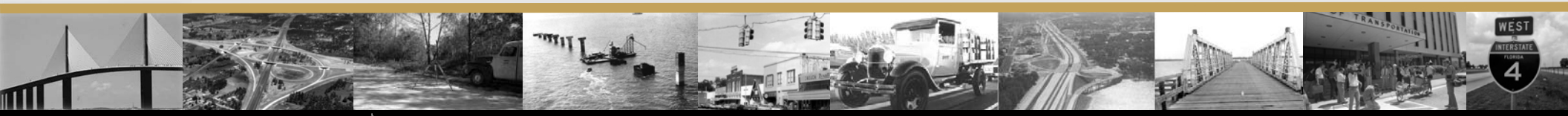
Monday 6-2-2014
Road closed at 12:01 AM.
3 days for demo of existing bridge, clearing & grubbing

Bridge Construction
10 days GRS abutments.
5 days C.I.P. beam seats.
5 days Beams & C.I.P. Topping
14 days for sidewalk, railings, junc. Slabs, etc.

Sunday 7-20-2014
Road re-opened at 7:00 AM

Total 48 day road closure (about 7 weeks)





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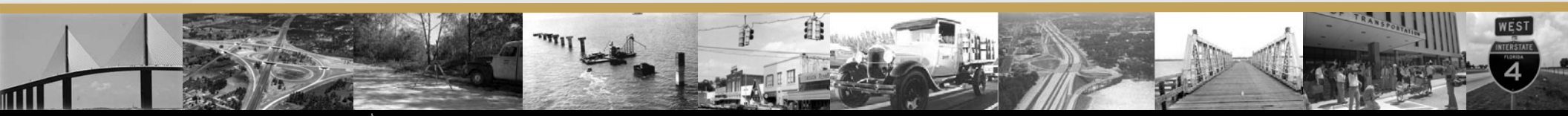

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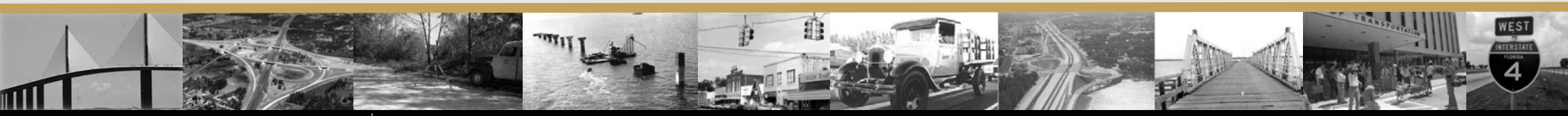

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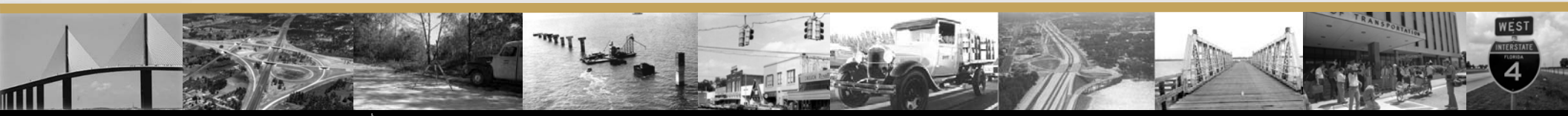

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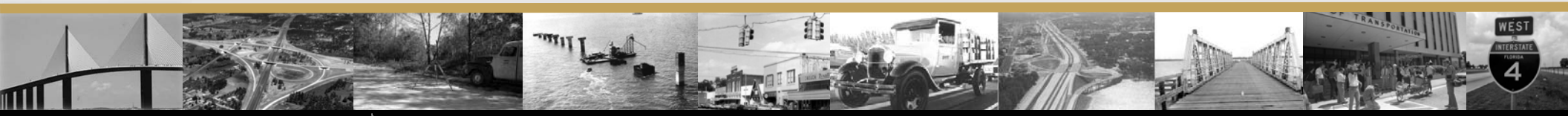
Construction Time Lapse Video

Crack mapping

Project Overview

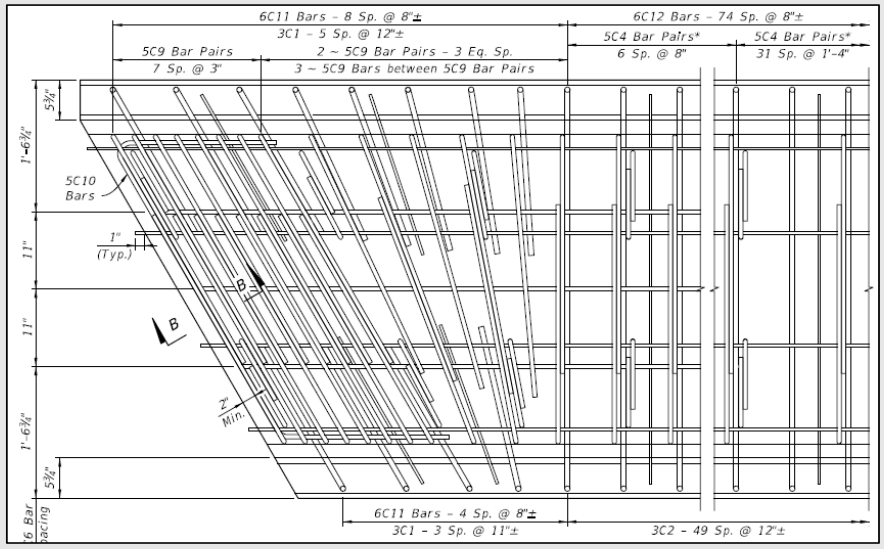
- Road Closure: 7 weeks
  - June 2nd to July 20th 2014
- $2.32M total project cost under two contracts
  - $151k for beams procured by District 3
  - $1.63M construction contract
  - $537k maximum incentive
- Designers:
  - FDOT State Structures Design Office (Superstructure & GRS)
  - George & Associates (Roadway, Drainage, Utilities, Permitting)
- Contractor: Anderson Columbia Co., Inc.
- CEI: American Consulting Professionals, LLC

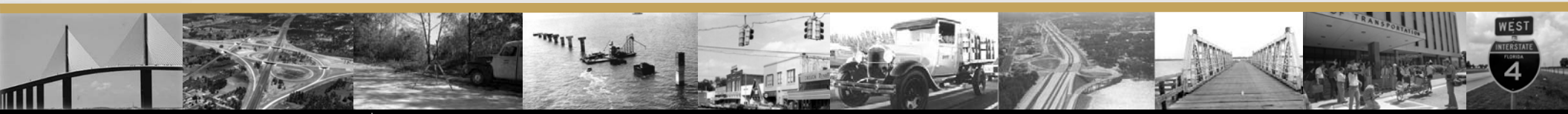
Lessons Learned



Don’t skew unless absolutely necessary!

Skewed FSB = 





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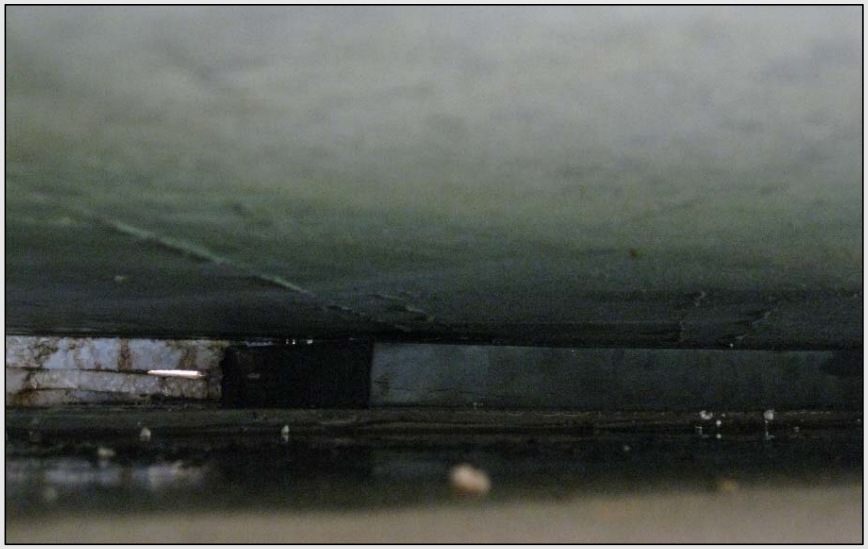
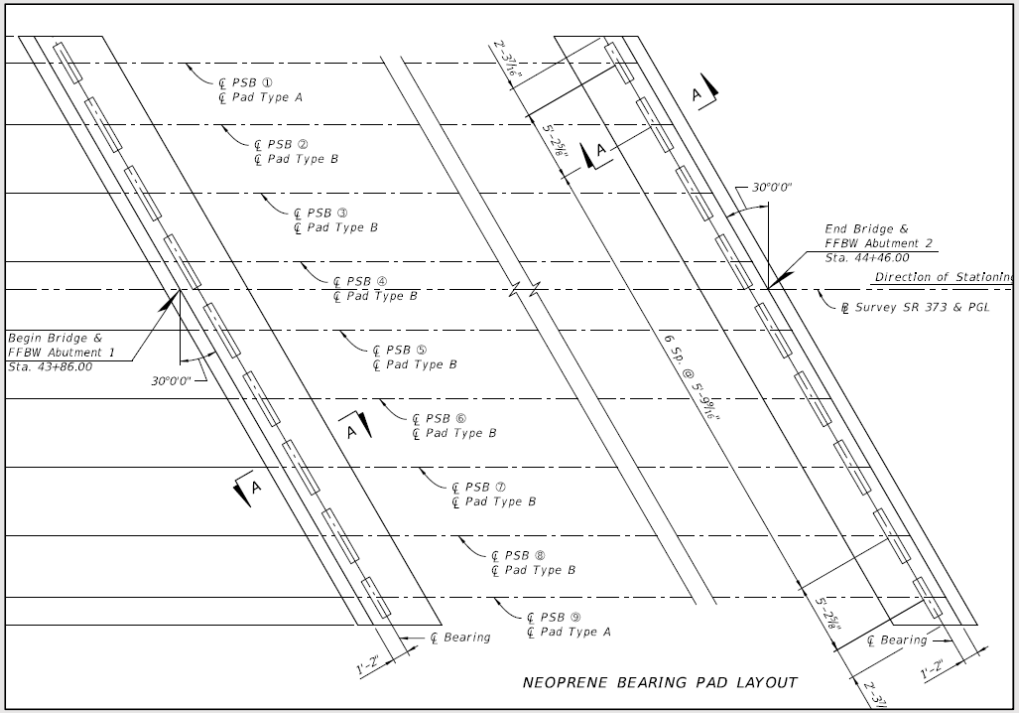
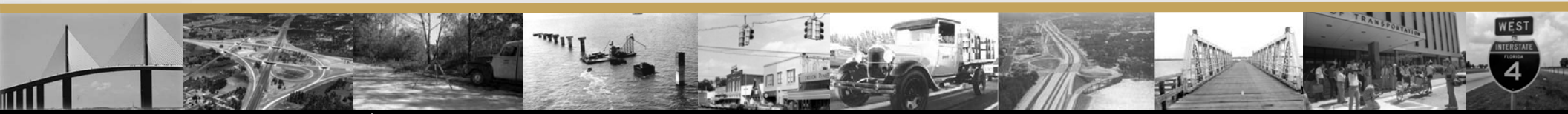
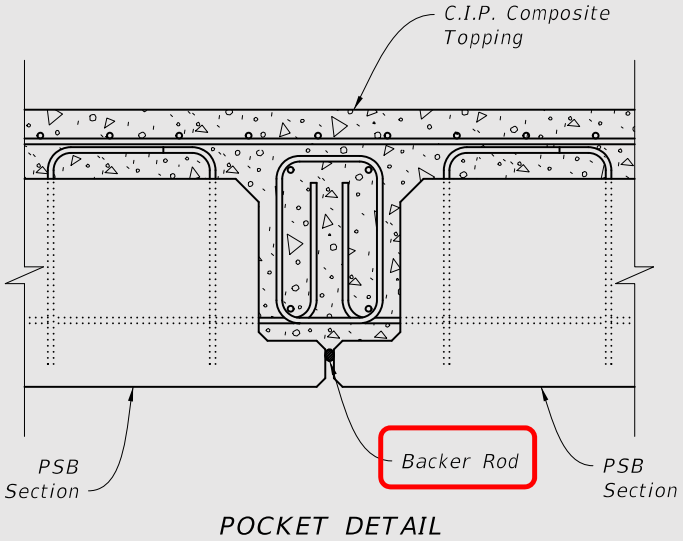






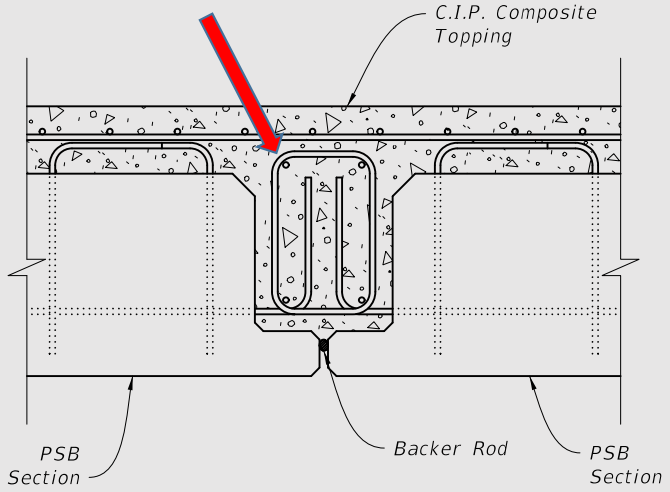
Backer rod between beams



POCKET DETAIL

Hoop bars in pocket

- #6 bar bends too close together
- Bars were bent according to Index 21300, Type 4
- Request to change #6 hoop bars to #5

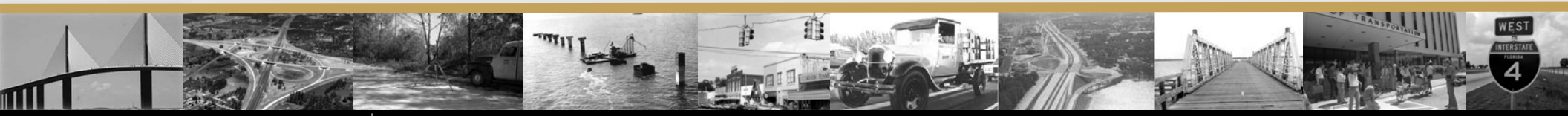


POCKET DETAIL

From bar manufacturer:

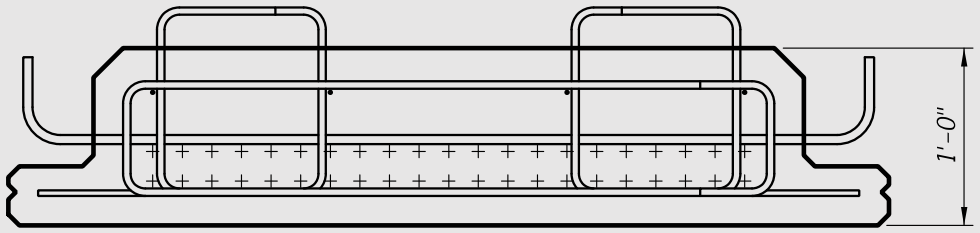
"Automated machines are used to put the bends on a straight pre-cut bar. When the bend is made, it weakens the bar at that bend. The stress is transferred down the leg of the rebar for each bend. The longer the leg, the more stress the bend can transfer. When making stirrups with short legs on stronger bars the weakest point is the bend. We are having the second bend collapse when we get to the third and fourth bends."

Implementation

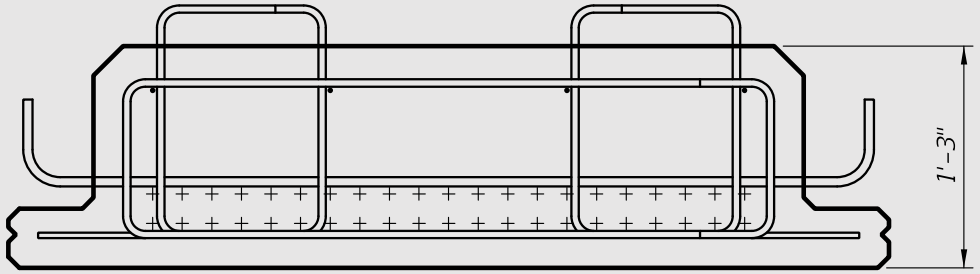


FSB Developmental Design Standard

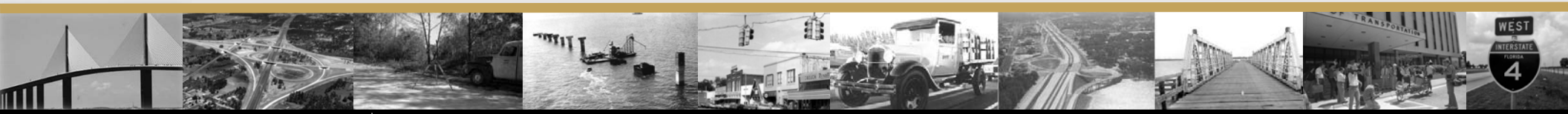
- 12” and 15” deep beams
- Maximum spans
  - 48’± for 12” beams
  - 55’± for 15” beams
- Custom beam widths
  - 4’ min. width
  - 5’ max. width
- Same shape for interior and exterior beams
- 6” C.I.P. composite topping with single mat of rebar



12" TYPICAL SECTION

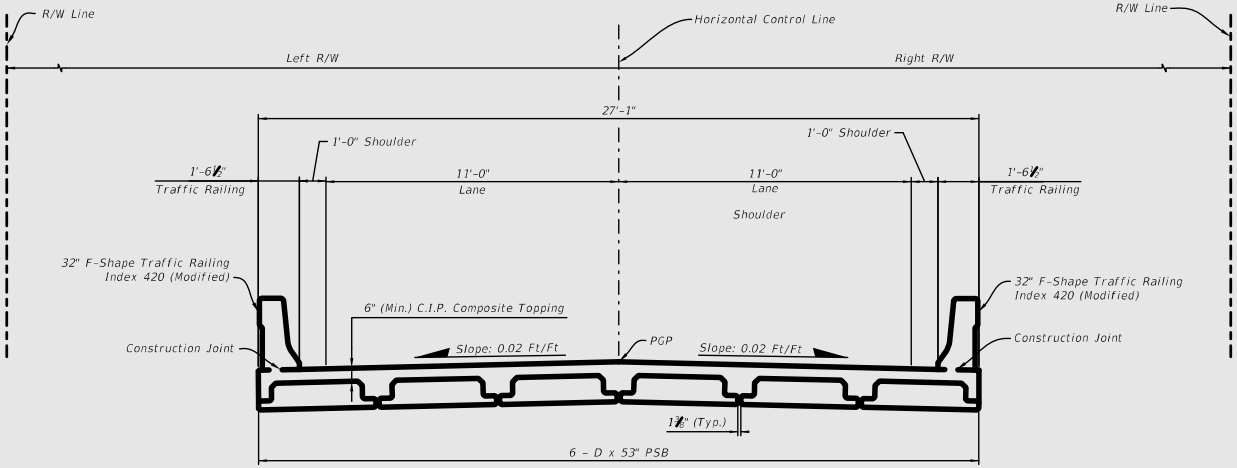


15" TYPICAL SECTION

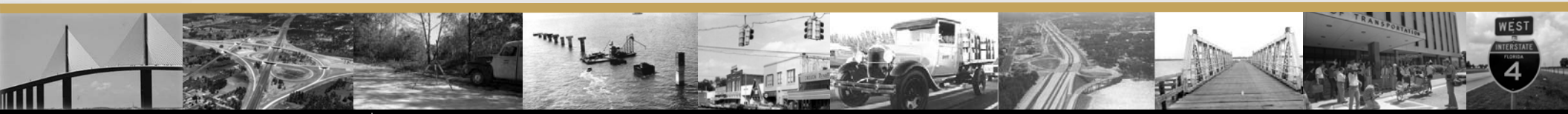


Off System Bridge Package (OSBP)

- 20 complete FSB superstructure plans
- 4 bridge lengths
  - 30’, 40’, 50’ and 60’
- 5 clear roadway widths
  - 15’, 24’, 28’, 32’, and 40’



TYPICAL SECTION WITH 11'-0" LANES



Thank you

Questions?