LOAD RATING CALCULATIONS

DEVELOPMENTAL DESIGN STANDARDS

FSB SUPERSTRUCTURE PACKAGE

15 FT. CLEAR WIDTH

D30015 - 30 Ft. Span
<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>
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</thead>
<tbody>
<tr>
<td>Design Operating</td>
<td>HL-93</td>
<td>36</td>
<td>2.42</td>
<td>5.55</td>
<td>N/A</td>
<td>2.80</td>
<td>7.18</td>
<td>N/A</td>
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<td>Design Inventory</td>
<td>HL-93</td>
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<td>1.87</td>
<td>4.28</td>
<td>1.74</td>
<td>2.16</td>
<td>5.54</td>
<td>2.00</td>
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<tr>
<td>Permit</td>
<td>FL-120</td>
<td>60</td>
<td>2.05</td>
<td>3.76</td>
<td>N/A</td>
<td>2.38</td>
<td>4.88</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Developmental Design Standards - FSB Superstructure Package
LRFD Prestressed Beam Program

Project = "D30015 30 FT, LR Ext. Bm."
DesignedBy = "VAY"
Date = "7-25-2016"

filename = "C:\FDOT Structures\Programs\LRFDBeamV5.0\FSB Data Files\D30015 30 FT LR.dat"
Comment = "FSB12x52 30 ft span"

Legend

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

Bridge Layout and Dimensions

![Bridge Layout Diagram]

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 = "FSB12x52"

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_{\text{integral.ws}} = 0-in  
n_{\text{building}} = 0-in  

NumberofBeams = 4  
t_{\text{slab}} = 6-in  
t_{\text{slab.delta}} = 0.22-in  
de = 0.83-ft

BeamPosition = "exterior"  

For calculating distribution factors must be either interior or exterior

\( b_c = 4.36\text{ft} \)  

effective slab width  
LRFD 4.6.2.6

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

Material Properties

Concrete:

Corrosion Classification  
Environment = "extremely"  
density of slab concrete \( \gamma_{\text{slab}} = 0.15\frac{\text{kip}}{\text{ft}^3} \)

strength of slab concrete \( f_{c,\text{slab}} = 4.5\text{-ksi} \)

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

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

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

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

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

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

\( E_c := \text{AggFactor} \cdot \left(\frac{f_{c,\text{beam}}}{\text{ksi}}\right)^{0.33} \)  
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**: \( n_{m_i} := \frac{E_s}{E_{ci}} \), \( n_{m_i} = 6.42 \)
- **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 Reinforcement**: \( A_{slab.rebar} = 0.31 \text{ in}^2 \text{/ ft} \)
- **Area of Mild Reinforcement Lumped at Centroid of Bar Locations**: \( A_{s.long} = 0 \text{ in}^2 \)
- **Distance from Top of Slab to Centroid of Slab Reinforcement**: \( d_{slab.rebar} = 2.5 \text{ in} \)
- **Distance from Top of Beam to Centroid of Mild Flexural Tension Reinforcement**: \( d_{long} = 0 \text{ in} \)
- **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**

- **Permit Axles**: 3

Indexes used to identify values in the P and d vectors

- **q**: 0 .. (PermitAxles - 1)
- **qt**: 0 .. PermitAxles

**Permit Axle Load** \( T = ( 13.33 \ 53.33 \ 53.33 ) \text{-kip} \)

**Permit Axle Spacing** \( T = ( 0 \ 14 \ 14 \ 0 ) \text{-ft} \)

Distribution Factors

DataMessage = "This is a FSB12x52 Florida Slab Beam design, AASHTO distribution factors used"

**Calculated Values**

- \( \text{tmp}_g_{mom} = 0.45 \)
- \( \text{tmp}_g_{shear} = 0.65 \)
- \( \text{tmp}_g_{mom.fatigue} = 0.32 \)

**User Value Overrides (Optional)**

- \( \text{user}_g_{mom} := 0.40 \)
- \( \text{user}_g_{shear} := 0 \)
- \( \text{user}_g_{mom.fatigue} := 0 \)

**Value Check**

- \( g_{mom} := \text{if}( \text{user}_g_{mom} \neq 0 , \text{user}_g_{mom} \cdot \text{tmp}_g_{mom} ) \)
- \( g_{shear} := \text{if}( \text{user}_g_{shear} \neq 0 , \text{user}_g_{shear} \cdot \text{tmp}_g_{shear} ) \)
- \( g_{mom.fatigue} := \text{if}( \text{user}_g_{mom.fatigue} \neq 0 , \text{user}_g_{mom.fatigue} \cdot \text{tmp}_g_{mom.fatigue} ) \)
Section Views

**Beam Section**

- BeamType \((1)\) ft
- BeamType \((0)\) ft

**Total Slab, Effective Slab, and Beam**

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

\[ w_{\text{slab}} = 0.434 \text{ kip/ft} \quad w_{\text{beam}} = 0.543 \text{ kip/ft} \quad w_{\text{forms}} = 0 \text{ kip/ft} \]

\[ \text{Add}_w_{\text{noncomp}} := 0.0 \text{ kip/ft} \quad \text{additional non composite dead load (positive or negative)} \]

\[ \text{note: not saved to data file, may be saved to Mathcad worksheet.} \]

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

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

**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*

\[ \text{EndDiaphragm}A := 0 \text{ kip} \quad \text{begin bridge} \]

\[ \text{IntDiaphragm}B := 0 \text{ kip} \]

\[ \text{Dist}B := 0 \text{ ft} \]

\[ \text{Longitudinal Distance B, C, & D - Measured from CL Bearing at begin bridge} \]

\[ \text{EndDiaphragm}E := 0 \text{ kip} \quad \text{end bridge} \]

\[ \text{IntDiaphragm}C := 0 \text{ kip} \]

\[ \text{Dist}C := 0 \text{ ft} \]

\[ \text{IntDiaphragm}D := 0 \text{ kip} \]

\[ \text{Dist}D := 0 \text{ ft} \]

**Composite Dead Load Input:**

\[ w_{\text{future.ws}} = 0.045 \text{ kip/ft} \quad w_{\text{barrier}} = 0.215 \text{ kip/ft} \]

\[ \text{Add}_w_{\text{comp}} := 0.0 \text{ kip/ft} \quad \text{additional composite dead load (positive or negative)} \]

\[ \text{note: not saved to data file, may be saved to Mathcad worksheet} \]

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

\[ w_{\text{comp.str}} := w_{\text{barrier}} + \text{Add}_w_{\text{comp}} \]
**Release Dead Load Moments and Shear**

\[
\begin{align*}
\text{max}(M_{\text{release}}) &= 56.5\text{-kip-ft} \\
\text{max}(V_{\text{release}}) &= 7.8\text{-kip}
\end{align*}
\]

**Noncomposite Dead Load Moments and Shear**

\[
\begin{align*}
\text{max}(M_{\text{dl.non.comp}}) &= 94\text{-kip-ft} \\
\text{max}(V_{\text{dl.non.comp}}) &= 13.6\text{-kip}
\end{align*}
\]
### Composite Dead Load Moments and Shear

- **Max M\(_{dl, comp}\)** = 24.9 kip-ft
- **Max V\(_{dl, comp}\)** = 3.6 kip

### Distributed Live Load Moments and Shear

- **Max M\(_{dist, live, pos}\)** = 183.3 kip-ft
- **Min M\(_{dist, live, neg}\)** = -9.3 kip-ft
- **Max V\(_{dist, live, pos}\)** = 46.9 kip
- **Max M\(_{shrdist, live, pos}\)** = 171.9 kip-ft
- **Max M\(_{shrdist, live, neg}\)** = -17.8 kip-ft
- **Reaction\(_{LL}\)** = 48.29 kip
- **Reaction\(_{DL}\)** = 17.83 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 :=
StrandMultiplier

Collapsed Region for Custom Strand Sizes...

Strand Multiplier
Strand Data and Pattern
Strand Properties

Tendon Layout

SupportLocation_{release} \equiv 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")

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

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

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

\[ \text{PartialPS}_\text{location} = \frac{2.4375 \text{-in}}{ \text{BeamTypeTog} = "\text{II}"} \]

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

\[ \text{PartialPS}_\text{location} = \frac{2 \text{-in}}{\text{if} \text{ substr(BeanTypeTog,0,5)} = "\text{FSB15}\text{"}\text{ otherwise} } \]

\[ \text{PartialPS}_\text{location} = \frac{3 \text{-in}}{\text{if} \text{ substr(BeanTypeTog,0,5)} = "\text{FSB18}\text{"}\text{ otherwise} } \]

Section Properties & Strand Profile Properties

Release Stresses

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

\[ f_{\text{top.beam.reln}} \]

\[ f_{\text{bot.beam.reln}} \]

\[ f_{\text{fall.tension.reln}} \]

\[ f_{\text{fall.comp.reln}} \]

Location (ft)

Prestress Force

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

<table>
<thead>
<tr>
<th>Location (ft)</th>
<th>ft</th>
<th></th>
<th></th>
<th>7.207</th>
<th>14.415</th>
<th>21.622</th>
<th>28.83</th>
</tr>
</thead>
<tbody>
<tr>
<td>f_{top.beam.stage8.c1_n}</td>
<td>ksi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f_{top_slab.stage8.c2_n}</td>
<td>ksi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f_{top.beam.stage8.c2_n}</td>
<td>ksi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f_{bot.beam.stage8.c2_n}</td>
<td>ksi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f_{top.beam.FatigueI}</td>
<td>ksi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f_{fall.comp.case1_n}</td>
<td>ksi</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>f_{fall.comp.case2_n}</td>
<td>ksi</td>
<td></td>
<td></td>
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<tr>
<td>f_{fall.comp.FatigueI}</td>
<td>ksi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f_{fall.tension}</td>
<td>ksi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Stress Checks

- \( \min(\text{CR}_{\text{f_tension.rel}}) = 10 \) \( \Rightarrow \) Check_{f_tension.rel} = "OK" (Release tension)
- \( \min(\text{CR}_{\text{f_comp.rel}}) = 1.89 \) \( \Rightarrow \) Check_{f_comp.rel} = "OK" (Release compression)
- \( \min(\text{CR}_{\text{f_tension.stage8}}) = 10 \) \( \Rightarrow \) Check_{f_tension.stage8} = "OK" (Service III, PS + DL + LL*0.8)
- \( \min(\text{CR}_{\text{f_comp.stage8.c1}}) = 3.28 \) \( \Rightarrow \) Check_{f_comp.stage8.c1} = "OK" (Service I, PS + DL)
- \( \min(\text{CR}_{\text{f_comp.stage8.c2}}) = 3.44 \) \( \Rightarrow \) Check_{f_comp.stage8.c2} = "OK" (Service I, PS + DL + LL)
- \( \min(\text{CR}_{\text{f_comp.FatigueI}}) = 4.26 \) \( \Rightarrow \) Check_{f_comp.FatigueI} = "OK" (Fatigue I, (PS + DL)*0.5 + 1.5 Fatigue Truck)
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_{beam} = 521.75-in^2  Concrete area of beam
I_{beam} = 6355.6223-in^4  Gross Moment of Inertia of Beam about CG
y_{comp} = -3.37-in  Dist. from top of beam to CG of gross composite section
I_{comp} = 22686.8567-in^4  Gross Moment of Inertia Composite Section about CG
A_{deck} = 337.55-in^2  Concrete area of deck slab
A_{ps} = 2.8-in^2  total area of strands
d_{b,ps} = 0.6-in  diameter of Prestressing strand
min(PrestressType) = 0  0 - low lax  1 - stress relieved
f_{py} = 243-ksi  tendon yield strength
f_{pj} = 203-ksi  prestress jacking stress

L_{shielding}^T = (0  0  0) \cdot \text{ft}

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

d_{ps,row} =

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<td>-9</td>
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<td>-9</td>
<td>-9</td>
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</tr>
<tr>
<td>1</td>
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<td></td>
</tr>
<tr>
<td>2</td>
<td>-3</td>
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<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td></td>
</tr>
</tbody>
</table>

TotalNumberOfTendons = 13  StrandSize = "0.6 in low lax"
NumberOfDebondedTendons = 0  StrandArea = 0.22-in^2
NumberOfDrapedTendons = 0  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

\[ \max(M_{pos.Ser1}) = 302 \text{ kip-ft} \]
\[ \max(M_{pos.Ser3}) = 265.3 \text{ kip-ft} \]
Summary of Values at Midspan

Stresses = 
\[
\begin{pmatrix}
\text{Stages} & \text{Top of Beam (ksi)} & \text{Bott of Beam (ksi)} \\
1 & -0.67 & -1.54 \\
2 & -0.67 & -1.35 \\
4 & -0.62 & -1.39 \\
6 & -1.12 & -0.96 \\
8 & -1.48 & -0.21
\end{pmatrix}
\]

PrestressForce =  
\[
\begin{pmatrix}
\text{Conditions} & \text{Axial (kip)} & \text{Moment (kip*ft)} \\
\text{Release} & -611.3 & -98.8 \\
\text{Final (about composite centroid)} & -557 & -87.2
\end{pmatrix}
\]

Properties =  
\[
\begin{pmatrix}
\text{Sections} & \text{Area (in}^2\text{)} & \text{Inertia (in}^4\text{)} & \text{distance to centroid from top of bm (in)} \\
\text{Net Beam} & 518.73 & 6336.87 & -6.38 \\
\text{Transformed Beam (initial)} & 537.78 & 6453.08 & -6.45 \\
\text{Transformed Beam} & 535.71 & 6440.7 & -6.44 \\
\text{Composite} & 879.65 & 23364.25 & -3.4
\end{pmatrix}
\]

ServiceMoments = 
\[
\begin{pmatrix}
\text{Types} & \text{Value (kip*ft)} \\
\text{Release} & 56.5 \\
\text{Non-composite (includes bm wt.)} & 94 \\
\text{Composite} & 24.9 \\
\text{Distributed Live Load} & 182.6
\end{pmatrix}
\]

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

<table>
<thead>
<tr>
<th>Location in feet</th>
<th>Deflection in inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-0.22</td>
</tr>
<tr>
<td>7.207</td>
<td>0.2</td>
</tr>
<tr>
<td>14.415</td>
<td>0.4</td>
</tr>
<tr>
<td>21.622</td>
<td>0.6</td>
</tr>
<tr>
<td>28.83</td>
<td>0.8</td>
</tr>
</tbody>
</table>

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

SlopeData =

<table>
<thead>
<tr>
<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>-0.0341</td>
<td>-0.1164</td>
<td>0.1528</td>
<td>0.2126</td>
</tr>
<tr>
<td>&quot;30 Days&quot;</td>
<td>-0.1073</td>
<td>-0.2407</td>
<td>0.26</td>
<td>0.3064</td>
</tr>
<tr>
<td>&quot;60 Days&quot;</td>
<td>-0.1343</td>
<td>-0.2866</td>
<td>0.3014</td>
<td>0.3489</td>
</tr>
<tr>
<td>&quot;90 Days&quot;</td>
<td>-0.1483</td>
<td>-0.3105</td>
<td>0.3229</td>
<td>0.3797</td>
</tr>
<tr>
<td>&quot;120 Days&quot;</td>
<td>-0.1569</td>
<td>-0.3251</td>
<td>0.3361</td>
<td>0.4037</td>
</tr>
<tr>
<td>&quot;240 Days&quot;</td>
<td>-0.1726</td>
<td>-0.3517</td>
<td>0.3602</td>
<td>0.464</td>
</tr>
<tr>
<td>&quot;non-comp DL&quot;</td>
<td>-0.022</td>
<td>0.019</td>
<td>-0.0977</td>
<td>-0.1774</td>
</tr>
<tr>
<td>&quot;comp DL&quot;</td>
<td>-0.0019</td>
<td>0.0048</td>
<td>-0.0161</td>
<td>-0.0292</td>
</tr>
<tr>
<td>&quot;LL&quot;</td>
<td>-0.0126</td>
<td>0.0318</td>
<td>-0.106</td>
<td>-0.191</td>
</tr>
</tbody>
</table>
**Strength Limit State Moments**

![Graph showing nominal and ultimate moment strength (kip-ft)]

\[ \phi_{momn} (M_{mn})_0 \]

kip ft

\[ M_{crmn} \]
kip ft

\[ M_{pos.Str1mn} \]
kip ft

\[ M_{pos.Str2mn} \]
kip ft

\[ M_{reqdmn} \]
kip ft

\[ CRStr.momn \]

\[ CRStr.momn := 10 \]

\[ CRStr.momn := \frac{\phi_{momn} (M_{mn})_0}{M_{reqdmn}} \]

*(LRFD 5.7.3.3.2)*

\[ \min(CRStr.momn) = 1.2 \]

max(Mreqd) = 621.5 kip-ft

CheckMomentCapacity := if(\( \min(CRStr.momn) > 0.99 \), "OK", "No Good!"

CheckMomentCapacity = "OK"

**FSB only - Design Check of Transverse reinforcing Bars E**

**Shear Analysis**

**Strength Shear and Associated Moments**

![Graph showing shear and corresponding moments (kip-ft)]

\[ V_{u.Strn} \]
kip

\[ M_{shru.Strn} \]
kip-ft

\[ \max(V_{u.Str}) = 105.6 \text{-kip} \]

\[ \max(M_{shru.Str}) = 449.5 \text{-kip-ft} \]

7/25/2016 MainProgram.xmcd v5.0
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 in</td>
<td>1</td>
<td>(0.8) in²</td>
</tr>
<tr>
<td>A2 stirrup</td>
<td>18 in</td>
<td>1</td>
<td>0.8 in²</td>
</tr>
<tr>
<td>A3 stirrup</td>
<td>18 in</td>
<td>1</td>
<td>0.8 in²</td>
</tr>
<tr>
<td>S1 stirrup</td>
<td>tmp_s = 18 in</td>
<td>tmp_NumberSpaces = 1</td>
<td>0.8 in²</td>
</tr>
<tr>
<td>S2 stirrup</td>
<td>18 in</td>
<td>1</td>
<td>0.8 in²</td>
</tr>
<tr>
<td>S3 stirrup</td>
<td>18 in</td>
<td>1</td>
<td>0.8 in²</td>
</tr>
<tr>
<td>S4 stirrup</td>
<td>18 in</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>Location</th>
<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>A1 stirrup</td>
<td>-1 in</td>
<td>-1</td>
<td>-1</td>
<td>0.25</td>
</tr>
<tr>
<td>A2 stirrup</td>
<td>-1 in</td>
<td>-1</td>
<td>-1</td>
<td>0.5</td>
</tr>
<tr>
<td>A3 stirrup</td>
<td>-1 in</td>
<td>-1</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>S1 stirrup</td>
<td>-1 in</td>
<td>-1</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>S2 stirrup</td>
<td>-1 in</td>
<td>-1</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>S3 stirrup</td>
<td>-1 in</td>
<td>-1</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>S4 stirrup</td>
<td>-1 in</td>
<td>-1</td>
<td>-1</td>
<td>1</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Location</th>
<th>NumberSpaces =</th>
<th>A_stirrup =</th>
<th>EndCover = 6.5 in</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 stirrup</td>
<td>3.25</td>
<td>0.8 in²</td>
<td></td>
</tr>
<tr>
<td>A2 stirrup</td>
<td>1</td>
<td>0.8 in²</td>
<td></td>
</tr>
<tr>
<td>A3 stirrup</td>
<td>1</td>
<td>0.8 in²</td>
<td></td>
</tr>
<tr>
<td>S1 stirrup</td>
<td>1</td>
<td>0.8 in²</td>
<td></td>
</tr>
<tr>
<td>S2 stirrup</td>
<td>1</td>
<td>0.8 in²</td>
<td></td>
</tr>
<tr>
<td>S3 stirrup</td>
<td>1</td>
<td>0.8 in²</td>
<td></td>
</tr>
<tr>
<td>S4 stirrup</td>
<td>1</td>
<td>0.8 in²</td>
<td></td>
</tr>
</tbody>
</table>
Computation for Checks

CheckShearCapacity = "OK"

CheckMaxShearStress = "OK"

CheckStirArea = "OK"

CheckMinStirArea = "OK"

CheckMaxStirSpacing = "OK"

Longitudinal Reinforcement

Longitudinal Steel Required vs. Provided

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

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

Location (ft)

CR_{\text{Long Steel}} = \begin{cases} 
\frac{V_{\text{long, reqd}}}{V_{\text{long, prov}}} & \text{if } V_{\text{long, reqd}} < 0.01 \text{kip} \times 100 \\
\min(CR_{\text{Long Steel}}) & \text{otherwise}
\end{cases}

\text{CheckLongSteel} \leftarrow \text{if } \min(CR_{\text{Long Steel}}) > 1 \text{, "OK", "No Good, add steel!"}

Interface Shear Reinforcement

Interface Steel Required vs Provided

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

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

Location (ft)

CheckLongSteel = "OK"
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.

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

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

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

CheckInterfaceSpacing = "OK"

\[
\text{CheckInterfaceSpacing} := \begin{cases} 
\text{if } \frac{\text{TotalInterfaceSteelProvided}}{\text{TotalInterfaceSteelRequired} + 0.001 \text{ in}^2} \geq 1, \text{"OK"}, \text{"No Good"} 
\end{cases}
\]

CheckInterfaceSteel := \begin{cases} 
\text{if } \text{substr(BeamTypeTog, 0, 3) = "FLT", "N.A.", CheckInterfaceSteel} \text{ } \text{CheckInterfaceSteel} = "OK"
\end{cases}

**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\(_1\) := AcceptSDG = "N.A."

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

check\(_3\) := Check\(_f_{pt}\) = "OK"

check\(_4\) := Check\(_f_{comp,rel}\) = "OK"

check\(_5\) := Check\(_f_{tiension,rel}\) = "OK"

check\(_6\) := Check\(_f_{comp,stage8,c1}\) = "OK"

check\(_7\) := Check\(_f_{comp,stage8,c2}\) = "OK"

check\(_8\) := Check\(_f_{comp,Fatigue}\) = "OK"

check\(_9\) := Check\(_f_{comp,stage8}\) = "OK"

check\(_10\) := Check\(_f_{tension}\) = "OK"

check\(_11\) := Check\(_f_{comp,stage8}\) = "OK"

check\(_12\) := CheckMaxCapacity = "OK"

check\(_13\) := CheckMinStirArea = "OK"

check\(_14\) := CheckShearCapacity = "OK"

check\(_15\) := CheckLongSteel = "OK"

check\(_16\) := CheckMaxStirSpacing = "OK"

check\(_17\) := CheckPattern0 = "OK"

check\(_18\) := CheckInterfaceSpacing = "OK"

check\(_19\) := CheckPattern1 = "OK"

check\(_20\) := CheckInterfaceSteel = "OK"

check\(_21\) := CheckPattern2 = "OK"

check\(_22\) := CheckPattern3 = "OK"

check\(_23\) := CheckPattern4 = "OK"

check\(_24\) := CheckPattern5 = "OK"

check\(_25\) := CheckPattern6 = "OK"

check\(_26\) := CheckStrandFit = "OK"
check28 := Check_SDG1.2.display2 = "OK"

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><strong>Limit State</strong></td>
<td><strong>DF</strong></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 = \[
\begin{bmatrix}
"Limit State" & "DF" & "Rating" & "Tons" & "Dim(ft)" & "DF" & "Rating" & "Tons" & "Dim(ft)"
\hline
"Strength I(Inv)" & 0.40 & 1.87 & "N/A" & 13.32 & 0.65 & 4.28 & "N/A" & 1.39 \\
"Strength I(Op)" & 0.40 & 2.42 & "N/A" & 13.32 & 0.65 & 5.55 & "N/A" & 1.39 \\
"Service III(Inv)" & 0.40 & 1.74 & "N/A" & 13.32 & "N/A" & "N/A" & "N/A" & 1.39 \\
"Service III(Op)" & 0.40 & 2.38 & "N/A" & 13.32 & "N/A" & "N/A" & "N/A" & "N/A" \\
"Strength II" & 0.40 & 2.05 & 123.07 & 10.54 & 0.65 & 3.76 & 225.87 & 1.39 \\
\end{bmatrix}
\]

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

**Longitudinal Steel Check:**

\[ CR_{LongSteel.HL93} = 1.54 \quad CR_{LongSteel.Permits} = 1.36 \]

CheckLongSteel.loadrating = "OK"

**Write Data Out**

7/25/2016 MainProgram.xmcd v5.0
**LRFD Prestressed Beam Program**

**Project** = "D30015 30 FT, LR Int. Bm."

**DesignedBy** = "VAY"

**Date** = "7-25-2016"

filename = "C:\FDOT Structures\Programs\LRFDBeamV5.0\FSB Data Files\D30015 30 FT LR Int. Bm.dat"

Comment = "FSB12x52 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 Layout Diagram]

- L_{beam} = 28.83\text{-ft}
- Span = 27.75\text{-ft}
- BearingDistance = 6.5\text{-in}
- PadWidth = 8\text{-in}

BeamTypeTog = "FSB12x52"

*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 = 4  t_{slab.delta} = 0.22-in
de = 0.83 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} := \text{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  \( \gamma_{slab} = 0.15 \frac{\text{kip}}{\text{ft}^3} \)

strength of slab concrete  \( f_{c,\text{slab}} = 4.5\text{-ksi} \)

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

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

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

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

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

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

\( E_{c} := \text{AggFactor} \left( \frac{f_{c,\text{beam}}}{\text{ksi}} \right)^{0.33} \text{-ksi} \) 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** \( n_{mi} := \frac{E_s}{E_{ci}} \quad n_{mi} = 6.42 \)
- **area per unit width of longitudinal slab rein.** \( A_{slab.rebar} = 0.31\text{-in}^2\text{-ft} \)
- **ratio of rebar modulus to beam concrete modulus** \( n_m := \frac{E_s}{E_c} \quad n_m = 5.72 \)
- **area of mild reinf lumped at centroid of bar locations** \( A_{s,long} = 0\text{-in}^2 \)
- **d distance from top of slab to centroid of slab rein.** \( d_{slab.rebar} = 2.5\text{-in} \)
- **d distance from top of beam to centroid of mild flexural tension rein.** \( d_{long} = 0\text{-in} \)
- **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

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

\[
\text{PermitAxleLoad}^T = (\text{13.33} \quad \text{53.33} \quad \text{53.33})\text{-kip}
\]

\[
\text{PermitAxleSpacing}^T = (\text{0} \quad \text{14} \quad \text{14} \quad \text{0})\text{-ft}
\]

**Distribution Factors**

DataMessage = "This is a FSB12x52 Florida Slab Beam design, AASHTO distribution factors used"

Calculated values:

- \( \text{tmp}_g\text{mom} = 0.42 \)
- \( \text{tmp}_g\text{shear} = 0.55 \)
- \( \text{tmp}_g\text{mom.fatigue} = 0.28 \)

User value overrides (optional):

- \( \text{user}_g\text{mom} := 0.344 \)
- \( \text{user}_g\text{shear} := 0.502 \)
- \( \text{user}_g\text{mom.fatigue} := 0 \)

Value check:

- \( g_{mom} := \text{if}(\text{user}_g\text{mom} \neq 0, \text{user}_g\text{mom} \cdot \text{tmp}_g\text{mom}) \quad g_{mom} = 0.34 \)
- \( g_{shear} := \text{if}(\text{user}_g\text{shear} \neq 0, \text{user}_g\text{shear} \cdot \text{tmp}_g\text{shear}) \quad g_{shear} = 0.5 \)
- \( g_{mom.fatigue} := \text{if}(\text{user}_g\text{mom.fatigue} \neq 0, \text{user}_g\text{mom.fatigue} \cdot \text{tmp}_g\text{mom.fatigue}) \quad g_{mom.fatigue} = 0.28 \)
Section Views

Beam Section

Beam Type \((1)\) ft

Beam Type \((2)\) ft

Total Slab, Effective Slab, and Beam

feet

feet

-1

-0.5

0

0.5

slab

effective slab

beam
Non-Composite Dead Load Input:

\[ w_{slab} = 0.453 \text{ kip/ft} \quad w_{beam} = 0.543 \text{ kip/ft} \quad w_{forms} = 0 \text{ kip/ft} \]

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

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

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

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

\[ w_{noncomposite} = 0.996 \text{ kip/ft} \]

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

\[ w_{bnoncomposite} = 0.453 \text{ kip/ft} \]

Diaphragms/Point Load Input

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

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

\[ \text{begin bridge} \]

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

\[ \text{end bridge} \]

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

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

input load is per beam

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

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

Longitudinal Distance B, C, & D - Measured from CL

Bearing at begin bridge

Composite Dead Load Input:

\[ w_{future.ws} = 0.067 \text{ kip/ft} \quad w_{barrier} = 0.215 \text{ kip/ft} \]

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

*additional composite dead load (positive or negative)*

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

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

\[ w_{composite} = 0.282 \text{ kip/ft} \]

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

\[ w_{comp.str} = 0.215 \text{ kip/ft} \]
**Release Dead Load Moments and Shear**

\[ \text{max}(M_{\text{release}}) = 56.5 \text{-kip\cdot ft} \]
\[ \text{max}(V_{\text{release}}) = 7.8 \text{-kip} \]

**Noncomposite Dead Load Moments and Shear**

\[ \text{max}(M_{\text{dl.non.comp}}) = 95.9 \text{-kip\cdot ft} \]
\[ \text{max}(V_{\text{dl.non.comp}}) = 13.8 \text{-kip} \]
**Composite Dead Load Moments and Shear**

\[
\begin{align*}
\text{max}(M_{\text{dl,comp}}) &= 27.1 \text{-kip-ft} \\
\text{max}(V_{\text{dl,comp}}) &= 3.9 \text{-kip}
\end{align*}
\]

**Distributed Live Load Moments and Shear**

\[
\begin{align*}
\text{max}(M_{\text{dist.live.pos}, \text{shr}}) &= 147.8 \text{-kip-ft} \\
\text{max}(M_{\text{dist.live.pos}}) &= 157.7 \text{-kip-ft} \\
\text{min}(M_{\text{dist.live.neg}}) &= -8 \text{-kip-ft} \\
\text{max}(V_{\text{dist.live.pos}}) &= 36.4 \text{-kip} \\
\text{max}(M_{\text{shr, dist.live.pos}}) &= 147.8 \text{-kip-ft}
\end{align*}
\]

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

- Reaction_{LL} = 37.47 \text{-kip}
- Reaction_{DL} = 18.42 \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

Support Location_{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")

**PartialPSforce** = 40-kip  \( partial \) prestress total force

**PartialPSforce** := if(\( BeamTypeTog = "II", 20\)-kip, PartialPSforce)  \( partial \) prestress total force

**PartialPSlocation** = 1.4375 in  \( centroid \) location of partial prestress from the top of the beam

**PartialPSlocation** :=

\[
\begin{align*}
2.4375 \text{ in} & \quad \text{if} \quad BeamTypeTog = "II" \\
3 \text{ in} & \quad \text{if} \quad \text{substr}(BeamTypeTog, 0, 5) = "FSB12" \\
2 \text{ in} & \quad \text{if} \quad \text{substr}(BeamTypeTog, 0, 5) = "FSB15" \\
3 \text{ in} & \quad \text{if} \quad \text{substr}(BeamTypeTog, 0, 5) = "FSB18" \\
\text{PartialPSlocation} & \quad \text{otherwise}
\end{align*}
\]

Section Properties & Strand Profile Properties

**Release Stresses**

![Graph showing Release Stresses (ksi) Top, Bot., & Allow.]

**Location**

<table>
<thead>
<tr>
<th>Location (ft)</th>
<th>f(_{\text{top, beam, rel, n}}) ( \text{ksi} )</th>
<th>f(_{\text{bot, beam, rel, n}}) ( \text{ksi} )</th>
<th>f(_{\text{fall, tension, rel, n}}) ( \text{ksi} )</th>
<th>f(_{\text{fall, comp, rel, n}}) ( \text{ksi} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.207</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.415</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.622</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28.83</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Prestress Force
**Final Stresses**

<table>
<thead>
<tr>
<th></th>
<th>f_{top.beam.stage8,c1}^n</th>
<th>f_{top_slab.stage8,c2}^n</th>
<th>f_{top.beam.stage8,c2}^n</th>
<th>f_{bot.beam.stage8,c2}^n</th>
<th>f_{top.beam.FatigueI}^n</th>
<th>f_{fall.comp.case1}^n</th>
<th>f_{fall.comp.case2}^n</th>
<th>f_{fall.comp.FatigueI}^n</th>
<th>f_{fall.tension}^n</th>
</tr>
</thead>
<tbody>
<tr>
<td>ksi</td>
<td>7.207</td>
<td>14.415</td>
<td>21.622</td>
<td>28.83</td>
<td>6</td>
<td>-4</td>
<td>-2</td>
<td>-2</td>
<td>-6</td>
</tr>
</tbody>
</table>

**Stress Checks**

\[
\begin{align*}
\min(CR_{f_{\text{tension.rel}}}) &= 10 & \text{Check}_{f_{\text{tension.rel}}} &= \text{"OK"} \\
\min(CR_{f_{\text{comp.rel}}}) &= 1.89 & \text{Check}_{f_{\text{comp.rel}}} &= \text{"OK"} \\
\min(CR_{f_{\text{tension.stage8}}}) &= 10 & \text{Check}_{f_{\text{tension.stage8}}} &= \text{"OK"} \\
\min(CR_{f_{\text{comp.stage8,c1}}}) &= 3.21 & \text{Check}_{f_{\text{comp.stage8,c1}}} &= \text{"OK"} \\
\min(CR_{f_{\text{comp.stage8,c2}}}) &= 3.5 & \text{Check}_{f_{\text{comp.stage8,c2}}} &= \text{"OK"} \\
\min(CR_{f_{\text{comp.FatigueI}}}) &= 4.38 & \text{Check}_{f_{\text{comp.FatigueI}}} &= \text{"OK"}
\end{align*}
\]

- **Release Checks & Final Checks for Capacity Ratio (CR)**
  - **Release tension**: \( CR_{f_{\text{tension.rel}}} \geq 10 \)
  - **Release compression**: \( CR_{f_{\text{comp.rel}}} \geq 1.89 \)
  - **Service III, PS + DL + LL*0.8**: \( CR_{f_{\text{tension.stage8}}} \geq 10 \)
  - **Service I, PS + DL**: \( CR_{f_{\text{comp.stage8,c1}}} \geq 3.21 \)
  - **Service I, PS + DL + LL**: \( CR_{f_{\text{comp.stage8,c2}}} \geq 3.5 \)
  - **Fatigue I, (PS + DL)*0.5 + 1.5 Fatigue Truck**: \( CR_{f_{\text{comp.FatigueI}}} \geq 4.38 \)
**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_{beam}** = 521.75 in\(^2\)  Concrete area of beam
- **I_{beam}** = 6355.6223 in\(^4\)  Gross Moment of Inertia of Beam about CG
- **y_{comp}** = -3.33 in  Dist. from top of beam to CG of gross composite section
- **I_{comp}** = 23012.1315 in\(^4\)  Gross Moment of Inertia Composite Section about CG
- **A_{deck}** = 352.45 in\(^2\)  Concrete area of deck slab
- **A_{ps}** = 2.8 in\(^2\)  total area of strands
- **d_{b,ps}** = 0.6 in  diameter of Prestressing strand
- **min(PrestressType())** = 0  0 - low lax  1 - stress relieved
- **f_{py}** = 243 ksi  tendon yield strength
- **f_{pj}** = 203 ksi  prestress jacking stress
- **L_{shielding} \^T** = (0 0 0) ft
- **A_{ps,row} \^T** = (2.4 0.4 0.2) in\(^2\)
- **d_{ps,row}** = 

<table>
<thead>
<tr>
<th></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>-3</td>
</tr>
</tbody>
</table>

- **TotalNumberOfTendons** = 13
- **NumberOfDebondedTendons** = 0
- **NumberOfDrapedTendons** = 0
- **StrandSize** = "0.6 in low lax"
- **StrandArea** = 0.22 in\(^2\)
- **JackingForce_{per.strand}** = 43.94 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

\[ \Delta f_{pT} = -18 \text{ ksi} \]

\[ \frac{\Delta f_{pT}}{f_{pj}} = -8.88\% \]

\[ f_{pc} = 185 \text{ ksi} \]

\[ \frac{f_{pc}}{f_{pj}} = 91.12\% \]

0.8 \( f_{py} = 194 \text{ ksi} \)

Check \( f_{pc} = "OK" \)

Service Limit State Moments

max \( M_{pos.Ser1} = 280.3 \text{ kip-ft} \)

max \( M_{pos.Ser3} = 248.8 \text{ kip-ft} \)
**Summary of Values at Midspan**

<table>
<thead>
<tr>
<th>Stage</th>
<th>&quot;Top of Beam (ksi)&quot;</th>
<th>&quot;Bott of Beam (ksi)&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-0.67</td>
<td>-1.54</td>
</tr>
<tr>
<td>2</td>
<td>-0.67</td>
<td>-1.35</td>
</tr>
<tr>
<td>4</td>
<td>-0.62</td>
<td>-1.39</td>
</tr>
<tr>
<td>6</td>
<td>-1.14</td>
<td>-0.94</td>
</tr>
<tr>
<td>8</td>
<td>-1.46</td>
<td>-0.27</td>
</tr>
</tbody>
</table>

\[
\text{PrestressForce} = \begin{pmatrix}
\text{"Condition "} & \text{"Axial (kip)"} & \text{"Moment (kip*ft)"} \\
\text{"Release"} & -611.3 & -98.8 \\
\text{"Final (about composite centroid)"} & -557 & -87.2
\end{pmatrix}
\]

\[
\text{Properties} = \begin{pmatrix}
\text{"Section "} & \text{"Area (in^2)"} & \text{"Inertia (in^4)"} & \text{"distance to centroid from top of bm (in)"} \\
\text{"Net Beam "} & 518.73 & 6336.87 & -6.38 \\
\text{"Transformed Beam (initial)"} & 537.78 & 6453.08 & -6.45 \\
\text{"Transformed Beam "} & 535.71 & 6440.7 & -6.44 \\
\text{"Composite "} & 894.7 & 23699.09 & -3.35
\end{pmatrix}
\]

\[
\text{ServiceMoments} = \begin{pmatrix}
\text{"Type "} & \text{"Value (kip*ft)"} \\
\text{"Release"} & 56.5 \\
\text{"Non-composite (includes bm wt.)"} & 95.9 \\
\text{"Composite"} & 27.1 \\
\text{"Distributed Live Load"} & 157
\end{pmatrix}
\]

*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

- camber @ release
- camber @ 30 days
- camber @ 60 days
- camber @ 90 days
- camber @ 120 days
- camber @ 240 days
- non-composite dead load deflection
- composite dead load deflection
- live load deflection

SlopeData =

<table>
<thead>
<tr>
<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>-0.0341</td>
<td>-0.1164</td>
<td>0.1528</td>
<td>0.2126</td>
</tr>
<tr>
<td>&quot;30 Days&quot;</td>
<td>-0.1073</td>
<td>-0.2407</td>
<td>0.26</td>
<td>0.3064</td>
</tr>
<tr>
<td>&quot;60 Days&quot;</td>
<td>-0.1343</td>
<td>-0.2866</td>
<td>0.3014</td>
<td>0.3489</td>
</tr>
<tr>
<td>&quot;90 Days&quot;</td>
<td>-0.1483</td>
<td>-0.3105</td>
<td>0.3229</td>
<td>0.3797</td>
</tr>
<tr>
<td>&quot;120 Days&quot;</td>
<td>-0.1569</td>
<td>-0.3251</td>
<td>0.3361</td>
<td>0.4037</td>
</tr>
<tr>
<td>&quot;240 Days&quot;</td>
<td>-0.1726</td>
<td>-0.3517</td>
<td>0.3602</td>
<td>0.464</td>
</tr>
<tr>
<td>&quot;non-comp DL&quot;</td>
<td>-0.023</td>
<td>0.0198</td>
<td>-0.1022</td>
<td>-0.1855</td>
</tr>
<tr>
<td>&quot;comp DL&quot;</td>
<td>-0.002</td>
<td>0.0052</td>
<td>-0.0172</td>
<td>-0.0312</td>
</tr>
<tr>
<td>&quot;LL&quot;</td>
<td>-0.0105</td>
<td>0.0271</td>
<td>-0.0899</td>
<td>-0.1619</td>
</tr>
</tbody>
</table>

Ultimate Moment Capacity

7/25/2016 MainProgram.xamld v5.0
### Strength Limit State Moments

#### Nominal and Ultimate Moment Strength (kip-ft)

<table>
<thead>
<tr>
<th>Location (ft)</th>
<th>Nominal Moment ($M_{nm}$)</th>
<th>Ultimate Moment ($M_{um}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7.207</td>
<td>7.207</td>
<td>14.415</td>
</tr>
<tr>
<td>14.415</td>
<td>21.622</td>
<td>28.830</td>
</tr>
<tr>
<td>21.622</td>
<td>28.830</td>
<td>36.060</td>
</tr>
<tr>
<td>28.83</td>
<td>36.060</td>
<td>43.290</td>
</tr>
</tbody>
</table>

#### Moment Equations

- $\phi_{mom} (M_{nm})_0$
- $M_{cr} = \phi_{mom} (M_{nm})_0$
- $M_{pos.Str1} = \phi_{mom} (M_{nm})_0$
- $M_{pos.Str2} = \phi_{mom} (M_{nm})_0$
- $M_{reqd} = \phi_{mom} (M_{nm})_0$

**Location mn ft**

- CRStr.mom := 10
- CRStr.mom := $\phi_{mom} (M_{nm})_0$

#### Check Moment Capacity

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

### Shear Analysis

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

- $V_{u.Str} = \phi_{mom} (M_{nm})_0$
- $M_{shr.u.Str} = \phi_{mom} (M_{nm})_0$

**Location n ft**

- $\max (V_{u.Str}) = 87.1 \text{kip}$
- $\max (M_{shr.u.Str}) = 413.0 \text{kip-ft}$

---

**FSB only - Design Check of Transverse reinforcing Bars E**

**Shear Analysis**

---

**MainProgram.xmcd v5.0**
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 in</td>
<td>1</td>
<td>(0.8) in²</td>
</tr>
<tr>
<td>A2 stirrup</td>
<td>18 in</td>
<td>1</td>
<td>(0.8) in²</td>
</tr>
<tr>
<td>A3 stirrup</td>
<td>18 in</td>
<td>1</td>
<td>(0.8) in²</td>
</tr>
<tr>
<td>S1 stirrup</td>
<td>18 in</td>
<td>1</td>
<td>(0.8) in²</td>
</tr>
<tr>
<td>S2 stirrup</td>
<td>18 in</td>
<td>1</td>
<td>(0.8) in²</td>
</tr>
<tr>
<td>S3 stirrup</td>
<td>18 in</td>
<td>1</td>
<td>(0.8) in²</td>
</tr>
<tr>
<td>S4 stirrup</td>
<td>18 in</td>
<td>0</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.

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
Computation for Checks

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

Longitudinal Reinforcement

Longitudinal Steel Required vs. Provided

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

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

Location (hs)
ft

\[ \text{CR}_{\text{LongSteel}} := \text{if} \left( V_{\text{long,reqd}} < .01 \times \frac{\text{kip}}{\text{ft}}, \frac{V_{\text{long,prov}}}{V_{\text{long,reqd}}} \right) \]

\[ \text{min}(\text{CR}_{\text{LongSteel}}) = 1.7 \]

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

CheckLongSteel = "OK"

Interface Shear Reinforcement

Interface Steel Required vs Provided

\[ A_{\text{v,f,reqd}} \]
\( \frac{\text{in}^2}{\text{ft}} \)

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

Location (hs)
ft
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.

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

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 \(\frac{\text{TotalInterfaceSteelProvided}}{\text{TotalInterfaceSteelRequired} + 0.001 \text{in}^2} \geq 1\), "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)

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

CheckMaxPrestressingForce = "OK"

Summary of Design Checks

check₀ := AcceptAASHTO = "OK"

check₁ := AcceptSDG = "N.A."

check₂ := AcceptOntario = "N.A."

check₃ := Check_f_p = "OK"

check₄ := Check_f_tension.rel = "OK"

check₅ := Check_f_comps.tension.stage8 = "OK"

check₆ := Check_f_comps.tension.stage8.c1 = "OK"

check₇ := Check_f_comps.tension.stage8.c2 = "OK"

check₈ := CheckShearCapacity = "OK"

check₉ := CheckMaxStirSpacing = "OK"

check₁₀ := CheckInterfaceSpacing = "OK"

check₁₁ := CheckMomentCapacity = "OK"

check₁₂ := CheckMaxCapacity = "OK"

check₁₃ := CheckStirArea = "OK"

check₁₄ := CheckMinStirArea = "OK"

check₁₅ := CheckLongSteel = "OK"

check₁₆ := CheckMaxStirSpacing = "OK"

check₁₇ := CheckPattern0 = "OK"

check₁₈ := CheckMaxPrestressingForce = "OK"

check₁₉ := CheckPattern1 = "OK"

check₂₀ := CheckPattern2 = "OK"

check₂₁ := CheckPattern3 = "OK"

check₂₂ := CheckPattern4 = "OK"

check₂₃ := CheckPattern5 = "OK"

check₂₄ := CheckInterfaceSteel = "OK"

check₂₅ := CheckStrandFit = "OK"
check_28 := Check_SDG1.2_Display_2 = "OK"

Link to Note- Checks, 0, 1 & 2

LRFR Load Rating Analysis

FDOT Maintenance Office Bridge Load Rating Manual

Load Rating Computations

<table>
<thead>
<tr>
<th>Limit State</th>
<th>DF</th>
<th>Rating</th>
<th>Tons</th>
<th>Dim(ft)</th>
<th>DF</th>
<th>Rating</th>
<th>Tons</th>
<th>Dim(ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength I(Inv)</td>
<td>0.34</td>
<td>2.16</td>
<td>&quot;N/A&quot;</td>
<td>13.32</td>
<td>0.50</td>
<td>5.54</td>
<td>&quot;N/A&quot;</td>
<td>1.39</td>
</tr>
<tr>
<td>Strength I(Op)</td>
<td>0.34</td>
<td>2.80</td>
<td>&quot;N/A&quot;</td>
<td>13.32</td>
<td>0.50</td>
<td>7.18</td>
<td>&quot;N/A&quot;</td>
<td>1.39</td>
</tr>
<tr>
<td>Service III(Inv)</td>
<td>0.34</td>
<td>2.00</td>
<td>&quot;N/A&quot;</td>
<td>13.32</td>
<td>&quot;N/A&quot;</td>
<td>&quot;N/A&quot;</td>
<td>&quot;N/A&quot;</td>
<td>&quot;N/A&quot;</td>
</tr>
<tr>
<td>Service III(Op)</td>
<td>0.34</td>
<td>2.75</td>
<td>&quot;N/A&quot;</td>
<td>13.32</td>
<td>&quot;N/A&quot;</td>
<td>&quot;N/A&quot;</td>
<td>&quot;N/A&quot;</td>
<td>&quot;N/A&quot;</td>
</tr>
<tr>
<td>Strength II</td>
<td>0.34</td>
<td>2.38</td>
<td>142.57</td>
<td>10.54</td>
<td>0.50</td>
<td>4.88</td>
<td>292.51</td>
<td>1.39</td>
</tr>
</tbody>
</table>

LRFR_{loadrating} = \begin{array}{llllllll}
\text{HL-93}
\end{array}

Longitudinal Steel Check:

CR_{LongSteel,Hl93} = 1.7 \quad CR_{LongSteel,Permit} = 1.71 \quad \text{CheckLongSteel}_{loadrating} = "OK"

Write Data Out

*note: default permit load is FL120 per input worksheet

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