LOAD RATING CALCULATIONS
DEVELOPMENTAL DESIGN STANDARDS
FSB SUPERSTRUCTURE PACKAGE
24 FT. CLEAR WIDTH

D30024 - 40 Ft. Span
### FDOT Bridge Load Rating Summary

<table>
<thead>
<tr>
<th>Rating Level</th>
<th>Vehicle</th>
<th>Weight (Tons)</th>
<th>Flexure (Strength)</th>
<th>Shear (Strength)</th>
<th>Stress (Service)</th>
<th>Flexure (Strength)</th>
<th>Shear (Strength)</th>
<th>Stress (Service)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Operating</td>
<td>HL-93</td>
<td>36</td>
<td>2.04</td>
<td>5.88</td>
<td>N/A</td>
<td>2.20</td>
<td>6.87</td>
<td>N/A</td>
</tr>
<tr>
<td>Design Inventory</td>
<td>HL-93</td>
<td>36</td>
<td>1.57</td>
<td>4.54</td>
<td>1.21</td>
<td>1.70</td>
<td>5.30</td>
<td>1.26</td>
</tr>
<tr>
<td>Permit</td>
<td>FL-120</td>
<td>60</td>
<td>1.53</td>
<td>4.05</td>
<td>N/A</td>
<td>1.65</td>
<td>4.73</td>
<td>N/A</td>
</tr>
</tbody>
</table>

#### LRFR using Part A

<table>
<thead>
<tr>
<th>Int. / Ext. Beam</th>
<th>Ext.</th>
<th>Int.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Span Length (ft)</td>
<td>40</td>
<td>40</td>
</tr>
</tbody>
</table>
26'-8" Out-to-Out C-I-P Topping

1'-4"
Traffic Railing

24'-0" Clear Width

Slope

Florida Slab Beam (FSB)
(Index D20450) (Typ.)

6 - 53" FSB = 26'-9" Out-to-Out

1'-4"
Traffic Railing

36" Single-Slope
Traffic Railing
(Index 427) (Typ.)

D30024 - SUPERSTRUCTURE SECTION
Bridge Layout and Dimensions

L_{beam} = 38.83\,\text{ft} \quad \text{Span} = 37.75\,\text{ft} \quad \text{BearingDistance} = 6.5\,\text{in} \quad \text{PadWidth} = 8\,\text{in}

BeamTypeTog = "FSB12x53"  
"These are typically the FDOT designations found in our standards. The user can also create a coordinate file for a custom shape. In all cases the top of the beam is at the y=0 ordinate."
Overhang = 0-ft
Skew = 0-deg

BeamSpacing = 4.47-ft
t_{integral.ws} = 0-in

NumberofBeams = 6
t_{slab} = 6-in
t_{slab.delta} = 0.28-in
de = 0.83 ft

h_{buildup} = 0-in

BeamPosition = "exterior"

For calculating distribution factors
must be either interior or exterior

b_{c} = 4.4 ft
effective slab width

LRFD 4.6.2.6

Provide a minimum slab thickness to prevent divide by zero errors

Material Properties

Concrete:

**Corrosion Classification**

Environment = "extremely"
density of slab concrete

\[ \gamma_{slab} = 0.15 \text{ kip/ft}^3 \]

strength of slab concrete

\[ f_{c,slab} = 4.5 \text{ ksi} \]

density of beam concrete

\[ \gamma_{beam} = 0.15 \text{ kip/ft}^3 \]

strength of beam concrete

\[ f_{c,beam} = 8.5 \text{ ksi} \]

release beam strength

\[ f_{ci,beam} = 6 \text{ ksi} \]

weight of future wearing surface

Weight_{future.ws} = 0.015 \text{ kip/ft}^2

AggregateType = "Florida"
relative humidity

\[ H = 75 \]

\[ n_d := \left( \frac{f_{c,beam}}{f_{c,slab}} \right)^{0.33} \]

used in distribution calculation

\[ n_d = 1.23 \]

AggFactor := if[AggregateType = "Florida", (1.0-2500), 2500] (SDG 1.4.1) AggFactor = 2500

\[ E_{ci} := \text{AggFactor} \left( \frac{f_{ci,beam}}{\text{ksi}} \right)^{0.33} \text{kSi} \]

initial beam concrete modulus of elasticity (LRFD 5.4.2.4) \[ E_{ci} = 4516 \text{kSi} \]

\[ E_{c} := \text{AggFactor} \left( \frac{f_{c,beam}}{\text{ksi}} \right)^{0.33} \text{ksi} \]

beam concrete modulus of elasticity (LRFD 5.4.2.4) \[ E_{c} = 5066 \text{kSi} \]

Prestressing Tendons:

tendon ultimate tensile strength

\[ f_{pu} = 270 \text{ ksi} \]

tendon modulus of elasticity

\[ E_{p} = 28500 \text{kSi} \]

time in days between jacking and transfer

\[ t_j = 0.75 \]

ratio of tendon modulus to initial beam concrete modulus

\[ n_{pi} := \frac{E_{p}}{E_{ci}} \]

ratio of tendon modulus to beam concrete modulus

\[ n_{p} := \frac{E_{p}}{E_{c}} \]
**Mild Steel:**

- **mild steel yield strength** \( f_y = 60\text{-ksi} \)
- **mild steel modulus of elasticity** \( E_s = 29000\text{-ksi} \)
- **ratio of rebar modulus to initial beam concrete modulus** \( n_{ni} := \frac{E_s}{E_{ci}} \), \( n_{ni} = 6.42 \)
- **ratio of rebar modulus to beam concrete modulus** \( n_m := \frac{E_s}{E_c} \), \( n_m = 5.72 \)
- **area per unit width of longitudinal slab reinf.** \( A_{slab, rebar} = 0.31 \text{-in}^2 \text{-ft} \)
- **area of mild reinf lumped at centroid of bar locations** \( A_{s, long} = 0 \cdot \text{in}^2 \)
- **Size of bar used create used to calculate development length** \( \text{BarSize} = 5 \)

**Permit Loads**

- **This is the number of wheel loads that comprise the truck, max for DLL is 11**
  - PermitAxles = 3
- **Indexes used to identify values in the P and d vectors**
  - \( q := 0 .. (\text{PermitAxles} - 1) \)
  - \( q_{t} := 0 .. \text{PermitAxles} \)
- PermitAxleLoad^T = ( 13.33 53.33 53.33 )-kip
- PermitAxleSpacing^T = ( 0 14 14 0 )-ft

**Distribution Factors**

- DataMessage = "This is a FSB12x53 Florida Slab Beam design, AASHTO distribution factors used"
- **calculated values:**
  - \( \text{tmp} \_ \text{gmom} = 0.4 \)
  - \( \text{tmp} \_ \text{gshar} = 0.63 \)
  - \( \text{tmp} \_ \text{gmom, fatigue} = 0.26 \)
- **user value overrides (optional):**
  - user \_ gmom := 0
  - user \_ gshar := 0
  - user \_ gmom, fatigue := 0
- **value check**
  - \( g_{\text{mom}} := \text{if}(\text{user} \_ gmom \neq 0, \text{user} \_ gmom \_ \text{tmp} \_ gmom) \)
  - \( g_{\text{mom}} = 0.4 \)
  - \( g_{\text{shear}} := \text{if}(\text{user} \_ gshear \neq 0, \text{user} \_ gshear \_ \text{tmp} \_ gshear) \)
  - \( g_{\text{shear}} = 0.63 \)
  - \( g_{\text{mom, fatigue}} := \text{if}(\text{user} \_ gmom, \text{fatigue} \neq 0, \text{user} \_ gmom, \text{fatigue} \_ \text{tmp} \_ gmom, \text{fatigue}) \)
  - \( g_{\text{mom, fatigue}} = 0.26 \)
Non-Composite Dead Load Input:

\[ w_{\text{slab}} = 0.433 \text{ kip/ft} \quad w_{\text{beam}} = 0.556 \text{ kip/ft} \quad w_{\text{forms}} = 0 \text{ kip/ft} \]

\[ \text{Add}_w_{\text{noncomp}} := 0.0 \text{ kip/ft} \]

*additional non composite dead load (positive or negative)*

*note: not saved to data file, may be saved to Mathcad worksheet.*

\[ w_{\text{noncomposite}} := w_{\text{slab}} + w_{\text{beam}} + w_{\text{forms}} + \text{Add}_w_{\text{noncomp}} \]

\[ w_{\text{noncomposite}} = 0.989 \text{ kip/ft} \]

\[ w_{\text{noncomposite}} = 0.433 \text{ kip/ft} \]

Diaphragms/Point Load Input

*End Diaphragms or Misc. Point Loads over bearing... included in bearing reaction calculation only*

*Intermediate Diaphragms or Misc. Point Loads... included in shear, moment, and bearing reaction calculations*

\[ \text{EndDiaphragmA} := 0 \text{ kip begin bridge} \]

\[ \text{IntDiaphragmB} := 0 \text{ kip} \]

\[ \text{DistB} := 0 \text{ ft} \]

\[ \text{input load is per beam} \]

\[ \text{Longitudinal Distance B, C, } \]

\[ \& D - \text{Measured from CL} \]

\[ \text{Bearing at begin bridge} \]

\[ \text{EndDiaphragmE} := 0 \text{ kip end bridge} \]

\[ \text{IntDiaphragmC} := 0 \text{ kip} \]

\[ \text{DistC} := 0 \text{ ft} \]

\[ \text{IntDiaphragmD} := 0 \text{ kip} \]

\[ \text{DistD} := 0 \text{ ft} \]

Composite Dead Load Input:

\[ w_{\text{future.ws}} = 0.046 \text{ kip/ft} \quad w_{\text{barrier}} = 0.143 \text{ kip/ft} \]

\[ \text{Add}_w_{\text{comp}} := 0.0 \text{ kip/ft} \]

*additional composite dead load (positive or negative)*

*note: not saved to data file, may be saved to Mathcad worksheet*

\[ w_{\text{composite}} := w_{\text{future.ws}} + w_{\text{barrier}} + \text{Add}_w_{\text{comp}} \]

\[ w_{\text{composite}} = 0.189 \text{ kip/ft} \]

\[ w_{\text{comp.str}} := w_{\text{barrier}} + \text{Add}_w_{\text{comp}} \]

\[ w_{\text{comp.str}} = 0.143 \text{ kip/ft} \]
**Release Dead Load Moments and Shear**

\[
\text{max}(M_{\text{release}}) = 104.8 \text{-kip-ft} \quad \text{max}(V_{\text{release}}) = 10.8 \text{-kip}
\]

**Noncomposite Dead Load Moments and Shear**

\[
\text{max}(M_{\text{dl.non.comp}}) = 176.1 \text{-kip-ft} \quad \text{max}(V_{\text{dl.non.comp}}) = 18.7 \text{-kip}
\]
Composite Dead Load Moments and Shear

\[ \text{Composite DL, } M(\text{kip-ft}) \text{ & } V(\text{kip}) \]

\[ M_{\text{dl.comp}} \text{ kip ft} \]
\[ V_{\text{dl.comp}} \text{ kip} \]

max \( M_{\text{dl.comp}} \) = 33.6·kip·ft  \quad \text{max} \( V_{\text{dl.comp}} \) = 3.6·kip

Distributed Live Load Moments and Shear

\[ \text{Dist. LL, } M(\text{kip-ft}) \text{ & } V(\text{kip}) \]

\[ M_{\text{dist.live.pos}} \text{ kip ft} \]
\[ M_{\text{dist.live.neg}} \text{ kip ft} \]
\[ V_{\text{dist.live.pos}} \text{ kip} \]
\[ V_{\text{dist.live.neg}} \text{ kip} \]
\[ M_{\text{shr.dist.live.pos}} \text{ kip ft} \]
\[ M_{\text{shr.dist.live.neg}} \text{ kip ft} \]

max \( M_{\text{dist.live.pos}} \) = 269.4·kip·ft  \quad \min \( M_{\text{dist.live.neg}} \) = −9.2·kip·ft  \quad \text{Reaction}_{\text{LL}} = 54.53·kip

max \( V_{\text{dist.live.pos}} \) = 53.4·kip  \quad \max \( M_{\text{shr.dist.live.pos}} \) = 247.7·kip·ft  \quad \text{Reaction}_{\text{DL}} = 22.86·kip

Beam End Reactions... with IM factor only

7/21/2016  
MainProgram.xmcd v5.0
**Prestress Strand Layout Input**

*Instructions:* Double click the icon to open the 'Strand Pattern Generator'. Specify the type, location, size, and debonding of strands. When finished, press the 'Continue' button. Then press 'Read Strand Data' button. Then press 'Recalculate Worksheet' button.

**Strand Pattern Input Mode:**

StrandTemplate:=

| Standard | Custom |

Recalculate Worksheet  
Read Strand Data

**Collapsed Region for Custom Strand Sizes...**

- **Strand Multiplier**
- **Strand Data and Pattern**
- **Strand Properties**

**Tendon Layout**

![Tendon Layout Diagram](image)

- **Debonded**
- **Full Length**
- **Draped**
- **Beam Surface**

**SupportLocation**_{release} = 0·ft

distance supports are located from the end of the beam after release; may be used to check lifting points immediately after transfer.
**Partially Stressed Tendons ("Strand N")**

\[ \text{PartialPS}_{\text{force}} = 40 \text{-kip} \quad \text{partial prestress total force} \]

\[ \text{PartialPS}_{\text{force}} := \text{if}\left( \text{BeamTypeTog} = "II", \text{20-kip}, \text{PartialPS}_{\text{force}} \right) \]

\[ \text{PartialPS}_{\text{location}} = 1.4375 \text{in} \quad \text{centroid location of partial prestress from the top of the beam} \]

\[ \text{PartialPS}_{\text{location}} := \begin{cases} 
2.4375 \text{in} & \text{if BeamTypeTog} = "II" \\
3 \text{in} & \text{if} \ \text{substr(BeamTypeTog, 0, 5)} = "FSB12" \\
2 \text{in} & \text{if} \ \text{substr(BeamTypeTog, 0, 5)} = "FSB15" \\
3 \text{in} & \text{if} \ \text{substr(BeamTypeTog, 0, 5)} = "FSB18" \\
\text{PartialPS}_{\text{location}} & \text{otherwise} 
\end{cases} \]

**Release Stresses**

![Release Stresses Graph](graph.png)

**Prestress Force**
Final Stresses

Final Stresses (ksi) Top, Bot., & Allowable

\[
\begin{align*}
\text{ftop.beam.stage8.c1}_n & = 9.707 \\
\text{ftop.slabs.stage8.c2}_n & = 19.415 \\
\text{ftop.beam.stage8.c3}_n & = 29.122 \\
\text{fbot.beam.stage8.c2}_n & = 38.83
\end{align*}
\]

Release Checks & Final Checks for Capacity Ratio (CR)

Stress Checks

\[
\begin{align*}
\text{min} (\text{CR, f}_\text{tension,rel}) & = 10 & \text{Check } f\text{tension.rel} = "OK" \\
\text{min} (\text{CR, f}_\text{comp,rel}) & = 1.31 & \text{Check } f\text{comp.rel} = "OK" \\
\text{min} (\text{CR, f}_\text{tension,stage8}) & = 3.52 & \text{Check } f\text{tension.stage8} = "OK" \\
\text{min} (\text{CR, f}_\text{comp,stage8,c1}) & = 1.95 & \text{Check } f\text{comp.stage8,c1} = "OK" \\
\text{min} (\text{CR, f}_\text{comp,stage8,c2}) & = 2.1 & \text{Check } f\text{comp.stage8,c2} = "OK" \\
\text{min} (\text{CR, f}_\text{comp,FatigueI}) & = 2.78 & \text{Check } f\text{comp.FatigueI} = "OK"
\end{align*}
\]

(Release tension)

(Release compression)

(Service III, PS + DL + LL*0.8)

(Service I, PS + DL)

(Service I, PS + DL + LL)

(Fatigue I, (PS + DL)*0.5 + 1.5 Fatigue Truck)
Strand Pattern Checks

- **CheckPattern\textsubscript{0} = “OK”**
  - check 0 - no debonded tendon in outside row

- **CheckPattern\textsubscript{1} = “OK”**
  - check 1 - less than 25\% debonded tendons total

- **CheckPattern\textsubscript{2} = “OK”**
  - check 2 - less than 40\% debonded tendons in any row

- **CheckPattern\textsubscript{3} = “OK”**
  - check 3 - less than 40\% of debonded tendons terminated at same section

- **CheckPattern\textsubscript{4} = “OK”**
  - check 4 - more than half beam depth debond length

*Note: Check 1 may be less than 30\% provided that debonding does not occur within the horizontal limits of the web (See SDG 4.3.1)*

Section and Strand Properties Summary

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete area of beam</td>
<td>(533.75\text{ in}^2)</td>
</tr>
<tr>
<td>Gross Moment of Inertia of Beam about CG</td>
<td>(6501.409\text{ in}^4)</td>
</tr>
<tr>
<td>Dist. from top of beam to CG of gross composite section</td>
<td>(-3.38\text{ in})</td>
</tr>
<tr>
<td>Gross Moment of Inertia Composite Section about CG</td>
<td>(23001.1148\text{ in}^4)</td>
</tr>
<tr>
<td>Concrete area of deck slab</td>
<td>(336.74\text{ in}^2)</td>
</tr>
<tr>
<td>Total area of strands</td>
<td>(4.1\text{ in}^2)</td>
</tr>
<tr>
<td>Diameter of Prestressing strand</td>
<td>(0.6\text{ in})</td>
</tr>
<tr>
<td>Tendon yield strength</td>
<td>(243\text{ ksi})</td>
</tr>
<tr>
<td>Prestress jacking stress</td>
<td>(203\text{ ksi})</td>
</tr>
<tr>
<td>Shielding length</td>
<td>((0\ 0\ 0)\text{ ft})</td>
</tr>
<tr>
<td>Strand area</td>
<td>(0.22\text{ in}^2)</td>
</tr>
<tr>
<td>Jacking force per strand</td>
<td>(43.94\text{ kip})</td>
</tr>
</tbody>
</table>

```
<table>
<thead>
<tr>
<th>Row</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-7</td>
<td>-7</td>
<td>-7</td>
<td>-7</td>
<td>-7</td>
<td>-7</td>
<td>-7</td>
<td>-7</td>
<td>-7</td>
<td>-7</td>
</tr>
<tr>
<td>2</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>...</td>
</tr>
</tbody>
</table>
```

- TotalNumber\textsubscript{of Tendons} = 19
- Strand\textsubscript{Size} = "0.6 in low lax"
- Number\textsubscript{of Debonded Tendons} = 0
- Number\textsubscript{of Draped Tendons} = 0
- Strand\textsubscript{Area} = 0.22\text{ in}^2
- Jacking\textsubscript{Force per strand} = 43.94\text{ kip}
### Section and Strand Properties Summary

#### Prestress Losses Summary

\[ f_{pj} = 202.5 \text{ ksi} \]

\[ \Delta f_{pES} = 0 \text{ ksi} \]

\[ \Delta f_{pT} = -21 \text{ ksi} \]  
\[ \frac{\Delta f_{pT}}{f_{pj}} = -10.45 \% \]

\[ f_{pe} = 181 \text{ ksi} \]  
\[ \frac{f_{pe}}{f_{pj}} = 89.55 \% \]

\[ 0.8 \cdot f_{py} = 194 \text{ ksi} \]

**Note:** Elastic shortening losses are zero in concrete stress calculations when using transformed section properties per LRFD 5.9.5.2.3.

#### Service Limit State Moments

\[ \text{max}(M_{\text{pos.Ser1}}) = 478.9 \text{ kip-ft} \]

\[ \text{max}(M_{\text{pos.Ser3}}) = 425 \text{ kip-ft} \]
### Summary of Values at Midspan

<table>
<thead>
<tr>
<th>Stage</th>
<th>Top of Beam (ksi)</th>
<th>Bott of Beam (ksi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-1.05</td>
<td>-2.02</td>
</tr>
<tr>
<td>2</td>
<td>-1.06</td>
<td>-1.7</td>
</tr>
<tr>
<td>4</td>
<td>-1</td>
<td>-1.76</td>
</tr>
<tr>
<td>6</td>
<td>-1.9</td>
<td>-0.98</td>
</tr>
<tr>
<td>8</td>
<td>-2.42</td>
<td>0.08</td>
</tr>
</tbody>
</table>

\[
\text{Stresses} = \left[\begin{array}{ccc}
\text{Stage} & \text{Top of Beam} & \text{Bott of Beam} \\
1 & -1.05 & -2.02 \\
2 & -1.06 & -1.7 \\
4 & -1 & -1.76 \\
6 & -1.9 & -0.98 \\
8 & -2.42 & 0.08
\end{array}\right]
\]

\[
\text{PrestressForce} = \left[\begin{array}{ccc}
\text{Condition} & \text{Axial (kip)} & \text{Moment (kip*ft)} \\
\text{Release} & -874.9 & -157.5 \\
\text{Final (about composite centroid)} & -783.5 & -134.9
\end{array}\right]
\]

\[
\text{Properties} = \left[\begin{array}{ccc}
\text{Section} & \text{Area (in^2)} & \text{Inertia (in^4)} & \text{distance to centroid from top of bm (in)} \\
\text{Net Beam} & 529.43 & 6473.54 & -6.36 \\
\text{Transformed Beam (initial)} & 556.7 & 6644.24 & -6.47 \\
\text{Transformed Beam} & 553.74 & 6626.28 & -6.46 \\
\text{Composite} & 896.92 & 23867.58 & -3.45
\end{array}\right]
\]

\[
\text{ServiceMoments} = \left[\begin{array}{c}
\text{Type} \\
\text{Release} \\
\text{Non-composite (includes bm wt.)} \\
\text{Composite} \\
\text{Distributed Live Load}
\end{array}\right] = \left[\begin{array}{c}
104.8 \\
176.1 \\
33.6 \\
268.8
\end{array}\right]
\]

**Stage 1** — At release with span length equal to length of the beam. Prestress losses are elastic shortening and overnight relax

**Stage 2** — Same as release with the addition of the remaining prestress losses applied to the transformed beam

**Stage 4** — Same as stage 2 with supports changed from the end of the beam to the bearing locations

**Stage 6** — Stage 4 with the addition of non-composite dead load excluding beam weight which has been included since Stage 1

**Stage 8** — Stage 6 with the addition of composite dead load and live loads applied to the composite section
# Camber, Shrinkage, and Dead Load Deflection Components

The diagram illustrates the deflection components over time, showing the effects of camber, shrinkage, and dead load. The graph represents deflection in inches over location in feet. Key components include:

- Camber at release
- Camber at 30 days, 60 days, 90 days, 120 days, 240 days
- Non-composite dead load deflection
- Composite dead load deflection
- Live load deflection

### Slope Data

<table>
<thead>
<tr>
<th>Stage</th>
<th>Change in L @ Top (in)</th>
<th>Change in L @ Bot. (in)</th>
<th>Slope at End (deg)</th>
<th>Midspan defl (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Release&quot;</td>
<td>-0.0671</td>
<td>-0.2219</td>
<td>0.2694</td>
<td>0.446</td>
</tr>
<tr>
<td>&quot;30 Days&quot;</td>
<td>-0.1787</td>
<td>-0.4297</td>
<td>0.468</td>
<td>0.6579</td>
</tr>
<tr>
<td>&quot;60 Days&quot;</td>
<td>-0.2199</td>
<td>-0.5063</td>
<td>0.5448</td>
<td>0.7543</td>
</tr>
<tr>
<td>&quot;90 Days&quot;</td>
<td>-0.2413</td>
<td>-0.5463</td>
<td>0.5847</td>
<td>0.8246</td>
</tr>
<tr>
<td>&quot;120 Days&quot;</td>
<td>-0.2545</td>
<td>-0.5707</td>
<td>0.6092</td>
<td>0.8792</td>
</tr>
<tr>
<td>&quot;240 Days&quot;</td>
<td>-0.2784</td>
<td>-0.6152</td>
<td>0.6538</td>
<td>1.0168</td>
</tr>
<tr>
<td>&quot;non-comp DL&quot;</td>
<td>-0.0538</td>
<td>0.0462</td>
<td>-0.2389</td>
<td>-0.5899</td>
</tr>
<tr>
<td>&quot;comp DL&quot;</td>
<td>-0.0035</td>
<td>0.0086</td>
<td>-0.0289</td>
<td>-0.0713</td>
</tr>
<tr>
<td>&quot;LL&quot;</td>
<td>-0.0244</td>
<td>0.0606</td>
<td>-0.2031</td>
<td>-0.4921</td>
</tr>
</tbody>
</table>

### Ultimate Moment Capacity

The table above shows the deflection data for various stages and load cases, providing insights into the structural behavior over time.

---

**7/21/2016**

MainProgram.xmcd v5.0
**Strength Limit State Moments**

\[
\phi_{\text{mom}} \left( M_{\text{mom}} \right) \bigg|_0
\]

- \( M_{\text{cr}} \) kip ft
- \( M_{\text{pos.Str1}} \) kip ft
- \( M_{\text{pos.Str2}} \) kip ft
- \( M_{\text{reqd}} \) kip ft

\[\text{CR}_{\text{Str.mom}} := 10\]

\[
\text{CR}_{\text{Str.mom}} := \frac{\phi_{\text{mom}} \left( M_{\text{mom}} \right) \bigg|_0}{M_{\text{reqd}}} \quad (LRFD 5.7.3.3.2)
\]

\[\text{CheckMomentCapacity} := \text{if} \left( \min \left( \text{CR}_{\text{Str.mom}} \right) > 0.99, \text{"OK"}, \text{"No Good!"} \right)\]

CheckMomentCapacity = "OK"

**Strength Shear and Associated Moments**

- \( V_{\text{u.Str}} \) kip
- \( M_{\text{shr u.Str}} \) kip-ft

\[\max(V_{\text{u.Str}}) = 122.7\text{ kip} \quad \max(M_{\text{shr u.Str}}) = 730.5\text{ kip-ft}\]
Design Shear, Longitudinal, Interface and Anchorage Reinforcement

Stirrup sizes and spacings assigned in input file

<table>
<thead>
<tr>
<th>Location</th>
<th>spacing</th>
<th>Number of Spaces</th>
<th>area per stirrup</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 stirrup</td>
<td>6, 18</td>
<td>8</td>
<td>(0.8)</td>
</tr>
<tr>
<td>A2 stirrup</td>
<td>18</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>A3 stirrup</td>
<td>18</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>S1 stirrup</td>
<td>18, 18</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>S2 stirrup</td>
<td>18</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>S3 stirrup</td>
<td>18</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>S4 stirrup</td>
<td>18</td>
<td>0</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Locally assigned stirrup sizes and spacings

To change the values from the input file enter the new values into the vectors below. Input only those that you wish to change. Values less than 0 are ignored.

A1 stirrup
A2 stirrup
A3 stirrup
S1 stirrup
S2 stirrup
S3 stirrup
S4 stirrup

The interface factor accounts for situations where not all of the shear reinforcing is embedded in the poured in place slab.

Spacing Computation

Stirrup sizes and spacings used in analysis

The number of spaces for the S4 stirrup is calculated by the program to complete the half beam length.

A1 stirrup
A2 stirrup
A3 stirrup
S1 stirrup
S2 stirrup
S3 stirrup
S4 stirrup

EndCover = 6.5 in
Sheer Steel Required vs. Provided Computation

Shear Steel Required vs. Provided

Av.reqdhs
in²
ft
Av.prov.shrhs
in²
ft
StirLocArea1

Locationhs
ft
Endanch
ft

Shear Capacity - Required vs. Provided

Vu,strhs
kip
ϕshr Vnhs
kip
ϕshr Vs.prov.shrhs
kip
ϕshr Vchs
kip
ϕshr Vphs
kip

Locationishear
Locationhs
ft
StirLocArea0

Locationhs
ft
Computation for Checks

CheckShearCapacity = "OK"  CheckMaxShearStress = "OK"
CheckStirArea = "OK"  CheckMinStirArea = "OK"  CheckMaxStirSpacing = "OK"

Longitudinal Reinforcement

\[ \text{Longitudinal Steel Required vs. Provided} \]

\[ \frac{V_{\text{long,reqd}}}{\text{kip}} \]

\[ \frac{V_{\text{long,prov}}}{\text{kip}} \]

\[ \text{Location}_{hs} \text{ ft} \]

\[ \text{Longitudinal Steel Required vs. Provided} \]

\[ \text{CheckLongSteel} := \text{if} \left( \frac{V_{\text{long,reqd}}}{V_{\text{long,prov}}} < 0.01 \text{kip}, 100 \times \frac{V_{\text{long,prov}}}{V_{\text{long,reqd}}} \right) \]

\[ \text{min}(\text{CR}_{\text{LongSteel}}) = 1.37 \]

\[ \text{CheckLongSteel} := \text{if} \left( \text{min}(\text{CR}_{\text{LongSteel}}) > 1, "OK", "No Good, add steel!" \right) \]

CheckLongSteel = "OK"

Interface Shear Reinforcement

\[ \text{Interface Steel Required vs Provided} \]

\[ \frac{A_{\text{vf,reqd}}}{\text{in}^2 \text{ ft}} \]

\[ \frac{A_{\text{vf,prov.interface}}}{\text{in}^2 \text{ ft}} \]

\[ \text{Location}_{hs} \text{ ft} \]
**Interface Steel**

Typically shear steel is extended up into the deck slab. These calculations are based on shear steel functioning as interface reinforcing. The interface factor can be used to adjust this assumption.

\[
\max(A_{vf,min}) = 0 \text{ in}^2/\text{ft} \qquad \max(A_{vf,des}) = 0 \text{ in}^2/\text{ft}
\]

If \(\max(A_{vf,min})\) or \(\max(A_{vf,des})\) is greater than 0 in\(^2/ft\), interface steel is required.

CheckInterfaceSpacing = "OK"

CheckInterfaceSteel := if \(\frac{\text{TotalInterfaceSteelProvided}}{\text{TotalInterfaceSteelRequired} + 0.001 \text{in}^2} \geq 1\), "OK", "No Good"

CheckInterfaceSteel := if (substr(BeamTypeTog, 0, 3) = "FLT", "N.A.", CheckInterfaceSteel) CheckInterfaceSteel = "OK"

**Anchorage Reinforcement and Maximum Prestressing Force**

Was FDOT Design Standard splitting reinforcing used? (bars Y.K, & Z)

CheckSplittingSteel = "N.A."

CheckMaxPrestressingForce = "OK"

**Summary of Design Checks**

check\_0 := AcceptAASHTO = "OK"

check\_1 := AcceptSDG = "N.A."

check\_2 := AcceptOntario = "N.A."

check\_3 := Check\_fpt = "OK"

check\_4 := Check\_fpe = "OK"

check\_5 := Check\_f\_tension\_rel = "OK"

check\_6 := Check\_f\_comp\_rel = "OK"

check\_7 := Check\_f\_tension\_stage8 = "OK"

check\_8 := Check\_f\_comp\_stage8\_c1 = "OK"

check\_9 := Check\_f\_comp\_stage8\_c2 = "OK"

check\_10 := Check\_f\_comp\_Fatigue\_1 = "OK"

check\_11 := Check\_Max\_Capacity = "OK"

check\_12 := Check\_Min\_Stir\_Area = "OK"

check\_13 := Check\_Min\_Stir\_Spacing = "OK"

check\_14 := Check\_Shear\_Capacity = "OK"

check\_15 := Check\_Max\_Stir\_Spacing = "OK"

check\_16 := Check\_Long\_Steel = "OK"

check\_17 := Check\_Interface\_Spacing = "OK"

check\_18 := Check\_Min\_Stir\_Area = "OK"

check\_19 := Check\_Splitting\_Steel = "N.A."

check\_20 := Check\_Max\_Prestressing\_Force = "OK"

check\_21 := Check\_Pattern\_0 = "OK"
check₂₂ := CheckPattern₁ = "OK"

check₂₄ := CheckPattern₃ = "OK"

check₂₆ := CheckInterfaceSteel = "OK"

check₂₈ := Check_SDG1.2_Display₂ = "OK"

check₂₃ := CheckPattern₂ = "OK"

check₂₅ := CheckPattern₄ = "OK"

check₂₇ := CheckStrandFit = "OK"

Link to Note- Checks, 0, 1 & 2

Total Check Table

TotalCheck = "OK"

**LRFR Load Rating Analysis**

*FDOT Maintenance Office Bridge Load Rating Manual*

**Load Rating Computations**

<table>
<thead>
<tr>
<th>Moment (Strength) or Stress (Service)</th>
<th>Shear (Strength)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Limit State&quot;</td>
<td>&quot;DF&quot;</td>
</tr>
<tr>
<td>&quot;Strength I(Inv)&quot;</td>
<td>0.40</td>
</tr>
<tr>
<td>&quot;Strength I(Op)&quot;</td>
<td>0.40</td>
</tr>
<tr>
<td>&quot;Service III(Inv)&quot;</td>
<td>0.40</td>
</tr>
<tr>
<td>&quot;Service III(Op)&quot;</td>
<td>0.40</td>
</tr>
<tr>
<td>&quot;Strength II&quot;</td>
<td>0.40</td>
</tr>
</tbody>
</table>

LRFR_loadrating = \[
\begin{bmatrix}
0.40 & 1.57 & "N/A" & 18.50 & 0.63 & 4.54 & "N/A" & 4.15 \\
0.40 & 2.04 & "N/A" & 18.50 & 0.63 & 5.88 & "N/A" & 4.15 \\
0.40 & 1.21 & "N/A" & 18.50 & "N/A" & "N/A" & "N/A" & "N/A" \\
0.40 & 1.65 & "N/A" & 18.50 & "N/A" & "N/A" & "N/A" & "N/A" \\
0.40 & 1.53 & 91.73 & 16.99 & 0.63 & 4.05 & 242.89 & 4.15 \\
\end{bmatrix}
\]

*Permit

*note: default permit load is FL120 per input worksheet

**Longitudinal Steel Check:**

\[ CR_{\text{LongSteel.HL93}} = 1.46 \quad CR_{\text{LongSteel.Permit}} = 1.37 \]

CheckLongSteelloadrating = "OK"

**Write Data Out**
LRFD Prestressed Beam Program

Project = "D30024 40 FT, LR Int. Beam"
DesignedBy = "VAY"
Date = "7-21-2016"

filename = "C:\FDOT Structures\Programs\LRFDPBeamV5.0\FSB Data Files\FSB12x53 40 ft span.dat"
Comment = "FSB12x53 40 ft span"

Legend

<table>
<thead>
<tr>
<th>TanHighlight = DataEntry</th>
<th>YellowHighlight = CheckValues</th>
<th>GreyHighlight = UserComments + Graphs</th>
</tr>
</thead>
<tbody>
<tr>
<td>BlackText = ProgramEquations</td>
<td>Maroon Text = Code Reference</td>
<td>Blue Text = Commentary</td>
</tr>
</tbody>
</table>

Bridge Layout and Dimensions

L<sub>beam</sub> = 38.83-ft  Span = 37.75-ft  BearingDistance = 6.5-in  PadWidth = 8-in

BeamTypeTog = "FSB12x53"  *These are typically the FDOT designations found in our standards. The user can also create a coordinate file for a custom shape. In all cases the top of the beam is at the y=0 ordinate.*

Partial Section

7/21/2016  MainProgram.xmcd v5.0
Overhang = 0-ft  BeamSpacing = 4.47-ft  t_{slab} = 6-in  h_{buildup} = 0-in
Skew = 0-deg  t_{integral,ws} = 0-in  NumberOfBeams = 6  t_{slab,\Delta} = 0.28-in
dc = 0.83 ft

BeamPosition = "interior"  \textit{For calculating distribution factors must be either interior or exterior}

b_c = 4.47 ft  \textit{effective slab width}  LRFD 4.6.2.6

t_{slab} := \text{if}(t_{slab} \leq 0\text{-in}, 0.00001\text{-in}, t_{slab})  \textit{Provide a minimum slab thickness to prevent divide by zero errors}

\textbf{Material Properties}

\textbf{Concrete:}

\textbf{Corrosion Classification}  Environment = "extremely"  \textit{density of slab concrete}  \gamma_{slab} = 0.15~\text{kip/ft}^3

\textit{strength of slab concrete}  \quad f_{c,slab} = 4.5-ksi

\textit{strength of beam concrete}  \quad f_{c,beam} = 8.5-ksi

\textit{release beam strength}  \quad f_{c,\Delta,beam} = 6-ksi

\textit{type of course aggregate}  \quad \text{AggregateType} = "Florida"  \textit{relative humidity}  \quad H = 75

\quad n_d := \left(f_{c,\Delta,beam}/f_{c,slab}\right)^{0.33}  \textit{used in distribution calculation}  \quad n_d = 1.23

\text{AggFactor} := \text{if}[\text{AggregateType} = "Florida", (1.0-2500), 2500]  \quad \text{(SDG 1.4.1)}  \quad \text{AggFactor} = 2500

\quad E_{ci} := \text{AggFactor} \cdot \left(f_{c,\Delta,beam}/\text{ksi}\right)^{0.33}  \textit{initial beam concrete modulus of elasticity}  \quad (LRFD 5.4.2.4)  \quad E_{ci} = 4516\text{-ksi}

\quad E_{c} := \text{AggFactor} \cdot \left(f_{c,\Delta,beam}/\text{ksi}\right)^{0.33}  \textit{beam concrete modulus of elasticity}  \quad (LRFD 5.4.2.4)  \quad E_{c} = 5066\text{-ksi}

\textbf{Prestressing Tendons:}

\textit{tendon ultimate tensile strength}  \quad f_{pu} = 270-ksi  \quad \textit{tendon modulus of elasticity}  \quad E_p = 28500\text{-ksi}

\textit{time in days between jacking and transfer}  \quad t_j = 0.75

\quad \text{ratio of tendon modulus to initial beam concrete modulus}  \quad n_{pi} := \frac{E_p}{E_{ci}}

\quad \text{ratio of tendon modulus to beam concrete modulus}  \quad n_p := \frac{E_p}{E_c}
**Mild Steel:**

- **mild steel yield strength** \( f_y = 60 \text{ ksi} \)
- **mild steel modulus of elasticity** \( E_s = 29000 \text{ ksi} \)
- \( n_{mi} \) := \( \frac{E_s}{E_{ci}} \) \( n_{mi} = 6.42 \)
- \( n_m \) := \( \frac{E_s}{E_c} \) \( n_m = 5.72 \)
- **area per unit width of longitudinal slab reinf.** \( A_{slab.rebar} = 0.31 \text{ in}^2 \text{ ft} \)
- **area of mild reinf lumped at centroid of bar locations** \( A_{s, long} = 0 \text{ in}^2 \)
- **distance from top of slab to centroid of slab reinf.** \( d_{slab.rebar} = 2.5 \text{ in} \)
- **distance from top of beam to centroid of mild flexural tension reinf.** \( d_{long} = 0 \text{ in} \)
- **Size of bar used create used to calculate development length** \( \text{BarSize} = 5 \)

**Permit Loads**

- *This is the number of wheel loads that comprise the truck, max for DLL is 11*
  \( \text{PermitAxles} = 3 \)
- *Indexes used to identify values in the P and d vectors*
  \( q := 0..(\text{PermitAxles} - 1) \)
  \( qt := 0..\text{PermitAxles} \)

- \( \text{PermitAxleLoad}^T = (13.33 \ 53.33 \ 53.33) \text{-kip} \)
- \( \text{PermitAxleSpacing}^T = (0 \ 14 \ 14 \ 0) \text{-ft} \)

**Distribution Factors**

- *DataMessage* = "This is a FSB12x53 Florida Slab Beam design, AASHTO distribution factors used"

- *calculated values:*
  \( \text{tmp}_g_{mom} = 0.37 \)
  \( \text{tmp}_g_{shear} = 0.55 \)
  \( \text{tmp}_g_{mom,fatigue} = 0.22 \)

- *user value overrides (optional):*
  \( \text{user}_g_{mom} := 0 \)
  \( \text{user}_g_{shear} := 0 \)
  \( \text{user}_g_{mom,fatigue} := 0 \)

- *value check*
  \( g_{mom} := \text{if} \left( \text{user}_g_{mom} \neq 0, \text{user}_g_{mom}, \text{tmp}_g_{mom} \right) \)
  \( g_{shear} := \text{if} \left( \text{user}_g_{shear} \neq 0, \text{user}_g_{shear}, \text{tmp}_g_{shear} \right) \)
  \( g_{mom,fatigue} := \text{if} \left( \text{user}_g_{mom,fatigue} \neq 0, \text{user}_g_{mom,fatigue}, \text{tmp}_g_{mom,fatigue} \right) \)
Section Views

Beam Section

Beam Type 1

Beam Type 0

Total Slab, Effective Slab, and Beam

feet

feet

slab
effective slab
beam
**Non-Composite Dead Load Input:**

\[ w_{slab} = 0.445 \, \text{kip/ft} \quad w_{beam} = 0.556 \, \text{kip/ft} \quad w_{forms} = 0 \, \text{kip/ft} \]

Add\_w\_noncomp := 0.0 \, \text{kip/ft}

*additional non composite dead load (positive or negative)*

*note: not saved to data file, may be saved to Mathcad worksheet.*

\[ w_{noncomposite} := w_{slab} + w_{beam} + w_{forms} + \text{Add\_w\_noncomp} \]

\[ w_{noncomposite} = 1.001 \, \text{kip/ft} \]

\[ w_{noncomposite} = 0.445 \, \text{kip/ft} \]

**Diaphragms/Point Load Input**

*End Diaphragms or Misc. Point Loads over bearing... included in bearing reaction calculation only*

*Intermediate Diaphragms or Misc. Point Loads... included in shear, moment, and bearing reaction calculations*

EndDiaphragmA := 0 \, \text{kip}  
begin bridge

IntDiaphragmB := 0 \, \text{kip}

DistB := 0 \, \text{ft}

EndDiaphragmE := 0 \, \text{kip}  
end bridge

IntDiaphragmC := 0 \, \text{kip}

DistC := 0 \, \text{ft}

IntDiaphragmD := 0 \, \text{kip}

DistD := 0 \, \text{ft}

**Composite Dead Load Input:**

\[ w_{future.ws} = 0.067 \, \text{kip/ft} \quad w_{barrier} = 0.143 \, \text{kip/ft} \]

Add\_w\_comp := 0.0 \, \text{kip/ft}

*additional composite dead load (positive or negative)*

*note: not saved to data file, may be saved to Mathcad worksheet*

\[ w_{composite} := w_{future.ws} + w_{barrier} + \text{Add\_w\_comp} \]

\[ w_{composite} = 0.21 \, \text{kip/ft} \]

\[ w_{comp.str} = 0.143 \, \text{kip/ft} \]
Release Dead Load Moments and Shear

Release DL, M(kip-ft) & V(kip)

max\( (M_{\text{release}}) = 104.8 \text{-kip-ft} \)

max\( (V_{\text{release}}) = 10.8 \text{-kip} \)

Noncomposite Dead Load Moments and Shear

Noncomp. DL, M(kip-ft) & V(kip)

max\( (M_{\text{dl.non.comp}}) = 178.4 \text{-kip-ft} \)

max\( (V_{\text{dl.non.comp}}) = 18.9 \text{-kip} \)
**Composite Dead Load Moments and Shear**

\[ \text{max}(M_{\text{dl,comp}}) = 37.4 \text{-kip-ft} \quad \text{max}(V_{\text{dl,comp}}) = 4 \text{-kip} \]

**Distributed Live Load Moments and Shear**

\[ \text{max}(M_{\text{dist, live, pos}}) = 251 \text{-kip-ft} \]
\[ \text{min}(M_{\text{dist, live, neg}}) = -8.6 \text{-kip-ft} \]
\[ \text{max}(V_{\text{dist, live, pos}}) = 45.9 \text{-kip} \]
\[ \text{max}(M_{\text{shrdist, live, pos}}) = 230.8 \text{-kip-ft} \]
\[ \text{max}(V_{\text{shrdist, live, pos}}) = 45.9 \text{-kip} \]

**Beam End Reactions... with IM factor only**

\[ \text{Reaction}_{LL} = 46.86 \text{-kip} \]
\[ \text{Reaction}_{DL} = 23.51 \text{-kip} \]
Prestress Strand Layout Input

Instructions:
Double click the icon to open the 'Strand Pattern Generator'. Specify the type, location, size, and debonding of strands. When finished, press the 'Continue' button. Then press 'Read Strand Data' button. Then press 'Recalculate Worksheet' button.

Strand Pattern Input Mode:
StrandTemplate :=

Standard
Custom

Collapsed Region for Custom Strand Sizes...

Strand Multiplier
Strand Data and Pattern
Strand Properties

Tendon Layout

SupportLocation_{release} = 0·ft distance supports are located from the end of the beam after release; may be used to check lifting points immediately after transfer
**Partially Stressed Tendons ("Strand N")**

\[
\text{PartialPS}_{\text{force}} = 40 \text{-kip} \\
\text{PartialPS}_{\text{force}} = \text{if} \left( \text{BeamTypeTog} = "\text{II}" \right) \cdot 20 \text{-kip} + \text{PartialPS}_{\text{force}}
\]

\[
\text{PartialPS}_{\text{force}} = 40 \text{-kip}
\]

\[
\text{PartialPS}_{\text{location}} = 1.4375 \text{in} \\
\text{PartialPS}_{\text{location}} = 2.4375 \text{in} \text{ if BeamTypeTog} = "\text{II}"
\]

\[
\text{PartialPS}_{\text{location}} = 1.4375 \text{in} \\
\text{PartialPS}_{\text{location}} = 3 \text{in} \text{ if \ substr(BeamTypeTog,0,5)} = "\text{FSB12}"
\]

\[
\text{PartialPS}_{\text{location}} = 1.4375 \text{in} \\
\text{PartialPS}_{\text{location}} = 2 \text{in} \text{ if \ substr(BeamTypeTog,0,5)} = "\text{FSB15}"
\]

\[
\text{PartialPS}_{\text{location}} = 1.4375 \text{in} \\
\text{PartialPS}_{\text{location}} = 3 \text{in} \text{ if \ substr(BeamTypeTog,0,5)} = "\text{FSB18}"
\]

\[
\text{PartialPS}_{\text{location}} = 1.4375 \text{in} \\
\text{PartialPS}_{\text{location}} \text{ otherwise}
\]

**Section Properties & Strand Profile Properties**

**Release Stresses**

<table>
<thead>
<tr>
<th>Location (ft)</th>
<th>$f_{\text{top.beam.rel}}$ (ksi)</th>
<th>$f_{\text{bot.beam.rel}}$ (ksi)</th>
<th>$f_{\text{fall.tension.rel}}$ (ksi)</th>
<th>$f_{\text{fall.comp.rel}}$ (ksi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>9.707</td>
<td>19.415</td>
<td>29.122</td>
<td>38.83</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>9.707</td>
<td>19.415</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>9.707</td>
<td>19.415</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>9.707</td>
<td>19.415</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>9.707</td>
<td>19.415</td>
</tr>
</tbody>
</table>

**Prestress Force**
### Final Stresses

#### Release Checks & Final Checks for Capacity Ratio (CR)

**Stress Checks**

- \( \min(CR_{f_{tension.rel}}) = 10 \)
  - Check \( f_{tension.rel} \) = "OK"
  - (Release tension)

- \( \min(CR_{f_{comp.rel}}) = 1.31 \)
  - Check \( f_{comp.rel} \) = "OK"
  - (Release compression)

- \( \min(CR_{f_{tension.stage8}}) = 5.4 \)
  - Check \( f_{tension.stage8} \) = "OK"
  - (Service III, PS + DL + LL\*0.8)

- \( \min(CR_{f_{comp.stage8}.c1}) = 1.92 \)
  - Check \( f_{comp.stage8}.c1 \) = "OK"
  - (Service I, PS + DL)

- \( \min(CR_{f_{comp.stage8}.c2}) = 2.11 \)
  - Check \( f_{comp.stage8}.c2 \) = "OK"
  - (Service I, PS + DL + LL)

- \( \min(CR_{f_{comp.FatigueI}}) = 2.82 \)
  - Check \( f_{comp.FatigueI} \) = "OK"
  - (Fatigue I, (PS + DL)*0.5 + 1.5 Fatigue Truck)
Strand Pattern Checks

- **Check 0**: no debonded tendon in outside row
- **Check 1**: less than 25% debonded tendons total
- **Check 2**: less than 40% debonded tendons in any row
- **Check 3**: less than 40% of debonded tendons terminated at same section
- **Check 4**: more than half beam depth debond length

*Note: Check 1 may be less than 30% provided that debonding does not occur within the horizontal limits of the web (See SDG 4.3.1)*

**Section and Strand Properties Summary**

- \( A_{beam} = 533.75 \text{ in}^2 \) \( \text{Concrete area of beam} \)
- \( I_{beam} = 6501.409 \text{ in}^4 \) \( \text{Gross Moment of Inertia of Beam about CG} \)
- \( y_{comp} = -3.36 \text{ in} \) \( \text{Dist. from top of beam to CG of gross composite section} \)
- \( I_{comp} = 23203.5285 \text{ in}^4 \) \( \text{Gross Moment of Inertia Composite Section about CG} \)
- \( A_{deck} = 345.96 \text{ in}^2 \) \( \text{Concrete area of deck slab} \)
- \( A_{ps} = 4.1 \text{ in}^2 \) \( \text{total area of strands} \)
- \( d_{b,ps} = 0.6 \text{ in} \) \( \text{diameter of Prestressing strand} \)
- \( f_{py} = 243 \text{ ksi} \) \( \text{tendon yield strength} \)
- \( f_{pj} = 203 \text{ ksi} \) \( \text{prestress jacking stress} \)
- \( L_{shielding} = (0 \ 0 \ 0) \text{ ft} \)
- \( A_{ps,row} = (3.7 \ 0.4 \ 0.2) \text{ in}^2 \)
- \( d_{ps,row} = \begin{array}{cccccccc}
0 & -9 & -9 & -9 & -9 & -9 & -9 & -9 \\
1 & -7 & -7 & -7 & -7 & -7 & -7 & -7 \\
2 & -3 & -3 & -3 & -3 & -3 & -3 & -3 \\
\end{array} \text{ in} \)

- TotalNumberOfTendons = 19
- NumberDebondedTendons = 0
- NumberDrapedTendons = 0
- StrandSize = "0.6 in low lax"
- StrandArea = 0.22 \text{ in}^2
- JackingForce_{per.strand} = 43.94-kip
**Prestress Losses Summary**

- \( f_{pj} = 202.5 \text{ ksi} \)
- \( \Delta f_{pES} = 0 \text{ ksi} \)
- \( \Delta f_{pT} = -21 \text{ ksi} \)
- \( f_{pc} = 181 \text{ ksi} \)
- \( 0.8 \cdot f_{py} = 194 \text{ ksi} \)

*Note: Elastic shortening losses are zero in concrete stress calculations when using transformed section properties per LRFD 5.9.5.2.3*

**Service Limit State Moments**

- Max \( M_{\text{pos.Ser1}} = 466.6 \text{ kip-ft} \)
- Max \( M_{\text{pos.Ser3}} = 416.4 \text{ kip-ft} \)
Summary of Values at Midspan

Stresses =

<table>
<thead>
<tr>
<th>Stage</th>
<th>Top of Beam (ksi)</th>
<th>Bott of Beam (ksi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-1.05</td>
<td>-2.02</td>
</tr>
<tr>
<td>2</td>
<td>-1.06</td>
<td>-1.7</td>
</tr>
<tr>
<td>4</td>
<td>-1.93</td>
<td>-0.96</td>
</tr>
<tr>
<td>6</td>
<td>-2.42</td>
<td>0.06</td>
</tr>
</tbody>
</table>

PrestressForce =

<table>
<thead>
<tr>
<th>Condition</th>
<th>Axial (kip)</th>
<th>Moment (kip*ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Release</td>
<td>-874.9</td>
<td>-157.5</td>
</tr>
<tr>
<td>Final (about composite centroid)</td>
<td>-783.5</td>
<td>-134.9</td>
</tr>
</tbody>
</table>

Properties =

<table>
<thead>
<tr>
<th>Section</th>
<th>Area (in^2)</th>
<th>Inertia (in^4)</th>
<th>distance to centroid from top of bm (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Beam</td>
<td>529.43</td>
<td>6473.54</td>
<td>-6.36</td>
</tr>
<tr>
<td>Transformed Beam (initial)</td>
<td>556.7</td>
<td>6644.24</td>
<td>-6.47</td>
</tr>
<tr>
<td>Transformed Beam</td>
<td>553.74</td>
<td>6626.28</td>
<td>-6.46</td>
</tr>
<tr>
<td>Composite</td>
<td>906.24</td>
<td>24077.64</td>
<td>-3.42</td>
</tr>
</tbody>
</table>

ServiceMoments =

<table>
<thead>
<tr>
<th>Type</th>
<th>Value (kip*ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Release</td>
<td>104.8</td>
</tr>
<tr>
<td>Non-composite (includes bm wt.)</td>
<td>178.4</td>
</tr>
<tr>
<td>Composite</td>
<td>37.4</td>
</tr>
<tr>
<td>Distributed Live Load</td>
<td>250.5</td>
</tr>
</tbody>
</table>

Stage 1 —> At release with span length equal to length of the beam. Prestress losses are elastic shortening and overnight relax

Stage 2 —> Same as release with the addition of the remaining prestress losses applied to the transformed beam

Stage 4 —> Same as stage 2 with supports changed from the end of the beam to the bearing locations

Stage 6 —> Stage 4 with the addition of non-composite dead load excluding beam weight which has been included since Stage 1

Stage 8 —> Stage 6 with the addition of composite dead load and live loads applied to the composite section
Camber, Shrinkage, and Dead Load Deflection Components

Camber & Deflection

Location in feet

<table>
<thead>
<tr>
<th>SlopeData</th>
<th>&quot;Stage&quot;</th>
<th>&quot;Change in L @ Top (in)&quot;</th>
<th>&quot;Change in L @ Bot. (in)&quot;</th>
<th>&quot;Slope at End (deg)&quot;</th>
<th>&quot;midspan defl (in)&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Release&quot;</td>
<td>-0.0671</td>
<td>-0.2219</td>
<td>0.2694</td>
<td>0.446</td>
<td></td>
</tr>
<tr>
<td>&quot;30 Days&quot;</td>
<td>-0.1787</td>
<td>-0.4297</td>
<td>0.468</td>
<td>0.6579</td>
<td></td>
</tr>
<tr>
<td>&quot;60 Days&quot;</td>
<td>-0.2199</td>
<td>-0.5063</td>
<td>0.5448</td>
<td>0.7543</td>
<td></td>
</tr>
<tr>
<td>&quot;90 Days&quot;</td>
<td>-0.2413</td>
<td>-0.5462</td>
<td>0.5847</td>
<td>0.8246</td>
<td></td>
</tr>
<tr>
<td>&quot;120 Days&quot;</td>
<td>-0.2545</td>
<td>-0.5707</td>
<td>0.6092</td>
<td>0.8792</td>
<td></td>
</tr>
<tr>
<td>&quot;240 Days&quot;</td>
<td>-0.2784</td>
<td>-0.6152</td>
<td>0.6538</td>
<td>1.0168</td>
<td></td>
</tr>
<tr>
<td>&quot;non-comp DL&quot;</td>
<td>-0.0555</td>
<td>0.0476</td>
<td>-0.2461</td>
<td>-0.6077</td>
<td></td>
</tr>
<tr>
<td>&quot;comp DL&quot;</td>
<td>-0.0038</td>
<td>0.0095</td>
<td>-0.0319</td>
<td>-0.0787</td>
<td></td>
</tr>
<tr>
<td>&quot;LL&quot;</td>
<td>-0.0224</td>
<td>0.0561</td>
<td>-0.1876</td>
<td>-0.4545</td>
<td></td>
</tr>
</tbody>
</table>

Ultimate Moment Capacity
**Strength Limit State Moments**

Nominal and Ultimate Moment Strength (kip-ft)

\[ \phi_{mom_{mn}} \left( \frac{M_{mn}}{M_{mn}} \right) \]

- CRStr.mom := 10
- \( CR_{Str.mom} := \frac{\phi_{mom_{mn}} \cdot \left( \frac{M_{mn}}{M_{mn}} \right)}{M_{reqd_{mn}}} \)  \( (LRFD\ 5.7.3.3.2) \)
- \( \min(CR_{Str.mom}) = 1.28 \)
- \( \max(M_{reqd}) = 794.6 \text{-kip-ft} \)
- \( \text{CheckMomentCapacity} := \text{if} \left( \min(CR_{Str.mom}) > 0.99, "OK", "No Good!" \right) \)

FSB only - Design Check of Transverse reinforcing Bars E

**Shear Analysis**

**Strength Shear and Associated Moments**

Str. V(kip) & Corresp. M(kip-ft)

\[ \max(V_{u.Str}) = 109.9 \text{-kip} \]
\[ \max(M_{shr.u.Str}) = 706.2 \text{-kip-ft} \]
Design Shear, Longitudinal, Interface and Anchorage Reinforcement

Stirrup sizes and spacings assigned in input file

<table>
<thead>
<tr>
<th>Location</th>
<th>spacing</th>
<th>Number of Spaces</th>
<th>area per stirrup</th>
</tr>
</thead>
</table>
| A1 stirrup | \[
6 \quad 18
\]
\[
18
\]
tmp_s = 18-in | tmp_NumberSpaces = \[
8 \\
1 \\
1 \\
0
\] | tmp_Astirrup = \[
0.8 \\
0.8 \\
0.8 \\
0.8
\] | in^2 |
| A2 stirrup | \[
18
\] |
| A3 stirrup | \[
18
\] |
| S1 stirrup | \[
18
\] |
| S2 stirrup | \[
18
\] |
| S3 stirrup | \[
18
\] |
| S4 stirrup | \[
18
\] |

Locally assigned stirrup sizes and spacings

To change the values from the input file enter the new values into the vectors below. Input only those that you wish to change. Values less than 0 are ignored.

user_s := \[
-1\text{in} \\
-1\text{in} \\
-1\text{in} \\
-1\text{in} \\
-1\text{in} \\
-1\text{in} \\
-1\text{in} \\
-1\text{in}
\]

user_NumberSpaces := \[
-1 \\
-1 \\
-1 \\
-1 \\
-1 \\
-1 \\
-1 \\
-1
\]

user_Astirrup := \[
-1\text{in}^2 \\
-1\text{in}^2 \\
-1\text{in}^2 \\
-1\text{in}^2 \\
-1\text{in}^2 \\
-1\text{in}^2 \\
-1\text{in}^2 \\
-1\text{in}^2
\]

interface_factor := \[
0.25 \\
0.5 \\
1 \\
1 \\
1 \\
1 \\
1 \\
1
\]

The interface_factor accounts for situations where not all of the shear reinforcing is embedded in the poured in place slab.

Recalculate Worksheet

Spacing Computation

Stirrup sizes and spacings used in analysis

The number of spaces for the S4 stirrup is calculated by the program to complete the half beam length.

\[
\begin{bmatrix}
6 \\
18 \\
18 \\
18
\end{bmatrix}
\]

\[
\begin{bmatrix}
8 \\
1 \\
1 \\
0
\end{bmatrix}
\]

\[
\begin{bmatrix}
0.8 \\
0.8 \\
0.8 \\
0.8
\end{bmatrix}
\]

EndCover = 6.5-in
Computation for Checks

CheckShearCapacity = "OK"  \[ \text{CheckMaxShearStress} = \text{"OK"} \]

CheckStirArea = "OK"  \[ \text{CheckMinStirArea} = \text{"OK"} \]

CheckMaxStirSpacing = "OK"

Longitudinal Reinforcement

Longitudinal Steel Required vs. Provided

\[
\text{CR}_{\text{LongSteel}} := \begin{cases} 
V_{\text{long,reqd}_{\text{hs}}} < 0.01 \text{kip}, & V_{\text{long,prov}_{\text{hs}}} / V_{\text{long,reqd}_{\text{hs}}} \\
\min(\text{CR}_{\text{LongSteel}}) = 1.44 & \end{cases}
\]

CheckLongSteel := \( \begin{cases} 
\min(\text{CR}_{\text{LongSteel}}) > 1, \text{ "OK"}, \text{ "No Good, add steel!"} \\
\text{CheckLongSteel} = \text{"OK"} & \end{cases}\)

Interface Shear Reinforcement

Interface Steel Required vs Provided

\[
\text{Avf,reqd}_{\text{hs}} := \begin{cases} 
\text{Avf,prov.interface}_{\text{hs}} & \end{cases}
\]

\[ \text{CheckLongSteel} = \text{"OK"} \]
Typically shear steel is extended into the deck slab. These calculations are based on shear steel functioning as interface reinforcing. The interface factor can be used to adjust this assumption.

\[
\max(A_{vf,\text{min}}) = 0 \text{ in}^2/\text{ft} \quad \max(A_{vf,\text{des}}) = 0 \text{ in}^2/\text{ft}
\]

If \( \max(A_{vf,\text{min}}) \) or \( \max(A_{vf,\text{des}}) \) is greater than 0 in²/ft, interface steel is required.

CheckInterfaceSpacing = "OK"

CheckInterfaceSteel := if \left( \frac{\text{TotalInterfaceSteelProvided}}{\text{TotalInterfaceSteelRequired} + 0.001\text{in}^2} \geq 1, "OK", "No Good" \right)

CheckInterfaceSteel := if (substr(BeamTypeTog, 0, 3) = "FLT", "N.A.", CheckInterfaceSteel) CheckInterfaceSteel = "OK"

**Anchorage Reinforcement and Maximum Prestressing Force**

Was FDOT Design Standard splitting reinforcing used? (bars Y, K, & Z)

StandardSplittingReinforcing := yes

if yes-> checks max allowable standard prestress force
if no-> checks stirrup area given input prestress force

CheckSplittingSteel = "N.A." CheckMaxPrestressingForce = "OK"

**Summary of Design Checks**

check₀ := AcceptAASHTO = "OK"

check₂ := AcceptOntario = "N.A."

check₄ := Check_fpe = "OK"

check₆ := Check_f_comp.rel = "OK"

check₈ := Check_f_comp.stage8.c1 = "OK"

check₁₀ := Check_f_comp.Fatiguel = "OK"

check₁₂ := CheckMaxCapacity = "OK"

check₁₄ := CheckShearCapacity = "OK"

check₁₆ := CheckMaxStirSpacing = "OK"

check₁₈ := CheckInterfaceSpacing = "OK"

check₂₀ := CheckMaxPrestressingForce = "OK"

check₁ := AcceptSDG = "N.A."

check₃ := Check_fpt = "OK"

check₅ := Check_f_comp.stage8 = "OK"

check₇ := Check_f_comp.stage8.c2 = "OK"

check₉ := CheckMomemntCapacity = "OK"

check₁₁ := CheckStirArea = "OK"

check₁₅ := CheckMinStirArea = "OK"

check₁₇ := CheckLongSteel = "OK"

check₁₉ := CheckSplittingSteel = "N.A."

check₂₁ := CheckPattern₀ = "OK"
check_22 := CheckPattern_1 = "OK"
check_23 := CheckPattern_2 = "OK"
check_24 := CheckPattern_3 = "OK"
check_25 := CheckPattern_4 = "OK"
check_26 := CheckInterfaceSteel = "OK"
check_27 := CheckStrandFit = "OK"
check_28 := Check_SDG1.2_Display = "OK"

**Total Check Table**

```
TotalCheck = "OK"
```

## LRFR Load Rating Analysis

**FDOT Maintenance Office Bridge Load Rating Manual**

### Load Rating Computations

<table>
<thead>
<tr>
<th>Moment (Strength) or Stress (Service)</th>
<th>Shear (Strength)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limit State</td>
<td>Rating</td>
</tr>
<tr>
<td>Strength I(Inv)</td>
<td>&quot;DF&quot; 0.37</td>
</tr>
<tr>
<td>Strength I(Op)</td>
<td>&quot;Rating&quot; 1.70</td>
</tr>
<tr>
<td>Service III(Inv)</td>
<td>&quot;Tons&quot; &quot;N/A&quot;</td>
</tr>
<tr>
<td>Service III(Op)</td>
<td>&quot;Dim(ft)&quot; 18.50</td>
</tr>
<tr>
<td>Strength II</td>
<td>&quot;DF&quot; 0.37</td>
</tr>
<tr>
<td></td>
<td>&quot;Rating&quot; 1.65</td>
</tr>
<tr>
<td></td>
<td>&quot;Tons&quot; 99.11</td>
</tr>
<tr>
<td></td>
<td>&quot;Dim(ft)&quot; 16.99</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LRFRloadrating =</th>
<th>HL-93</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Limit State&quot;</td>
<td>&quot;DF&quot;</td>
</tr>
<tr>
<td>&quot;Strength I(Inv)&quot;</td>
<td>0.37</td>
</tr>
<tr>
<td>&quot;Strength I(Op)&quot;</td>
<td>0.37</td>
</tr>
<tr>
<td>&quot;Service III(Inv)&quot;</td>
<td>0.37</td>
</tr>
<tr>
<td>&quot;Service III(Op)&quot;</td>
<td>0.37</td>
</tr>
<tr>
<td>&quot;Strength II&quot;</td>
<td>0.37</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.70</td>
</tr>
<tr>
<td>2.20</td>
</tr>
<tr>
<td>1.26</td>
</tr>
<tr>
<td>1.74</td>
</tr>
<tr>
<td>1.65</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;N/A&quot;</td>
</tr>
<tr>
<td>&quot;N/A&quot;</td>
</tr>
<tr>
<td>&quot;N/A&quot;</td>
</tr>
<tr>
<td>&quot;N/A&quot;</td>
</tr>
<tr>
<td>&quot;N/A&quot;</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Dim(ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.50</td>
</tr>
<tr>
<td>18.50</td>
</tr>
<tr>
<td>18.50</td>
</tr>
<tr>
<td>18.50</td>
</tr>
<tr>
<td>16.99</td>
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</table>

<table>
<thead>
<tr>
<th>DF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.55</td>
</tr>
<tr>
<td>0.55</td>
</tr>
<tr>
<td>&quot;N/A&quot;</td>
</tr>
<tr>
<td>&quot;N/A&quot;</td>
</tr>
<tr>
<td>0.55</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.30</td>
</tr>
<tr>
<td>6.87</td>
</tr>
<tr>
<td>&quot;N/A&quot;</td>
</tr>
<tr>
<td>&quot;N/A&quot;</td>
</tr>
<tr>
<td>4.73</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;N/A&quot;</td>
</tr>
<tr>
<td>&quot;N/A&quot;</td>
</tr>
<tr>
<td>&quot;N/A&quot;</td>
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<td>&quot;N/A&quot;</td>
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</table>

<table>
<thead>
<tr>
<th>Dim(ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.15</td>
</tr>
<tr>
<td>4.15</td>
</tr>
<tr>
<td>&quot;N/A&quot;</td>
</tr>
<tr>
<td>&quot;N/A&quot;</td>
</tr>
<tr>
<td>4.15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Permit</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.30</td>
</tr>
<tr>
<td>6.87</td>
</tr>
<tr>
<td>&quot;N/A&quot;</td>
</tr>
<tr>
<td>&quot;N/A&quot;</td>
</tr>
<tr>
<td>4.73</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;N/A&quot;</td>
</tr>
<tr>
<td>&quot;N/A&quot;</td>
</tr>
<tr>
<td>&quot;N/A&quot;</td>
</tr>
<tr>
<td>&quot;N/A&quot;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dim(ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.15</td>
</tr>
</tbody>
</table>

*note: default permit load is FL120 per input worksheet

### Longitudinal Steel Check:

CR_{LongSteel.HL93} = 1.53
CR_{LongSteel.Permit} = 1.44

CheckLongSteel_loadrating = "OK"

### Write Data Out