LOAD RATING CALCULATIONS

DEVELOPMENTAL DESIGN STANDARDS

FSB SUPERSTRUCTURE PACKAGE

24 FT. CLEAR WIDTH

D30024 - 30 Ft. Span
Developmental Design Standards - FSB Superstructure Package

<table>
<thead>
<tr>
<th>Rating Level</th>
<th>Vehicle</th>
<th>Weight (Tons)</th>
<th>LRFR using Part A</th>
<th>Controlling Rating Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Int. / Ext. Beam</td>
<td>Ext.</td>
</tr>
<tr>
<td>Span Length (ft)</td>
<td></td>
<td></td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Design Operating</td>
<td>HL-93</td>
<td>36</td>
<td>2.31</td>
<td>5.58</td>
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<tr>
<td>Design Inventory</td>
<td></td>
<td></td>
<td>1.78</td>
<td>4.30</td>
</tr>
<tr>
<td>Permit</td>
<td>FL-120</td>
<td>60</td>
<td>1.96</td>
<td>3.78</td>
</tr>
</tbody>
</table>
D30024 - SUPERSTRUCTURE SECTION
LRFD Prestressed Beam Program

Project = "D30024 30 FT, LR Ext. Bm."
DesignedBy = "JRM"
Date = "8-2-2016"

filename = "C:\FDOT Structures\Programs\LRFDBeamV5.0\FSB Data Files\D30024 30 FT LR.dat"
Comment = "FSB12x53 30 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

Beam Elevation

L_{beam} = 28.83 \text{ ft} \quad \text{Span} = 27.75 \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.

Partial Section
Overhang = 0·ft  
BeamSpacing = 4.47·ft  
t_{slab} = 6·in  
h_{buildup} = 0·in  

t_{integral.ws} = 0·in  
NumberOfBeams = 6  
t_{slab.delta} = 0.25·in  
d_{c} = 0.87·ft

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

t_{slab} := if(t_{slab} ≤ 0·in, 0.00001·in, t_{slab})  
For calculating distribution factors must be either interior or exterior

Material Properties

Concrete:

Corrosion Classification  
Environment = "extremely"  

Density of slab concrete  
\gamma_{slab} = 0.15 \text{kip/ft}^3

Density of beam concrete  
\gamma_{beam} = 0.15 \text{kip/ft}^3

Strength of slab concrete  
f_{c,slab} = 4.5\text{ksi}

Strength of beam concrete  
f_{c,beam} = 8.5\text{ksi}

Release beam strength  
f_{ci,beam} = 6\text{ksi}

Type of course aggregate  
AggregateType = "Florida" or "Standard"

Relative humidity  
H = 75

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

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

\[ E_{ci} := \text{AggFactor} \cdot \left(\frac{f_{c,beam}}{\text{ksi}}\right)^{0.33} \text{initial beam concrete modulus of elasticity} \]

(LRFD 5.4.2.4) \[ E_{ci} = 4516\text{ksi} \]

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

(LRFD 5.4.2.4) \[ E_{c} = 5066\text{ksi} \]

Prestressing Tendons:

tendon ultimate tensile strength  
f_{pu} = 270·ksi

tendon modulus of elasticity  
E_{p} = 28500·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** \( n_{mi} := \frac{E_s}{E_{ci}} \quad n_{mi} = 6.42 \)
- **ratio of rebar modulus to beam concrete modulus** \( n_m := \frac{E_s}{E_c} \quad n_m = 5.72 \)
- **area per unit width of longitudinal slab reinf.** \( A_{slab\text{-rebar}} = 0.31\text{-in}^2\text{-ft} \)
- **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.** \( d_{slab\text{-rebar}} = 2.5\text{-in} \)
- **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** \( BarSize = 5 \)

**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**
  - \( q := 0 \ldots (\text{PermitAxles} - 1) \)
  - \( qt := 0 \ldots \text{PermitAxles} \)

- **PermitAxleLoad**
  \( T = (13.33 \ 53.33 \ 53.33)\text{-kip} \)

- **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:**
  - \( \text{tmp\_g\_mom} = 0.42 \)
  - \( \text{tmp\_g\_shear} = 0.66 \)
  - \( \text{tmp\_g\_mom\_fatigue} = 0.3 \)

- **user value overrides (optional):**
  - \( \text{user\_g\_mom} := 0 \)
  - \( \text{user\_g\_shear} := 0 \)
  - \( \text{user\_g\_mom\_fatigue} := 0 \)

- **value check**
  - \( g\_mom := \text{if}\left(\text{user\_g\_mom} \neq 0, \text{user\_g\_mom} \cdot \text{tmp\_g\_mom}\right) \)
  - \( g\_shear := \text{if}\left(\text{user\_g\_shear} \neq 0, \text{user\_g\_shear} \cdot \text{tmp\_g\_shear}\right) \)
  - \( g\_mom\_fatigue := \text{if}\left(\text{user\_g\_mom\_fatigue} \neq 0, \text{user\_g\_mom\_fatigue} \cdot \text{tmp\_g\_mom\_fatigue}\right) \)
Beam Section

Total Slab, Effective Slab, and Beam

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

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

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

*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*

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

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

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

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

\[\text{Longitudinal Distance} \quad B, C, \quad \text{& D} \quad \text{- Measured from CL}\]

*End DiaphragmE := 0 \, \text{kip} \quad \text{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:**

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

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

*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**

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

- $M_{\text{release}}$ (kip-ft)
- $V_{\text{release}}$ (kip)

Max $M_{\text{release}} = 57.8$ kip-ft
Max $V_{\text{release}} = 8$ kip

**Noncomposite Dead Load Moments and Shear**

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

- $M_{\text{dl.non.comp}}$ (kip-ft)
- $V_{\text{dl.non.comp}}$ (kip)

Max $M_{\text{dl.non.comp}} = 95.1$ kip-ft
Max $V_{\text{dl.non.comp}} = 13.7$ kip
Composite Dead Load Moments and Shear

\[ \max(M_{dl,comp}) = 18.2 \text{kip-ft} \quad \quad \max(V_{dl,comp}) = 2.6 \text{kip} \]

Distributed Live Load Moments and Shear

\[ \max(M_{dist, live, pos}) = 194.4 \text{kip-ft} \quad \min(M_{dist, live, neg}) = -9.8 \text{kip-ft} \]
\[ \max(V_{dist, live, pos}) = 47.5 \text{kip} \quad \max(M_{shr, dist, live, pos}) = 182.3 \text{kip-ft} \quad \text{Reaction}_{LL} = 48.95 \text{kip} \]
\[ \text{Reaction}_{DL} = 16.98 \text{kip} \]
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

Recalculate Worksheet  Read Strand Data

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

8/2/2016  MainProgram.xmcd v5.0
**Partially Stressed Tendons ("Strand N")**

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

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

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

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

**Release Stresses**

![Graph showing release stresses for different locations](image)

**Prestress Force**

8/2/2016
**Final Stresses**

**Stress Checks**

\[
\begin{align*}
\text{Check}_{\text{f}_{\text{tension.rel}}} & = "OK" \quad \text{(Release tension)} \\
\text{Check}_{\text{f}_{\text{comp.rel}}} & = "OK" \quad \text{(Release compression)} \\
\text{Check}_{\text{f}_{\text{tension.stage8}}} & = "OK" \quad \text{(Service III, PS + DL +LL*0.8)} \\
\text{Check}_{\text{f}_{\text{comp.stage8.c1}}} & = "OK" \quad \text{(Service I, PS + DL)} \\
\text{Check}_{\text{f}_{\text{comp.stage8.c2}}} & = "OK" \quad \text{(Service I, PS + DL +LL)} \\
\text{Check}_{\text{f}_{\text{comp.FatigueI}}} & = "OK" \quad \text{(Fatigue I, (PS + DL)*0.5 +1.5 Fatigue Truck)}
\end{align*}
\]

\[
\begin{align*}
\text{min}(\text{CR}_{\text{f}_{\text{tension.rel}}}) & = 10 \\
\text{min}(\text{CR}_{\text{f}_{\text{comp.rel}}}) & = 1.93 \\
\text{min}(\text{CR}_{\text{f}_{\text{tension.stage8}}}) & = 10 \\
\text{min}(\text{CR}_{\text{f}_{\text{comp.stage8.c1}}}) & = 3.37 \\
\text{min}(\text{CR}_{\text{f}_{\text{comp.stage8.c2}}}) & = 3.47 \\
\text{min}(\text{CR}_{\text{f}_{\text{comp.FatigueI}}}) & = 4.44
\end{align*}
\]
Strand Pattern Checks

CheckPattern\textsubscript{0} = "OK"  
\textbf{check 0} - no debonded tendon in outside row

CheckPattern\textsubscript{1} = "OK"  
\textbf{check 1} - less than 25% debonded tendons total  
*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)

CheckPattern\textsubscript{2} = "OK"  
\textbf{check 2} - less than 40% debonded tendons in any row

CheckPattern\textsubscript{3} = "OK"  
\textbf{check 3} - less than 40% of debonded tendons terminated at same section  (LRFD 5.11.4.3)

CheckPattern\textsubscript{4} = "OK"  
\textbf{check 4} - more than half beam depth debond length  (SDG 4.3.1)

---

Section and Strand Properties Summary

\[ A_{\text{beam}} = 533.75 \text{ in}^2 \]  
\textbf{Concrete area of beam}

\[ I_{\text{beam}} = 6501.409 \text{ in}^4 \]  
\textbf{Gross Moment of Inertia of Beam about CG}

\[ y_{\text{comp}} = -3.38 \text{ in} \]  
\textbf{Dist. from top of beam to CG of gross composite section}

\[ I_{\text{comp}} = 23001.1148 \text{ in}^4 \]  
\textbf{Gross Moment of Inertia Composite Section about CG}

\[ A_{\text{deck}} = 336.74 \text{ in}^2 \]  
\textbf{Concrete area of deck slab}

\[ A_{\text{ps}} = 2.8 \text{ in}^2 \]  
\textbf{total area of strands}

\[ d_{b, ps} = 0.6 \text{ in} \]  
\textbf{diameter of Prestressing strand}

\[ f_{py} = 243 \text{ ksi} \]  
\textbf{tendon yield strength}

\[ f_{pj} = 203 \text{ ksi} \]  
\textbf{prestress jacking stress}

\[ L_{\text{shielding}} = (0 \quad 0 \quad 0) \text{ ft} \]

\[ A_{\text{ps, row}} = (2.4 \quad 0.4 \quad 0.2) \text{ in}^2 \]

\[ d_{ps, row} = \begin{array}{cccccccccc}
0 & -9 & -9 & -9 & -9 & -9 & -9 & -9 & -9 & -9 \\
1 & -7 & -7 & -7 & -7 & -7 & -7 & -7 & -7 & -7 \\
2 & -3 & -3 & -3 & -3 & -3 & -3 & -3 & -3 & -3 \\
\end{array} \text{ in} \]

\[ \text{TotalNumberOfTendons} = 13 \]  
\textbf{StrandSize: "0.6 in low lax"}

\[ \text{NumberOfDebondedTendons} = 0 \]  
\textbf{StrandArea = 0.22 in}^2

\[ \text{NumberOfDrapedTendons} = 0 \]  
\textbf{JackingForce per strand = 43.94 kip}
Section and Strand Properties Summary

Prestress Losses Summary

\[ f_{pj} = 202.5 \text{ ksi} \]
\[ \Delta f_{pES} = 0 \text{ ksi} \]
\[ \Delta f_{pT} = -18 \text{ ksi} \]
\[ f_{pc} = 185 \text{ ksi} \]
\[ 0.8 \cdot f_{py} = 194 \text{ ksi} \]

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

\[ \max(M_{pos.Ser1}) = 307.4 \text{ kip-ft} \]
\[ \max(M_{pos.Ser3}) = 268.6 \text{ kip-ft} \]
### 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>-0.67</td>
<td>-1.5</td>
</tr>
<tr>
<td>2</td>
<td>-0.67</td>
<td>-1.31</td>
</tr>
<tr>
<td>4</td>
<td>-0.62</td>
<td>-1.36</td>
</tr>
<tr>
<td>6</td>
<td>-1.1</td>
<td>-0.94</td>
</tr>
<tr>
<td>8</td>
<td>-1.47</td>
<td>-0.18</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>-611.3</td>
<td>-99.3</td>
</tr>
<tr>
<td>Final (about composite centroid)</td>
<td>-557.5</td>
<td>-87.7</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>530.73</td>
<td>6482.56</td>
<td>-6.37</td>
</tr>
<tr>
<td>Transformed Beam (initial)</td>
<td>549.78</td>
<td>6599.43</td>
<td>-6.44</td>
</tr>
<tr>
<td>Transformed Beam</td>
<td>547.71</td>
<td>6586.97</td>
<td>-6.43</td>
</tr>
<tr>
<td>Composite</td>
<td>890.9</td>
<td>23680.64</td>
<td>-3.41</td>
</tr>
</tbody>
</table>

**ServiceMoments**

<table>
<thead>
<tr>
<th>Type</th>
<th>Value (kip*ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Release</td>
<td>57.8</td>
</tr>
<tr>
<td>Non-composite (includes bm wt.)</td>
<td>95.1</td>
</tr>
<tr>
<td>Composite</td>
<td>18.2</td>
</tr>
<tr>
<td>Distributed Live Load</td>
<td>193.6</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

- Deflection in inches

- Slope at End (deg)

- Midspan defl (in)

SlopeData =

<table>
<thead>
<tr>
<th>Stage</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>-0.0338</td>
<td>-0.1136</td>
<td>0.148</td>
<td>0.2049</td>
</tr>
<tr>
<td>&quot;30 Days&quot;</td>
<td>-0.1068</td>
<td>-0.2362</td>
<td>0.2519</td>
<td>0.2947</td>
</tr>
<tr>
<td>&quot;60 Days&quot;</td>
<td>-0.1337</td>
<td>-0.2814</td>
<td>0.2921</td>
<td>0.3355</td>
</tr>
<tr>
<td>&quot;90 Days&quot;</td>
<td>-0.1477</td>
<td>-0.3049</td>
<td>0.313</td>
<td>0.3653</td>
</tr>
<tr>
<td>&quot;120 Days&quot;</td>
<td>-0.1563</td>
<td>-0.3193</td>
<td>0.3258</td>
<td>0.3884</td>
</tr>
<tr>
<td>&quot;240 Days&quot;</td>
<td>-0.1719</td>
<td>-0.3455</td>
<td>0.3492</td>
<td>0.4467</td>
</tr>
<tr>
<td>&quot;non-comp DL&quot;</td>
<td>-0.0214</td>
<td>0.0185</td>
<td>-0.0953</td>
<td>-0.1731</td>
</tr>
<tr>
<td>&quot;comp DL&quot;</td>
<td>-0.0014</td>
<td>0.0035</td>
<td>-0.0116</td>
<td>-0.021</td>
</tr>
<tr>
<td>&quot;LL&quot;</td>
<td>-0.0132</td>
<td>0.0332</td>
<td>-0.1109</td>
<td>-0.1998</td>
</tr>
</tbody>
</table>
**Strength Limit State Moments**

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

kip ft

\[
M_{\text{cr}}\text{ mn}
\]

kip ft

\[
M_{\text{pos.Str1 mn}}
\]

kip ft

\[
M_{\text{pos.Str2 mn}}
\]

kip ft

\[
M_{\text{reqd mn}}
\]

kip ft

\[
\text{Location mn ft}
\]

CRStr.momn := 10

\[
\text{CRStr.mom} := \frac{\phi_{\text{mom}}\left(M_{\text{mn}}\right)_0}{M_{\text{reqd mn}}}
\]

\[\text{LRFD 5.7.3.3.2}\]

\[
\text{min} (\text{CRStr.mom}) = 1.2
\]

\[
\text{CheckMomentCapacity} := \text{if} (\text{min} (\text{CRStr.mom}) > 0.99, \text{"OK"}, \text{"No Good!"})
\]

CheckMomentCapacity = "OK"

FSB only - Design Check of Transverse reinforcing Bars E

Shear Analysis

**Strength Shear and Associated Moments**

\[
\text{Str. V(kip) & Corresp. M(kip-ft)}
\]

kip

\[
V_{\text{u.Str}}\text{n}
\]

kip ft

\[
M_{\text{shr,u.Str}}\text{n}
\]

kip ft

\[
\text{Location n ft}
\]

max\(V_{\text{u.Str}}\) = 105.9 kip

max\(M_{\text{shr,u.Str}}\) = 460.7 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>18</td>
<td>1</td>
<td>0.8 in²</td>
</tr>
<tr>
<td>A2 stirrup</td>
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<td>0.8 in²</td>
</tr>
<tr>
<td>A3 stirrup</td>
<td>18</td>
<td>1</td>
<td>0.8 in²</td>
</tr>
<tr>
<td>S1 stirrup</td>
<td>18</td>
<td>1</td>
<td>0.8 in²</td>
</tr>
<tr>
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<td>18</td>
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<tr>
<td>S3 stirrup</td>
<td>18</td>
<td>1</td>
<td>0.8 in²</td>
</tr>
<tr>
<td>S4 stirrup</td>
<td>18</td>
<td>1</td>
<td>0.8 in²</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.

<table>
<thead>
<tr>
<th>user_s_nspacings</th>
<th>user_NumberSpaces_nspacings</th>
<th>user_Astirrup_nspacings</th>
<th>interface_factor_nspacings</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1 in</td>
<td>-1</td>
<td>-1 in²</td>
<td>0.25</td>
</tr>
<tr>
<td>-1 in</td>
<td>-1</td>
<td>-1 in²</td>
<td>0.5</td>
</tr>
<tr>
<td>-1 in</td>
<td>-1</td>
<td>-1 in²</td>
<td>1</td>
</tr>
<tr>
<td>-1 in</td>
<td>-1</td>
<td>-1 in²</td>
<td>1</td>
</tr>
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<td>-1 in²</td>
<td>1</td>
</tr>
<tr>
<td>-1 in</td>
<td>-1</td>
<td>-1 in²</td>
<td>1</td>
</tr>
</tbody>
</table>

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.

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</tr>
<tr>
<td>S3 stirrup</td>
<td>18</td>
<td>1</td>
<td>0.8 in²</td>
</tr>
<tr>
<td>S4 stirrup</td>
<td>18</td>
<td>1</td>
<td>0.8 in²</td>
</tr>
</tbody>
</table>

EndCover = 6.5 in
Computation for Checks

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

Longitudinal Reinforcement

\[
CR_{\text{LongSteel}} := \begin{cases} 
V_{\text{long,reqd}} & \text{if } V_{\text{long,reqd}} < 0.01 \text{kip}, \frac{V_{\text{long,prov}}}{100}, \\
\min(CR_{\text{LongSteel}}) = 1.44 & \text{if } \min(CR_{\text{LongSteel}}) > 1, \text{"OK"}, \text{"No Good, add steel!"}
\end{cases}
\]

CheckLongSteel := if \(\min(CR_{\text{LongSteel}}) > 1, \text{"OK"}, \text{"No Good, add steel!"}\)

Interface Shear Reinforcement

\[
A_{\text{v,reqd,interface}} := \begin{cases} 
A_{\text{v,prov,interface}} & \text{if } \frac{A_{\text{v,prov,interface}}}{\text{in}^2} \leq 0.4, \\
0.4 & \text{if } \frac{A_{\text{v,prov,interface}}}{\text{in}^2} > 0.4
\end{cases}
\]
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.

$$\max(A_{vf, min}) = 0 \text{ in}^2 \text{ft}^{-2}$$

$$\max(A_{vf, des}) = 0 \text{ in}^2 \text{ft}^{-2}$$

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)

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**

check_0 := AcceptAASHTO = "OK"

check_2 := AcceptOntario = "N.A."

check_4 := Check_f_pe = "OK"

check_6 := Check_f_comp.rel = "OK"

check_8 := Check_f_comp.stage8.c1 = "OK"

check_10 := Check_f_comp.Fatigue = "OK"

check_12 := CheckMaxCapacity = "OK"

check_14 := CheckShearCapacity = "OK"

check_16 := CheckMaxStirSpacing = "OK"

check_18 := CheckInterfaceSpacing = "OK"

check_20 := CheckMaxPrestressingForce = "OK"

check_22 := CheckPattern_1 = "OK"

check_24 := CheckPattern_3 = "OK"

check_26 := CheckInterfaceSteel = "OK"

check_1 := AcceptSDG = "N.A."

check_3 := Check_f_pt = "OK"

check_5 := Check_f_tension.rel = "OK"

check_7 := Check_f_tension.stage8 = "OK"

check_9 := Check_f_comp.stage8.c2 = "OK"

check_11 := CheckMomentCapacity = "OK"

check_13 := CheckStirArea = "OK"

check_15 := CheckMinStirArea = "OK"

check_17 := CheckLongSteel = "OK"

check_19 := CheckSplittingSteel = "N.A."

check_21 := CheckPattern_0 = "OK"

check_23 := CheckPattern_2 = "OK"

check_25 := CheckPattern_4 = "OK"

check_27 := CheckStrandFit = "OK"
check28 := Check_SDG1.2.Display2 = "OK" 

TotalCheck = "OK"

**LRFR Load Rating Analysis**

*FDOT Maintenance Office Bridge Load Rating Manual*

**Load Rating Computations**

Moment (Strength) or Stress (Service)  Shear (Strength)

\[
\begin{array}{ccccccc}
\text{"Limit State"} & \text{"DF"} & \text{"Rating"} & \text{"Tons"} & \text{"Dim(ft)"} & \text{"DF"} & \text{"Rating"} & \text{"Tons"} & \text{"Dim(ft)"} \\
\text{"Strength I(Inv)"} & 0.42 & 1.78 & \text{"N/A"} & 13.32 & 0.66 & 4.30 & \text{"N/A"} & 1.39 & \text{HL-93} \\
\text{"Strength I(Op)"} & 0.42 & 2.31 & \text{"N/A"} & 13.32 & 0.66 & 5.58 & \text{"N/A"} & 1.39 & \text{HL-93} \\
\text{"Service III(Inv)"} & 0.42 & 1.68 & \text{"N/A"} & 13.32 & \text{"N/A"} & \text{"N/A"} & \text{"N/A"} & \text{"N/A"} & \text{HL-93} \\
\text{"Service III(Op)"} & 0.42 & 2.29 & \text{"N/A"} & 13.32 & \text{"N/A"} & \text{"N/A"} & \text{"N/A"} & \text{"N/A"} & \text{HL-93} \\
\text{"Strength II"} & 0.42 & 1.96 & 117.54 & 10.54 & 0.66 & 3.78 & 226.82 & 1.39 & \text{*Permit} \\
\end{array}
\]

*note: default permit load is FL120 per input worksheet*

**Longitudinal Steel Check:**

\[
\text{CR}_{\text{LongSteel.HL93}} = 1.51 \quad \text{CR}_{\text{LongSteel.Permit}} = 1.36 \quad \text{CheckLongSteel.loadrating} = "OK"
\]

**Write Data Out**

8/2/2016 MainProgram.xmcd v5.0 20
LRFD Prestressed Beam Program

Project = "D30024 30 FT, LR Int. Bm."
DesignedBy = "JRM"
Date = "7-25-2016"

filename = "C:\FDOT Structures\Programs\LRFDPBeamV5.0\FSB Data Files\D30024 30 FT LR Int. Bm.dat"
Comment = "FSB12x53 30 ft span"

Legend

- TanHighlight = DataEntry
- YellowHighlight = CheckValues
- GreyHighlight = UserComments + Graphs
- BlackText = ProgramEquations
- Maroon Text = Code Reference
- Blue Text = Commentary

Bridge Layout and Dimensions

L_{beam} = 28.83\text{-ft} \quad \text{Span} = 27.75\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  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} = 0.25-in  
de = 0.87 ft

BeamPosition = "interior"  
For calculating distribution factors must be either interior or exterior

b_c = 4.47 ft  effective slab width  LRFD 4.6.2.6

t_{slab} := if(t_{slab} \leq 0\text{-in}, 0.00001\text{-in}, t_{slab})  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  \( f_{c,slab} = 4.5\text{-ksi} \)

strength of beam concrete  \( f_{c,beam} = 8.5\text{-ksi} \)

release beam strength  \( f_{ci,beam} = 6\text{-ksi} \)

type of course aggregate, "Florida" or "Standard"  AggregateType = "Florida"  relative humidity \( H = 75 \)

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

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  \( n_p := \frac{E_p}{E_c} \)

7/25/2016  MainProgram.xmcd v5.0  2
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: \( n_{mi} := \frac{E_s}{E_{ci}} \) \( n_{mi} = 6.42 \)
- 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.: \( A_{slab.rebar} = 0.31 \text{ in}^2 \text{ per ft} \)
- Area of mild reinf lumped at centroid of bar locations: \( A_{s.long} = 0 \text{ in}^2 \)
- 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

- Permit Axles: \( \text{PermitAxles} = 3 \)

Indexes used to identify values in the P and d vectors

- \( q := 0 \cdot (\text{PermitAxles} - 1) \)
- \( q_t := 0 \cdot \text{PermitAxles} \)

Permit Axle Load: \( \text{PermitAxleLoad}^T = (13.33 \ 53.33 \ 53.33) \text{ kip} \)

Permit Axle Spacing: \( \text{PermitAxleSpacing}^T = (0 \ 14 \ 14 \ 0) \text{ ft} \)

Distribution Factors

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

Calculated values:
- \( \text{tmp\_g\_mom} = 0.39 \)
- \( \text{tmp\_g\_shear} = 0.56 \)
- \( \text{tmp\_g\_mom\_fatigue} = 0.26 \)

User value overrides (optional):
- \( \text{user\_g\_mom} := 0 \)
- \( \text{user\_g\_shear} := 0 \)
- \( \text{user\_g\_mom\_fatigue} := 0 \)

Value check:
- \( g_{mom} := \text{if} (\text{user\_g\_mom} \neq 0, \text{user\_g\_mom} \cdot \text{tmp\_g\_mom}) \) \( g_{mom} = 0.39 \)
- \( g_{shear} := \text{if} (\text{user\_g\_shear} \neq 0, \text{user\_g\_shear} \cdot \text{tmp\_g\_shear}) \) \( g_{shear} = 0.56 \)
- \( g_{mom\_fatigue} := \text{if} (\text{user\_g\_mom\_fatigue} \neq 0, \text{user\_g\_mom\_fatigue} \cdot \text{tmp\_g\_mom\_fatigue}) \) \( g_{mom\_fatigue} = 0.26 \)
Section Views

Beam Section

Beam Type 1

Beam Type 0

Total Slab, Effective Slab, and Beam

slab
effective slab
beam
Non-Composite Dead Load Input:

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

\[ \text{Add}_{\text{w}}_{\text{noncomp}} := 0 \, \text{kip/ft} \]

additional non composite dead load (positive or negative)

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

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

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

\[ w_{\text{noncomposite}} := w_{\text{slab}} + w_{\text{forms}} + \text{Add}_{\text{w}}_{\text{noncomp}} \]

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

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

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

\[ \text{IntDiaphragmB} := 0 \, \text{kip} \quad \text{DistB} := 0 \, \text{ft} \]

input load is per beam

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

\[ \text{IntDiaphragmC} := 0 \, \text{kip} \quad \text{DistC} := 0 \, \text{ft} \]

\[ \text{IntDiaphragmD} := 0 \, \text{kip} \quad \text{DistD} := 0 \, \text{ft} \]

Composite Dead Load Input:

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

\[ \text{Add}_{\text{w}}_{\text{comp}} := 0 \, \text{kip/ft} \]

additional composite dead load (positive or negative)

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

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

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

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

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

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

\[ \text{max}(M_{\text{release}}) = 57.8 \text{kip-ft} \]
\[ \text{max}(V_{\text{release}}) = 8 \text{kip} \]

**Noncomposite Dead Load Moments and Shear**

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

\[ \text{max}(M_{\text{dl.non.comp}}) = 96.3 \text{kip-ft} \]
\[ \text{max}(V_{\text{dl.non.comp}}) = 13.9 \text{kip} \]
Composite Dead Load Moments and Shear

\[ \text{max}(M_{\text{dl.comp}}) = 20.2 \text{kip-ft} \]
\[ \text{max}(V_{\text{dl.comp}}) = 2.9 \text{kip} \]

Distributed Live Load Moments and Shear

\[ \text{max}(M_{\text{dist.live.pos}}) = 180.8 \text{kip-ft} \]
\[ \text{min}(M_{\text{dist.live.neg}}) = -9.1 \text{kip-ft} \]
\[ \text{max}(V_{\text{dist.live.pos}}) = 40.8 \text{kip} \]
\[ \text{max}(M_{\text{shr.dist.live.pos}}) = 169.5 \text{kip-ft} \]
\[ \text{Reaction}_{\text{LL}} = 42 \text{kip} \]
\[ \text{Reaction}_{\text{DL}} = 17.45 \text{kip} \]
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

Recalculate Worksheet  Read Strand Data

Collapsed Region for Custom Strand Sizes...

Tendon Layout

SupportLocation_{release} = 0\cdot\text{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")

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

\[
\text{PartialPS}_{\text{force}} := \text{if} \{ \text{BeamTypeTog} = "II", 20 \text{-kip}, \text{PartialPS}_{\text{force}} \} \quad \text{PartialPS}_{\text{force}} = 40 \text{-kip}
\]

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

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

Section Properties & Strand Profile Properties

Release Stresses

Release Stresses (ksi) Top, Bot., & Allow.

- \( f_{\text{top.beam.rel}}_n \)
- \( f_{\text{bot.beam.rel}}_n \)
- \( f_{\text{fall.tension.rel}}_n \)
- \( f_{\text{fall.comp.rel}}_n \)

Location \( \text{n} \) ft

7/25/2016 MainProgram.xmcd v5.0
**Final Stresses**

**Stress Checks**

\[
\begin{align*}
\min(CR_{f,tension.rel}) &= 10 & \text{Check}_{f,tension.rel} &= \text{"OK"} & \text{(Release tension)} \\
\min(CR_{f,comp.rel}) &= 1.93 & \text{Check}_{f,comp.rel} &= \text{"OK"} & \text{(Release compression)} \\
\min(CR_{f,tension.stage8}) &= 10 & \text{Check}_{f,tension.stage8} &= \text{"OK"} & \text{(Service III, PS + DL + LL*0.8)} \\
\min(CR_{f,comp.stage8,c1}) &= 3.32 & \text{Check}_{f,comp.stage8,c1} &= \text{"OK"} & \text{(Service I, PS + DL)} \\
\min(CR_{f,comp.stage8,c2}) &= 3.49 & \text{Check}_{f,comp.stage8,c2} &= \text{"OK"} & \text{(Service I, PS + DL + LL)} \\
\min(CR_{f,comp.Fatigue}) &= 4.56 & \text{Check}_{f,comp.Fatigue} &= \text{"OK"} & \text{(Fatigue I, (PS + DL)*0.5 + 1.5 Fatigue Truck)}
\end{align*}
\]
Strand Pattern Checks

CheckPattern_0 = "OK"  
**check 0 - no debonded tendon in outside row**

CheckPattern_1 = "OK"  
**check 1 - less than 25% debonded tendons total**

*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)*

CheckPattern_2 = "OK"  
**check 2 - less than 40% debonded tendons in any row**

CheckPattern_3 = "OK"  
**check 3 - less than 40% of debonded tendons terminated at same section**  (LRFD 5.11.4.3)

CheckPattern_4 = "OK"  
**check 4 - more than half beam depth debond length**  (SDG 4.3.1)

Section and Strand Properties Summary

\[ A_{\text{beam}} = 533.75 \text{ in}^2 \quad \text{Concrete area of beam} \]

\[ I_{\text{beam}} = 6501.409 \text{ in}^4 \quad \text{Gross Moment of Inertia of Beam about CG} \]

\[ y_{\text{comp}} = -3.36 \text{ in} \quad \text{Dist. from top of beam to CG of gross composite section} \]

\[ I_{\text{comp}} = 23203.5285 \text{ in}^4 \quad \text{Gross Moment of Inertia Composite Section about CG} \]

\[ A_{\text{deck}} = 345.96 \text{ in}^2 \quad \text{Concrete area of deck slab} \]

\[ A_{\text{ps}} = 2.8 \text{ in}^2 \quad \text{total area of strands} \]

\[ d_{\text{b,ps}} = 0.6 \text{ in} \quad \text{diameter of Prestressing strand} \]

\[ f_{\text{py}} = 243 \text{ ksi} \quad \text{tendon yield strength} \]

\[ f_{\text{pj}} = 203 \text{ ksi} \quad \text{prestress jacking stress} \]

\[ L_{\text{shielding}} = (0 \ 0 \ 0) \text{ ft} \]

\[ A_{\text{ps,row}} = (2.4 \ 0.4 \ 0.2) \text{ in}^2 \]

\[ d_{\text{ps,row}} = \begin{bmatrix} 0 & -9 & -9 & -9 & -9 & -9 & -9 & -9 & -9 \\ 1 & -7 & -7 & -7 & -7 & -7 & -7 & -7 & -7 \\ 2 & -3 & -3 & -3 & -3 & -3 & -3 & -3 & -3 \end{bmatrix} \text{ in} \]

TotalNumberOfTendons = 13  
NumberDebondedTendons = 0  
NumberDrapedTendons = 0  
StrandArea = 0.22 \text{ in}^2  
StrandSize = "0.6 in low lax"  
JackingForce_{per.strand} = 43.94 \text{ kip}
Section and Strand Properties Summary

Prestress Losses Summary

\( f_{pj} = 202.5 \text{ ksi} \)  
Check \( f_{pt} \) = "OK"

\( \Delta f_{pes} = 0 \text{ ksi} \)

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

\( \Delta f_{pT} = -18 \text{ ksi} \)  
\( \frac{\Delta f_{pT}}{f_{pj}} = -8.79 \% \)

\( f_{pc} = 185 \text{ ksi} \)  
\( \frac{f_{pc}}{f_{pj}} = 91.21 \% \)

\( 0.8 \cdot f_{py} = 194 \text{ ksi} \)  
Check \( f_{pc} \) = "OK"

Service Limit State Moments

\( \max(M_{\text{pos.Ser1}_n}) = 297.1 \text{ kip-ft} \)  
\( \max(M_{\text{pos.Ser3}_n}) = 260.9 \text{ kip-ft} \)
Calculation of Summary Values at Midspan & Stress Comparison with Different Methods

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>-0.67</td>
<td>-1.5</td>
</tr>
<tr>
<td>2</td>
<td>-0.67</td>
<td>-1.31</td>
</tr>
<tr>
<td>4</td>
<td>-0.62</td>
<td>-1.36</td>
</tr>
<tr>
<td>6</td>
<td>-1.12</td>
<td>-0.92</td>
</tr>
<tr>
<td>8</td>
<td>-1.46</td>
<td>-0.21</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>-611.3</td>
<td>-99.3</td>
</tr>
<tr>
<td>Final (about composite centroid)</td>
<td>-557.5</td>
<td>-87.7</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>530.73</td>
<td>6482.56</td>
<td>-6.37</td>
</tr>
<tr>
<td>Transformed Beam (initial)</td>
<td>549.78</td>
<td>6599.43</td>
<td>-6.44</td>
</tr>
<tr>
<td>Transformed Beam</td>
<td>547.71</td>
<td>6586.97</td>
<td>-6.43</td>
</tr>
<tr>
<td>Composite</td>
<td>900.22</td>
<td>23888.97</td>
<td>-3.38</td>
</tr>
</tbody>
</table>

ServiceMoments =

<table>
<thead>
<tr>
<th>Type</th>
<th>Value (kip*ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Release</td>
<td>57.8</td>
</tr>
<tr>
<td>Non-composite (includes bm wt.)</td>
<td>96.3</td>
</tr>
<tr>
<td>Composite</td>
<td>20.2</td>
</tr>
<tr>
<td>Distributed Live Load</td>
<td>180.1</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 @ Release, Short Term Camber, & Summary of Slope Data

\[
\begin{align*}
\text{SlopeData} &= \\
&= \begin{pmatrix}
\text{"Stage"} & \text{"Change in L @ Top (in)"} & \text{"Change in L @ Bot. (in)"} & \text{"Slope at End (deg)"} & \text{"midspan defl (in)"} \\
\text{"Release"} & -0.0338 & -0.1136 & 0.148 & 0.2049 \\
\text{"30 Days"} & -0.1068 & -0.2362 & 0.2519 & 0.2947 \\
\text{"60 Days"} & -0.1337 & -0.2814 & 0.2921 & 0.3355 \\
\text{"90 Days"} & -0.1477 & -0.3049 & 0.313 & 0.3653 \\
\text{"120 Days"} & -0.1563 & -0.3193 & 0.3258 & 0.3884 \\
\text{"240 Days"} & -0.1719 & -0.3455 & 0.3492 & 0.4467 \\
\text{"non-comp DL"} & -0.022 & 0.0191 & -0.0982 & -0.1782 \\
\text{"comp DL"} & -0.0015 & 0.0038 & -0.0127 & -0.0231 \\
\text{"LL"} & -0.0121 & 0.0307 & -0.1023 & -0.1843
\end{pmatrix}
\end{align*}
\]
**Strength Limit State Moments**

Nominal and Ultimate Moment Strength (kip-ft)

\[ \phi_{mom_{mn}} \left( M_{mn} \right)_0 \]

- \( M_{cr_{mn}} \) kip-ft
- \( M_{pos.Str1_{mn}} \) kip-ft
- \( M_{pos.Str2_{mn}} \) kip-ft
- \( M_{reqd_{mn}} \) kip-ft

\[ CR_{Str.mom_{n}} := 10 \]

\[ CR_{Str.mom_{n}} := \frac{\phi_{mom_{mn}} \left( M_{mn} \right)_0}{M_{reqd_{mn}}} \] (LRFD 5.7.3.3.2)

\[ \min(CR_{Str.mom}) = 1.22 \]

\[ \max(M_{reqd}) = 616.2 \text{-kip-ft} \]

CheckMomentCapacity := if(\( \min(CR_{Str.mom}) > 0.99 \), "OK", "No Good!")

CheckMomentCapacity = "OK"

**Shear Analysis**

**Strength Shear and Associated Moments**

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

- \( V_{u.Str_{n}} \) kip
- \( M_{shr.u.Str_{n}} \) kip-ft

\[ \max(V_{u.Str}) = 94.1 \text{-kip} \]

\[ \max(M_{shr.u.Str}) = 443.0 \text{-kip-ft} \]
**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>18</td>
<td>1</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</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.

**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.

<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>18</td>
<td>1</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</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>3.25</td>
<td>(0.8)</td>
</tr>
</tbody>
</table>

EndCover = 6.5-in
Computation for Checks

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

Longitudinal Reinforcement

\[ CR_{\text{LongSteel}} := \begin{cases} V_{\text{long,reqd}} < 0.01 \text{kip} \cdot 100 \cdot \frac{V_{\text{long,prov}}}{V_{\text{long,reqd}}} \\ \min(CR_{\text{LongSteel}}) = 1.57 \end{cases} \]

CheckLongSteel := if(\(\min(CR_{\text{LongSteel}}) > 1\), "OK", "No Good, add steel!"
\)

interface shear reinforcement

\[ CR_{\text{interface}} := \begin{cases} A_{\text{v,reqd}} < 0.2 \text{in}^2 / \text{ft} \\ \min(CR_{\text{interface}}) = 1.57 \end{cases} \]

CheckInterface := if(\(\min(CR_{\text{interface}}) > 1\), "OK", "No Good, add steel!"
\)
Typically shear steel is extended up into the deck slab. These calculations are based on shear steel functioning as interface reinforcing. The \textit{interface factor} can be used to adjust this assumption.

\[
\max(A_{vf,\text{min}}) = 0 \text{ in}^2 \text{ ft}^{-1} \quad \max(A_{vf,\text{des}}) = 0 \text{ in}^2 \text{ ft}^{-1}
\]

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

\[
\text{CheckInterfaceSpacing = "OK"}
\]

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

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

\text{CheckInterfaceSteel = "OK"}

\textbf{Anchorage Reinforcement and Maximum Prestressing Force}

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

\[
\text{StandardSplittingReinforcing := yes}
\]

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

\text{CheckSplittingSteel = "N.A."}

\text{CheckMaxPrestressingForce = "OK"}

\textbf{Summary of Design Checks}

\begin{align*}
\text{check}_0 & := \text{AcceptAASHTO} = "\text{OK}" \\
\text{check}_1 & := \text{AcceptSDG} = "\text{N.A.}" \\
\text{check}_2 & := \text{AcceptOntario} = "\text{N.A.}" \\
\text{check}_3 & := \text{Check}_{f_{\text{pc}}} = "\text{OK}" \\
\text{check}_4 & := \text{Check}_{f_{\text{comp,rel}}} = "\text{OK}" \\
\text{check}_5 & := \text{Check}_{f_{\text{comp,stage8,c1}}} = "\text{OK}" \\
\text{check}_6 & := \text{Check}_{f_{\text{comp,Fatigue}}} = "\text{OK}" \\
\text{check}_7 & := \text{CheckMaxCapacity} = "\text{OK}" \\
\text{check}_8 & := \text{CheckShearCapacity} = "\text{OK}" \\
\text{check}_9 & := \text{CheckMaxStirSpacing} = "\text{OK}" \\
\text{check}_{10} & := \text{CheckInterfaceSpacing} = "\text{OK}" \\
\text{check}_{11} & := \text{CheckMaxPrestressingForce} = "\text{OK}" \\
\text{check}_{12} & := \text{CheckPattern}_{0} = "\text{OK}" \\
\text{check}_{13} & := \text{CheckPattern}_{1} = "\text{OK}" \\
\text{check}_{14} & := \text{CheckPattern}_{2} = "\text{OK}" \\
\text{check}_{15} & := \text{CheckPattern}_{3} = "\text{OK}" \\
\text{check}_{16} & := \text{CheckPattern}_{4} = "\text{OK}" \\
\text{check}_{17} & := \text{CheckPattern}_{5} = "\text{OK}" \\
\text{check}_{18} & := \text{CheckPattern}_{6} = "\text{OK}" \\
\text{check}_{19} & := \text{CheckPattern}_{7} = "\text{OK}" \\
\text{check}_{20} & := \text{CheckPattern}_{8} = "\text{OK}" \\
\text{check}_{21} & := \text{CheckPattern}_{9} = "\text{OK}" \\
\text{check}_{22} & := \text{CheckPattern}_{10} = "\text{OK}" \\
\text{check}_{23} & := \text{CheckPattern}_{11} = "\text{OK}" \\
\text{check}_{24} & := \text{CheckPattern}_{12} = "\text{OK}" \\
\text{check}_{25} & := \text{CheckPattern}_{13} = "\text{OK}" \\
\text{check}_{26} & := \text{CheckPattern}_{14} = "\text{OK}" \\
\text{check}_{27} & := \text{CheckPattern}_{15} = "\text{OK}" \\
\end{align*}
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; &quot;Rating&quot; &quot;Tons&quot; &quot;Dim(ft)&quot; &quot;DF&quot; &quot;Rating&quot; &quot;Tons&quot; &quot;Dim(ft)&quot;</td>
</tr>
<tr>
<td>&quot;Strength I(Inv)&quot;</td>
<td>0.39 1.91 &quot;N/A&quot; 13.32 0.56 5.02 &quot;N/A&quot; 1.39</td>
</tr>
<tr>
<td>&quot;Strength I(Op)&quot;</td>
<td>0.39 2.47 &quot;N/A&quot; 13.32 0.56 6.51 &quot;N/A&quot; 1.39</td>
</tr>
<tr>
<td>&quot;Service III(Inv)&quot;</td>
<td>0.39 1.78 &quot;N/A&quot; 13.32 &quot;N/A&quot; &quot;N/A&quot; &quot;N/A&quot; 1.39</td>
</tr>
<tr>
<td>&quot;Service III(Op)&quot;</td>
<td>0.39 2.44 &quot;N/A&quot; 13.32 &quot;N/A&quot; &quot;N/A&quot; &quot;N/A&quot; 1.39</td>
</tr>
<tr>
<td>&quot;Strength II&quot;</td>
<td>0.39 2.10 125.86 10.54 0.56 4.42 264.98 1.39</td>
</tr>
</tbody>
</table>

LRFRloadrating = [HL-93 HL-93 HL-93] *Permit

*note: default permit load is FL120 per input worksheet

Longitudinal Steel Check:

CR_{LongSteel.HL93} = 1.58
CR_{LongSteel.Permit} = 1.57

CheckLongSteelloadrating = "OK"

Write Data Out