# *Short-Medium Span Bridge Beams (Prestressed Concrete)*

## *"Fill the Gap"*

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**FDOT State Structures Design Office**
**Study and Implementation:**
**Gevin McDaniel P.E.**
**Steve Nolan P.E.**

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## *Outline*

- Identify current "gap" in efficient span range for FDOT prestressed beams/slabs;
- Characterize the current inventory of Structurally Deficient and Functionally Obsolete bridges that will predominate construction needs for future projects;
- Summarize the different beam types investigated to "fill the gap";
- Describe the implementation schedule for the preferred alternative and other minor changes affecting Florida-I Beams;
- Elaborate on the studies undertaken by SDO to identify the optimum solution for current needs and identify future needs and enhancements;
- Questions?

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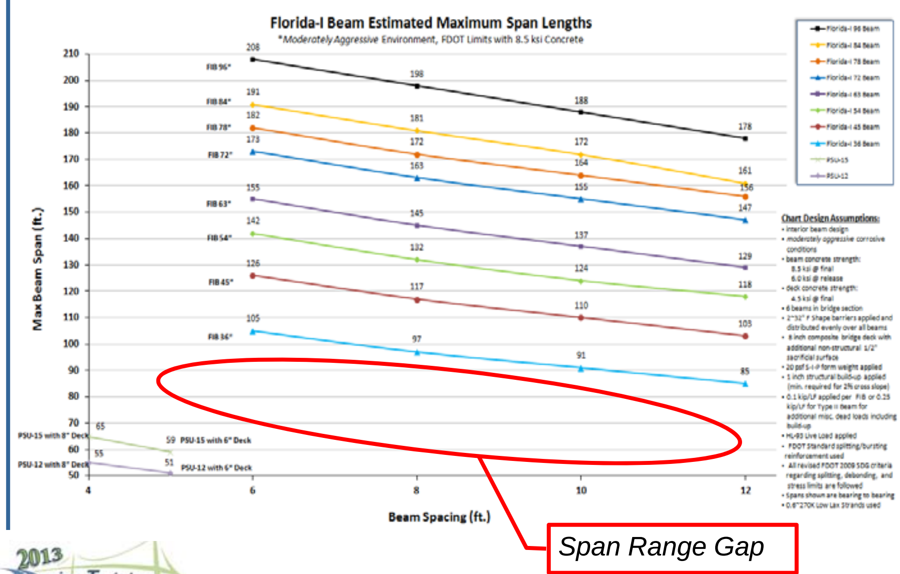
# Prestressed Beam Span Range Gap

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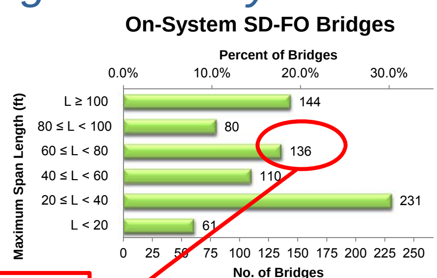
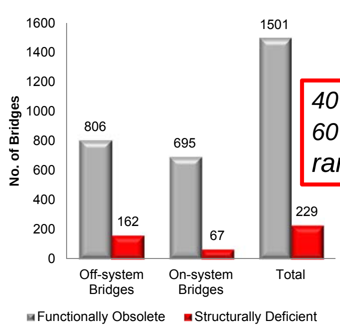
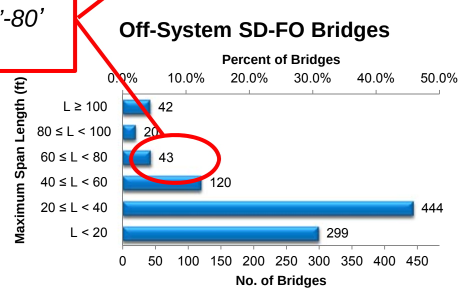
# Florida Bridge Inventory

- PONTIS data 2011: Structurally Deficient (SD) or Functionally Obsolete (FO)




*40% of Spans ≥ 60' are 60'-80' range*

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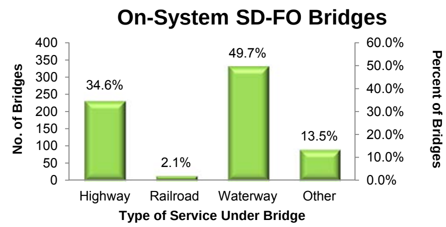
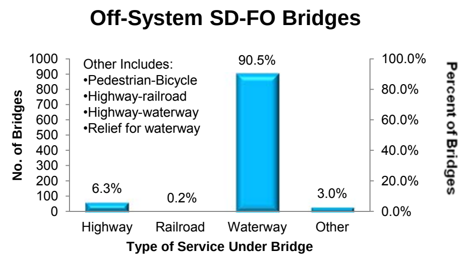
# Florida Bridge Inventory

- PONTIS data 2011 (continued):
  - ✓ 50 % of On-System SD-FO bridges are over waterways
  - ✓ 90% of Off-system SD-FO bridges are over waterways



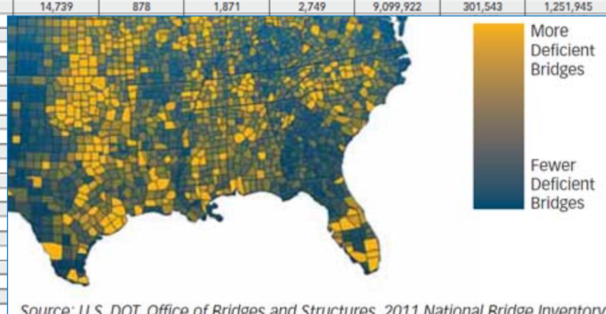



# Florida Bridge Inventory

- 2011 National Bridge Inventory comparison:

**Table 1. Deficient Bridges by State**

| State | # Bridges | # SD | # FO | # Def | Area | SD Area | FO Area | Def Area |
|---|---|---|---|---|---|---|---|---|
| ALABAMA | 16,070 | 1,448 | 2,205 | 3,653 | 8,985,363 | 342,546 | 1,523,268 | 1,865,814 |
| ALASKA | 1,173 | 128 | 147 | 275 | 658,950 | 68,824 | 86,331 | 155,155 |
| ARIZONA | 7,835 | 247 | 721 | 968 | 4,845,663 | 216,443 | 958,326 | 1,174,769 |
| ARKANSAS | 12,696 | 898 | 2,031 | 2,929 | 6,159,353 | 348,220 | 940,432 | 1,288,652 |
| CALIFORNIA | 24,812 | 2,978 | 4,178 | 7,156 | 28,081,411 | 4,430,018 | 6,147,292 | 10,577,310 |
| COLORADO | 8,591 | 566 | 907 | 1,473 | 4,769,085 | 268,894 | 724,425 | 993,319 |
| CONNECTICUT | 4,208 | 406 | 1,070 | 1,476 | 3,290,172 | 548,027 | 943,162 | 1,491,189 |
| DELAWARE | 862 | 53 | 122 | 175 | 942,620 | 40,448 | 197,593 | 238,041 |
| DIST. OF COL. | 239 | 30 | 155 | 185 | 538,596 | 97,552 | 324,734 | 422,286 |
| FLORIDA | 11,982 | 262 | 1,764 | 2,026 | 15,897,095 | 469,031 | 2,185,844 | 2,654,875 |
| GEORGIA | 14,739 | 878 | 1,871 | 2,749 | 9,099,922 | 301,543 | 1,251,945 | 1,553,488 |
| HAWAII | | | | | | | | 195,096 |
| IDAHO | | | | | | | | 359,433 |
| ILLINOIS | | | | | | | | 3,682,905 |
| INDIANA | | | | | | | | 1,860,701 |
| IOWA | | | | | | | | 1,640,468 |
| KANSAS | | | | | | | | 1,505,582 |
| KENTUCKY | | | | | | | | 1,695,830 |
| LOUISIANA | | | | | | | | 4,835,033 |
| MAINE | | | | | | | | 409,093 |
| MARYLAND | | | | | | | | 1,435,009 |
| MASSACHUSETTS | | | | | | | | 2,322,944 |
| MICHIGAN | | | | | | | | 2,060,868 |
| MINNESOTA | | | | | | | | 773,180 |
| MISSISSIPPI | | | | | | | | 1,377,180 |
| MISSOURI | | | | | | | | 2,785,085 |
| MONTANA | | | | | | | | 400,883 |
| NEBRASKA | | | | | | | | 694,260 |
| NEVADA | | | | | | | | 280,472 |
| NEW HAMPSHIRE | | | | | | | | 297,463 |
| NEW JERSEY | | | | | | | | 2,645,417 |
| NEW MEXICO | | | | | | | | 270,542 |
| NEW YORK | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 7,680,376 |
| NORTH CAROLINA | 18.165 | 2.192 | 3.296 | 5.488 | 8.873.890 | 904.938 | 1.871.831 | 2.776.769 |




*(Table 1 and Figure 3 from **Roads&Bridges** magazine, May 2013 edition.)*

# Florida Bridge Inventory

**Bridge Condition Terminology:**

**Structurally Deficient:** means that the department believes a bridge should undergo a series of repairs or replacement within the next six years. The department's policy is to repair or replace all the structurally deficient state owned bridges during that time. The department also recommends that local governments follow the same schedule for their structurally deficient bridges.

**Functionally Obsolete:** only means that a bridge does not meet current road design standards. For example, some bridges are "functionally obsolete" because they were built at a time when lane widths were narrower than the current standard.


Source: U.S. DOT, Office of Bridges and Structures, 2011 National Bridge Inventory

*(Bridge Condition Terminology from FDOT Bridge Maintenance website)*

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# Beam Types Investigated

- 8 different beam types investigated *(described in Part 2 of the presentation)*:
  - ✓ Truncated FIB-36 *(FDOT District 2)*
  - ✓ AASHTO Type II
  - ✓ Super-T's *(PCIJ 2000, ASCE Structures 2008, FWHA Bridge 2010)*
  - ✓ Florida Box Beam *(TxDOT modified open top section using Type II side forms - FBB)*
  - ✓ Pi-Girder *(FHWA Turner-Fairbank Highway Research Center)*
  - ✓ NEXT Beam *(PCINE)*
  - ✓ MnDOT Precast Composite Slab *(French "Poutre Dalle" system)*
  - ✓ Hillman Composite Beam *(Proprietary Hybrid FRP/Steel/Concrete)*

***AASHTO Type II Beam was the preferred alternative.***

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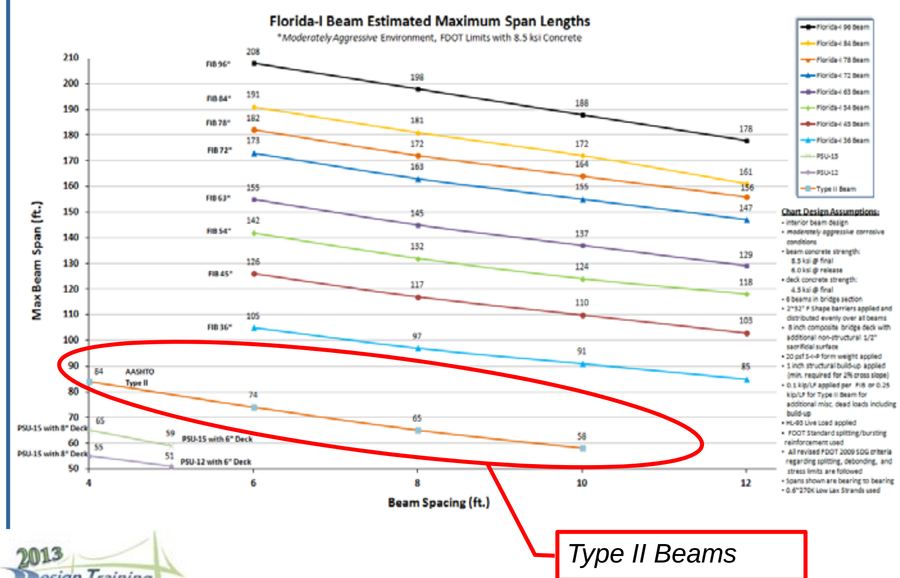
## Prestressed Beam Span Range Gap Filled

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## Implementation

- Type II Beams – ***Index 20120*** will be re-released in July 2013 with minor modifications:
  - ✓ WWR details will be added similar to FIB's;
  - ✓ Horizontal diaphragm reinforcing (Bars 4L) will be removed;
  - ✓ General Notes from previous ***Index 20110*** will be added;
  - ✓ ***Index 20199*** revised to reference Type II Beams;
  - ✓ IDS-20100 & Data Table will be reissued;
  - ✓ Bearing Pad ***Index 20510*** updated to include Pad Type A & C;
  - ✓ Bearing Plate ***Indexes 20511*** & ***20512*** updated to include Type II Beams;
  - ✓ ***SDG*** 4.3.1 will need to be revised to allow AASHTO Beams.

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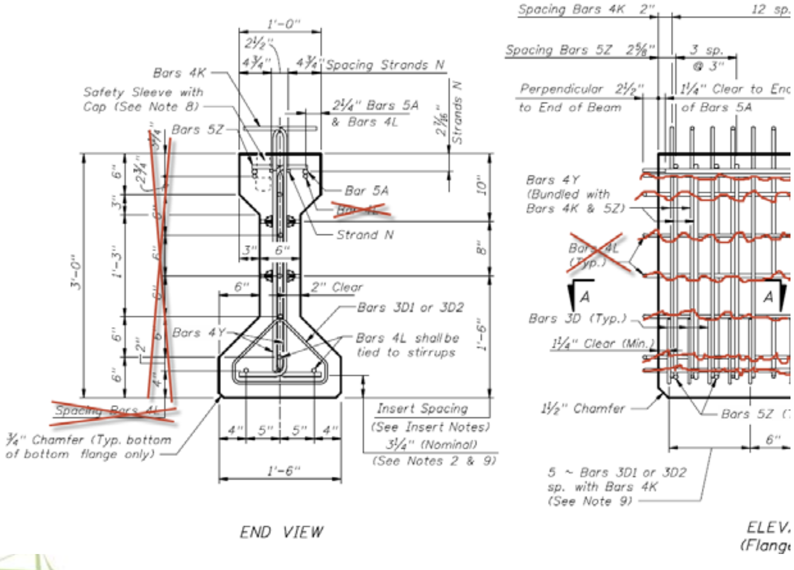
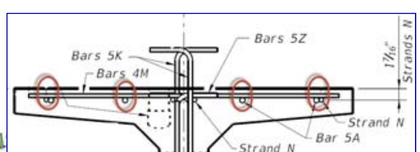
# Type II Beam

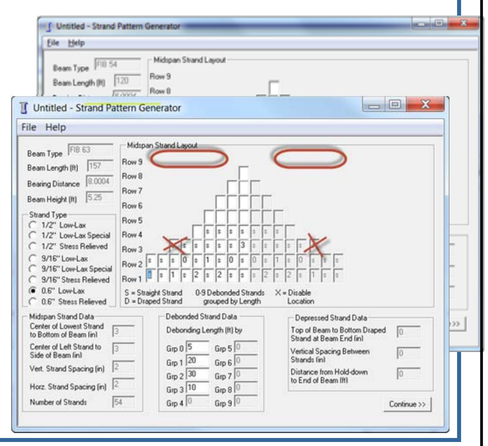



# Other Revisions to FDOT Prestressed Beam Design

- SDG 4.3.1 (January 2013) revisions:
  - ✓ Increase in *debonded strand limits* from 25% to 30%
  - ✓ Decrease in *top flange tension limits* for the outer 15% of beam length at release from $12\sqrt{f'_{ci}}$ to $7.5\sqrt{f'_{ci}}$
  - ✓ Tabulating *Minimum Top Flange Longitudinal Reinforcing in Beam Ends* in lieu of ***LRFD*** C5.9.4.1.2

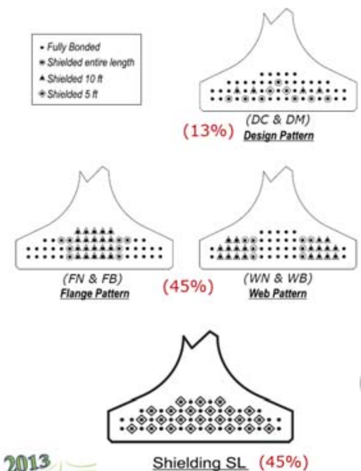



- FDOT LRFD Prestressed Beam Program update:
  - ✓ July release V3.32



## Other Revisions to FDOT Prestressed Beam Design

- ***SDG*** Debonding Limits (continued):
  - ✓ Increase in *debonded strand limits* from 25% to 30%



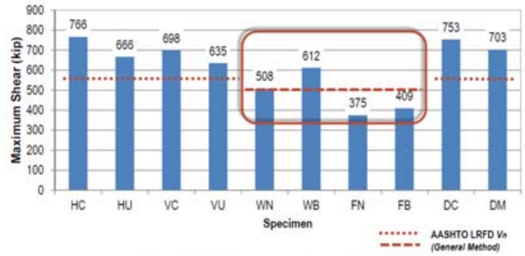




Figure 116–Maximum superimposed shear

Table 19–Code comparison with experimental shear forces

| Specimen | $V_{exp}$ (kip) | ACI $V_n$ (kip) | LRFD $V_n$ (kip) | Tie $V_n$ (kip) | EXP / ACI | EXP / LRFD | EXP / TIE |
|---|---|---|---|---|---|---|---|
| CT | 791 | 524 | 516 | 997 | 1.51 | 1.53 | 0.79 |
| SL | 609 | 524 | 516 | 673 | 1.16 | 1.18 | 0.90 |
| PT | 800 | 524 | 516 | 997 | 1.53 | 1.55 | 0.80 |
| LB | 612 | 524 | 516 | 997 | 1.17 | 1.19 | 0.61 |
| Average | | | | | 1.34 | 1.36 | 0.78 |

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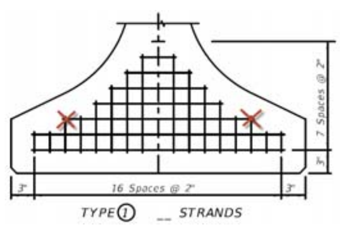
## Other Revisions to FDOT Prestressed Beam Design

- FDOT LRFD Prestressed Beam Program update (continued):
  - ✓ July release V3.32
  - ✓ IDS-20010 Data Table updated.



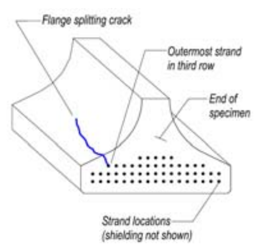
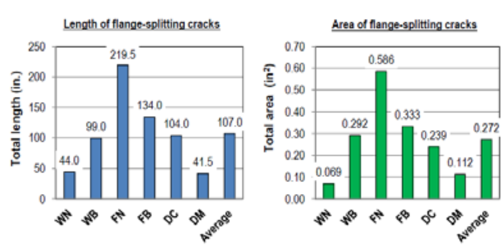




Figure 26–Typical flange splitting crack location

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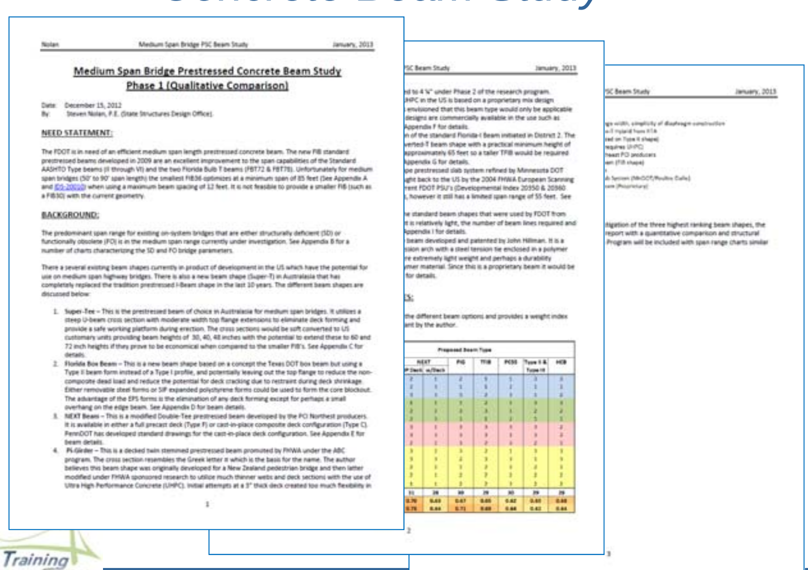
# *Short-Medium Span Bridge Beams (Prestressed Concrete)*

## *(Part 2)*

**FDOT State Structures Design Office**
**Study and Implementation**

# *Medium Span Bridge Prestressed Concrete Beam Study*



Nolan — Medium Span Bridge PSC Beam Study — January, 2013

**Medium Span Bridge Prestressed Concrete Beam Study**
**Phase 1 (Qualitative Comparison)**

Date: December 15, 2012
By: Steven Nolan, P.E. (State Structures Design Office)

**NEED STATEMENT:**

**BACKGROUND:**

# Medium Span Bridge Prestressed Concrete Beam Study

- 8 different beam types investigated:
  - ✓ Truncated FIB
  - ✓ Type II AASHTO
  - ✓ Super-T
  - ✓ Florida Box Beam (FBB - Modified open top)
  - ✓ Pi-Girder
  - ✓ NEXT Beam
  - ✓ MnDOT Precast Composite Slab System (T-shape)
  - ✓ Hillman Composite Beam

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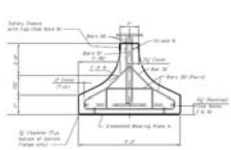
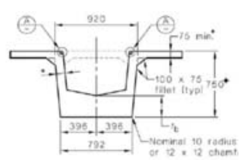
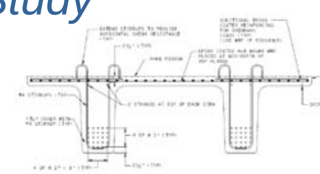
# Medium Span Bridge Prestressed Concrete Beam Study



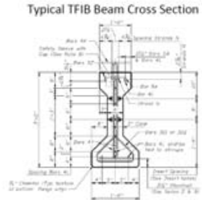
Typical TFIB Beam Cross Section



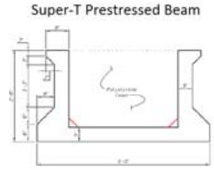
Super-T Prestressed Beam



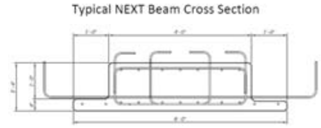
Typical NEXT Beam Cross Section



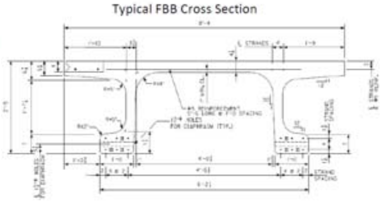
Typical Type II Beam Cross Section



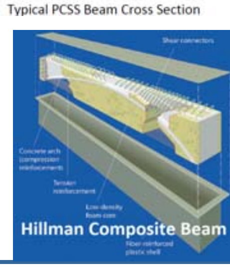
Typical FBB Cross Section



Typical PCSS Beam Cross Section



Typical Pi Girder Cross Section

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# Medium Span Bridge Prestressed Concrete Beam Study

| Criteria | Weighting Factor (≤ 1.0) Initial Case A | Weighting Factor (≤ 1.0) Longterm Case B | Super-T | FBB | NEXT CIP Deck | NEXT No Deck | PiG (Uses UHPC) | TFIB | PCSS | HCB (Proprietary) | AASHTO Type II |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Erection Weight | 0.05 | 0.00 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 3 | 3 |
| Speed of Construction | 0.05 | 0.00 | 2 | 2 | 2 | 3 | 1 | 1 | 2 | 1 | 1 |
| Stability | 0.05 | 0.00 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 1 |
| Setup Cost | 0.10 | 0.00 | 1 | 3 | 1 | 1 | 1 | 2 | 2 | 3 | 3 |
| Weight/Beam Spacing | 0.10 | 0.10 | 3 | 2 | 2 | 2 | 3 | 3 | 1 | 2 | 3 |
| Deck Casting Cost | 0.10 | 0.10 | 2 | 2 | 2 | 3 | 1 | 1 | 2 | 1 | 1 |
| Durability | 0.05 | 0.05 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 2 | 3 |
| Inspectability | 0.05 | 0.05 | 2 | 1 | 3 | 3 | 3 | 3 | 2 | 2 | 3 |
| Repairability/Redundan | 0.05 | 0.05 | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 1 | 2 |
| Span Range (40'-90') | 0.15 | 0.15 | 3 | 3 | 3 | 2 | 3 | 2 | 1 | 3 | 3 |
| Superstructure Depth | 0.10 | 0.10 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 1 |
| Continuity Adaptable | 0.05 | 0.05 | 3 | 3 | 2 | 2 | 1 | 2 | 3 | 1 | 2 |
| Curve Adaptable | 0.05 | 0.05 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 |
| GRS Useability [1] | 0.05 | 0.05 | 3 | 3 | 1 | 1 | 2 | 2 | 3 | 2 | 2 |
| Gross Sum = | 1.00 | 0.75 | 35 | 34 | 31 | 28 | 30 | 29 | 31 | 28 | 30 |
| Weighted Index (Case A) = | | | 0.78 | 0.80 | 0.70 | 0.63 | 0.67 | 0.65 | 0.65 | 0.68 | 0.68 |
| Weighted Index (Case B) = | | | 0.84 | 0.78 | 0.73 | 0.64 | 0.71 | 0.69 | 0.64 | 0.64 | 0.67 |

Blue X: Remove proprietary beam types.

Red X: Remove beam types that cannot accommodate the maximum span range.

COLOR LEGEND:
- Constructability
- Cost
- Maintenance
- Geometry

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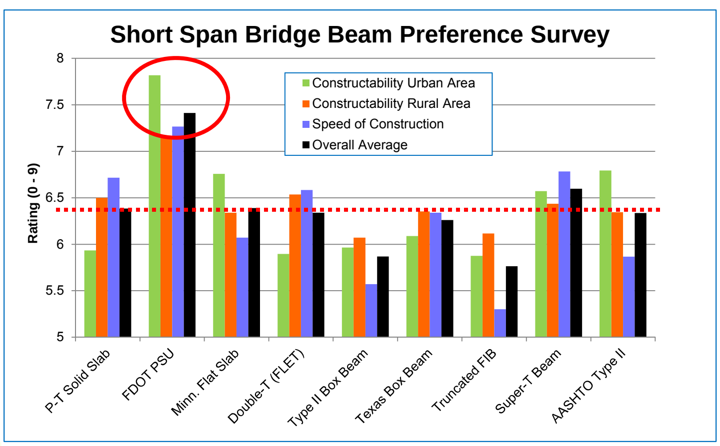
# Off-System Bridge Replacement Study
## (Short-Medium Span Bridges)

- Survey of stakeholders conducted for shorter span bridges as part of Off-System Bridge Package development project (Spans ≤ 60').

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## *Prestressed Slab Unit Advantages*

- Benefits of the PSU's over other beam types:
  - ✓ Significant preference from construction industry;
  - ✓ Relatively simple deck construction for durable system in Florida conditions;
  - ✓ Speed and simplicity of construction;
  - ✓ Low vertical profile;
  - ✓ Simple implementation for larger sections *(PSU-18 pending as **Index** D20370 series)*;
  - ✓ Simple/Low Cost (almost no cost) conversion to Continuous-For-Live Load. (≈ 5 ft span increase, ***SDG*** *4.1.7 variation required*);
  - ✓ Good candidate for lightweight deck concrete with the benefit of internal curing to minimize deck shrinkage cracking. (≈ 5 ft span increase, ***SDG*** *1.4.1.D approval required for Design-Bid-Build projects*);
  - ✓ Thickening overlay from 6" to 8" increases span capacity ≈ 5 ft.

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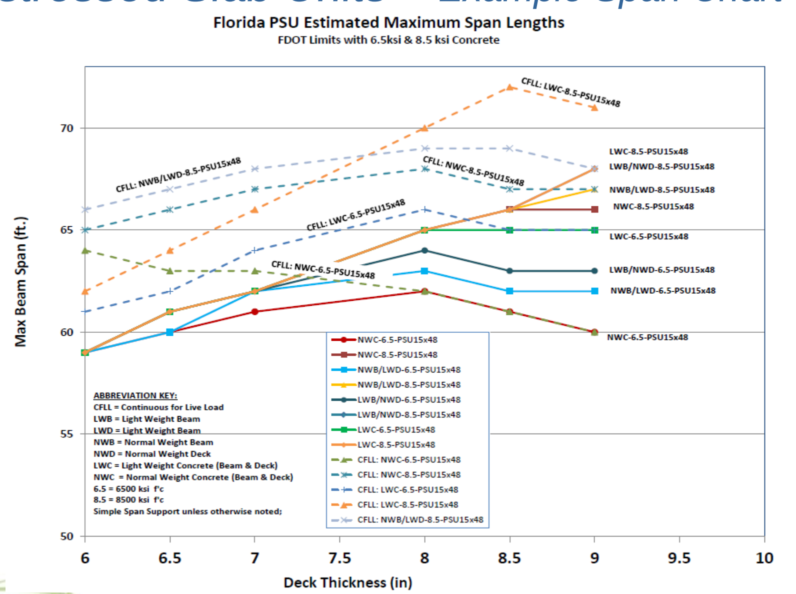
## *Prestressed Slab Units – Example Span Chart*

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## Other Beam Type Span Ranges:

| Proposed Beam Type | Depth (in) | Span Range (ft) Min. | Max. | Comments |
|---|---|---|---|---|
| **Super-T's** | | Span Range from John Connal AECOM (Australia - AS5100) | | |
| FST30 (750mm) | 29.5 | 49 | 79 | 76' (7.2' sp.) or 89' max (6' sp.) with |
| FST40 (1000mm) | 39.4 | 65 | 92 | FDOT modifications & HL-93 |
| FST48 (1200mm) | 47.2 | 80 | 105 | |
| FST60 (1500mm) | 59.1 | 95 | 118 | |
| FST72 (1800mm) | 70.9 | 105 | 131 | |
| **Florida Box Beam** | | | | |
| FBB30 | 30 | | | |
| FBB32 | 32 | | 86 | |
| FBB36 | 36 | | | |
| **NEXT Beam (CIP Deck - PennDOT)** | | Span Range from PCI Northeast | | |
| NEXT24 | 24 | 30 | 60 | |
| NEXT28 | 28 | 60 | 65 | |
| NEXT32 | 32 | 60 | 75 | |
| NEXT36 | 36 | 65 | 80 | |
| **NEXT Beam (Decked - PCINE)** | | Span Range from PCI Northeast | | |
| NEXT24 | 24 | 30 | 65 | |
| NEXT28 | 28 | 60 | 75 | |
| NEXT32 | 32 | 70 | 85 | |
| NEXT36 | 36 | 75 | 90 | |
| **Pi Girder (UHPC Decked)** | | | | |
| PIG33 | 33 | | 65 | |
| **Truncated Florida I Beam** | | | | |
| TFIB | 33 | | 65 | |
| **Prestressed Composite Slab System (Poutre Dalle)** | | | | |
| PCSS16 | 16 | | 50 | |
| **AASHTO Type Beams** | | | | |
| TYPE II | 36 | 40 | 84 | 4' to 11' spacing |
| TYPE III | 45 | 55 | 110 | 4' to 11' spacing |
| **Hillman Composite Beams** | | (Span range provided by John Hillman 11/14/12) | | |
| HCB21 | 21 | 25 | 42 | 4' to 6' spacing |
| HCB24 | 24 | 40 | 48 | 4' to 6' spacing |
| HCB27 | 27 | 48 | 55 | 4' to 6' spacing |
| HCB31 | 31 | 55 | 60 | 4' to 6' spacing |
| HCB33 | 33 | 60 | 70 | 4' to 6' spacing |
| HCB36 | 36 | 70 | 75 | 4' to 6' spacing |
| HCB39 | 39 | 75 | 82 | 4' to 6' spacing |
| HCB42 | 42 | 57 | @ | 7.33' spacing (High Road Bridge, ILL) |

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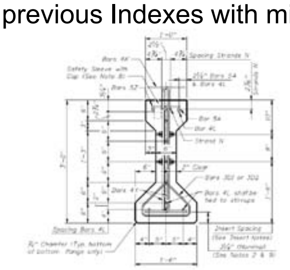
## Type II Beam Advantages

- Benefits of the Type II:
  - ✓ Variable camber heights have no effect on the as-built capacity – increased composite section balances additional dead load;
  - ✓ Relatively light weight (385 lb/ft) ≈ 46% of FIB-36 weight;
  - ✓ Established performance and constructability history;
  - ✓ Common form shape used in other states;
  - ✓ Simple implementation (re-issue previous Indexes with minor changes).
  - ✓ System redundancy



Typical Type II Beam Cross Section

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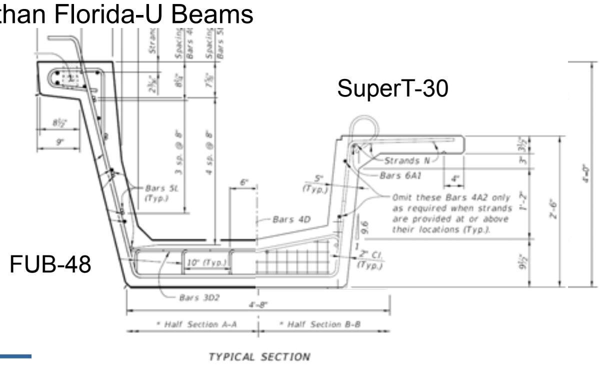
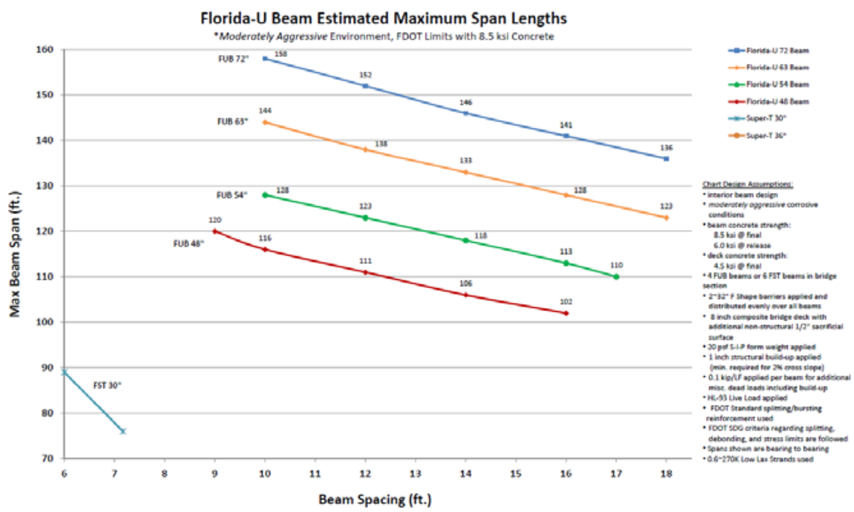
## Super-T Beam Advantages

- Benefits of the Super-T:
  - ✓ No under-deck forming required;
  - ✓ Torsionally stiff, so no intermediate bracing required;
  - ✓ Variable heights can be accommodated with single outside form;
  - ✓ Similar to Florida-U beam possible shallower depths;
  - ✓ Lighter weight than Florida-U Beams






## Super-T vs. FUB Span Chart



## *Questions and Comments?*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