

LOAD RATING CALCULATIONS

DEVELOPMENTAL DESIGN STANDARDS

FSB SUPERSTRUCTURE PACKAGE

15 FT. CLEAR WIDTH

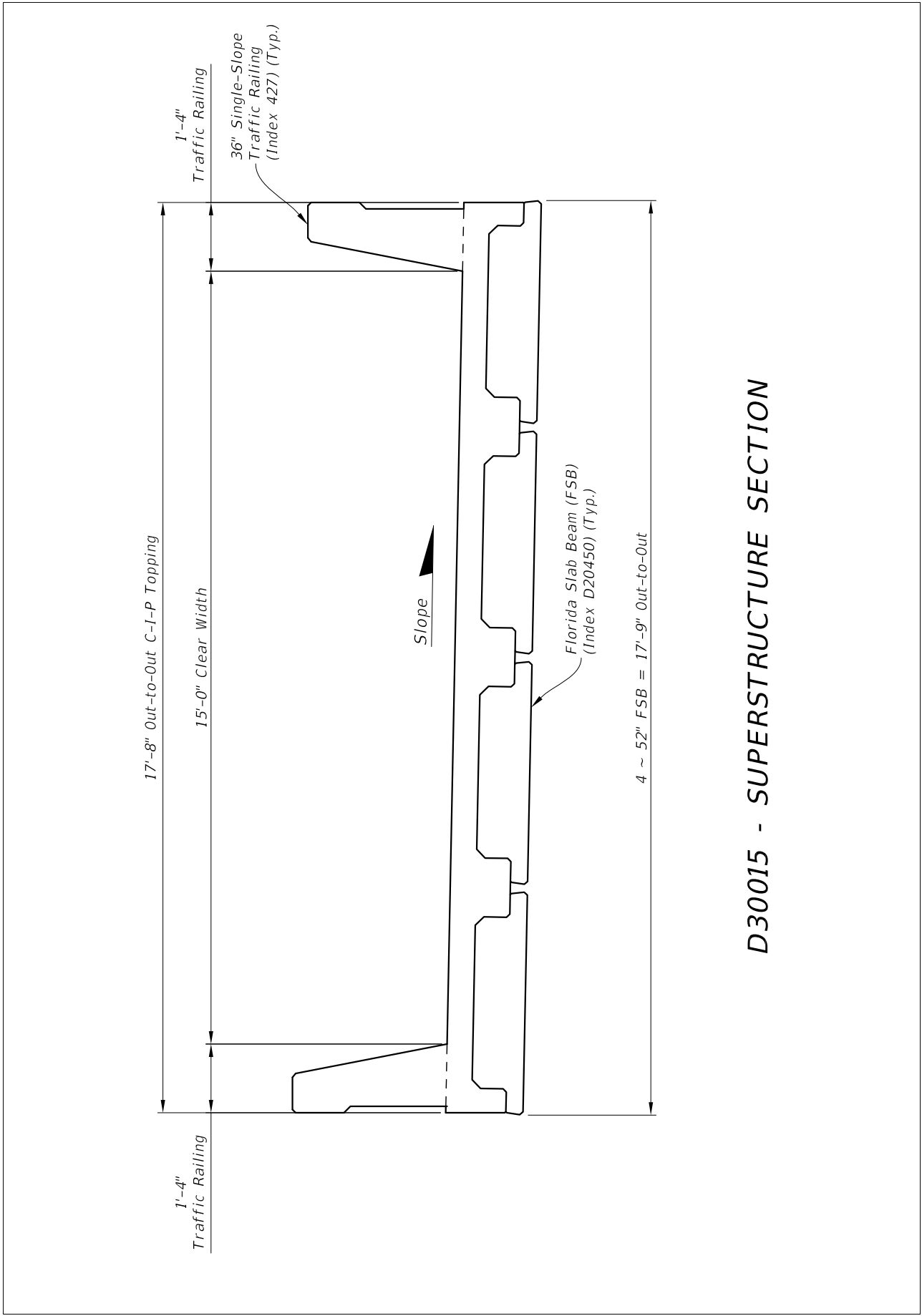
D30015 - 40 Ft. Span

Developmental Design Standards -FSB Superstructure Package

| | |
|---------------|--|
| D30015 | FDOT Bridge Load Rating Summary |
|---------------|--|

| | | |
|----------------------------------|------|------|
| LRFR using Part A | | |
| Int. / Ext. Beam | Ext. | Int. |
| Span Length (ft) | 40 | 40 |
| Controlling Rating Factor | | |

| Rating Level | Vehicle | Weight (Tons) | Flexure (Strength) | Shear (Strength) | Stress (Service) | Flexure (Strength) | Shear (Strength) | Stress (Service) |
|------------------|---------|---------------|--------------------|------------------|------------------|--------------------|------------------|------------------|
| Design Operating | HL-93 | 36 | 2.39 | 6.01 | N/A | 2.78 | 7.81 | N/A |
| Design Inventory | | | 1.84 | 4.64 | 1.40 | 2.15 | 6.02 | 1.54 |
| Permit | FL-120 | 60 | 1.79 | 4.14 | N/A | 2.09 | 5.39 | N/A |



D300015 - SUPERSTRUCTURE SECTION

LRFD Prestressed Beam Program

Project = "D30015 40 FT LR Ext Bm"

DesignedBy = "GW"

Date = "07/25/2016"

filename = "C:\FDOT Structures\Programs\LRFDBeamV5.0\FSB Data Files\D30015 40 FT LR Ext Bm.dat"

Comment = "FSB12x52 40 ft span"

Legend

TanHighlight = DataEntry

YellowHighlight = CheckValues

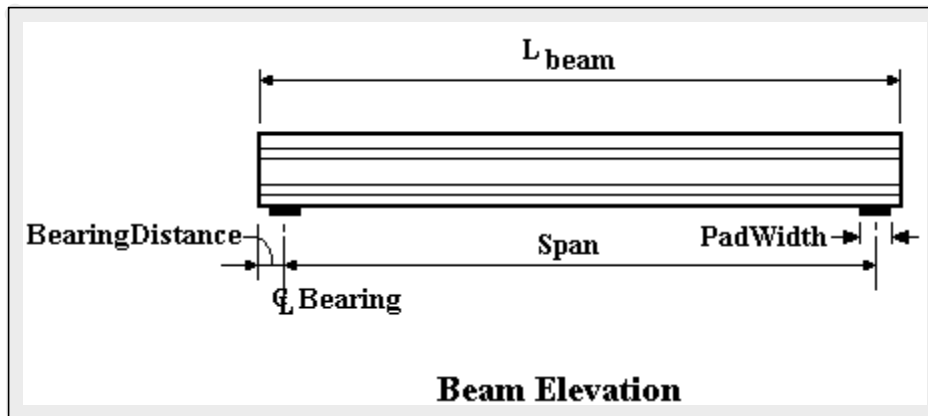
GreyHighlight = UserComments + Graphs

BlackText = ProgramEquations

Maroon Text = Code Reference

Blue Text = Commentary

Bridge Layout and Dimensions



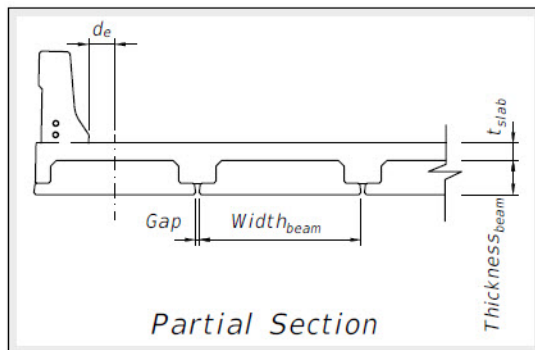
$L_{beam} = 38.83\text{-ft}$

Span = 37.75-ft

BearingDistance = 6.5-in

PadWidth = 8-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} = 0.32·in |
| | | | de = 0.79 ft |

BeamPosition = "exterior" [For calculating distribution factors must be either interior or exterior](#)

b_e = 4.36 ft [effective slab width](#) [LRFD 4.6.2.6](#)

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

Material Properties

Concrete:

| | | | |
|---|-------------------------------|--|---|
| Corrosion Classification | Environment = "extremely" | density of slab concrete | $\gamma_{slab} = 0.15 \cdot \frac{\text{kip}}{\text{ft}^3}$ |
| strength of slab concrete | f _{c,slab} = 4.5·ksi | density of beam concrete | $\gamma_{beam} = 0.15 \cdot \frac{\text{kip}}{\text{ft}^3}$ |
| strength of beam concrete | f _{c,beam} = 8.5·ksi | weight of future wearing surface | Weight _{future.ws} = 0.015· $\frac{\text{kip}}{\text{ft}^2}$ |
| release beam strength | f _{ci,beam} = 6·ksi | relative humidity | H = 75 |
| type of course aggregate "Florida" or "Standard" | AggregateType = "Florida" | | |

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

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

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

$E_c := \text{AggFactor} \cdot \left(\frac{f_{c,beam}}{\text{ksi}} \right)^{0.33} \cdot \text{ksi}$ [beam concrete modulus of elasticity](#) [\(LRFD 5.4.2.4\)](#) E_c = 5066·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:

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

Permit Loads

This is the number of wheel loads that comprise the truck, max for DLL is 11

$\text{PermitAxles} = 3$

Indexes used to identify values in the P and d vectors

$q := 0..(\text{PermitAxles} - 1)$

$qt := 0.. \text{PermitAxles}$

$\text{PermitAxleLoad}^T = (13.33 \ 53.33 \ 53.33) \cdot \text{kip}$

$\text{PermitAxleSpacing}^T = (0 \ 14 \ 14 \ 0) \cdot \text{ft}$

Distribution Factors

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

calculated values:

$\text{tmp_gmom} = 0.42$

$\text{tmp_gshear} = 0.63$

$\text{tmp_gmom.fatigue} = 0.28$

user value overrides (optional):

$\text{user_gmom} := 0.331$

$\text{user_gshear} := 0.615$

$\text{user_gmom.fatigue} := 0$

value check

$\text{gmom} := \text{if}(\text{user_gmom} \neq 0, \text{user_gmom}, \text{tmp_gmom})$

$\text{gmom} = 0.33$

$\text{gshear} := \text{if}(\text{user_gshear} \neq 0, \text{user_gshear}, \text{tmp_gshear})$

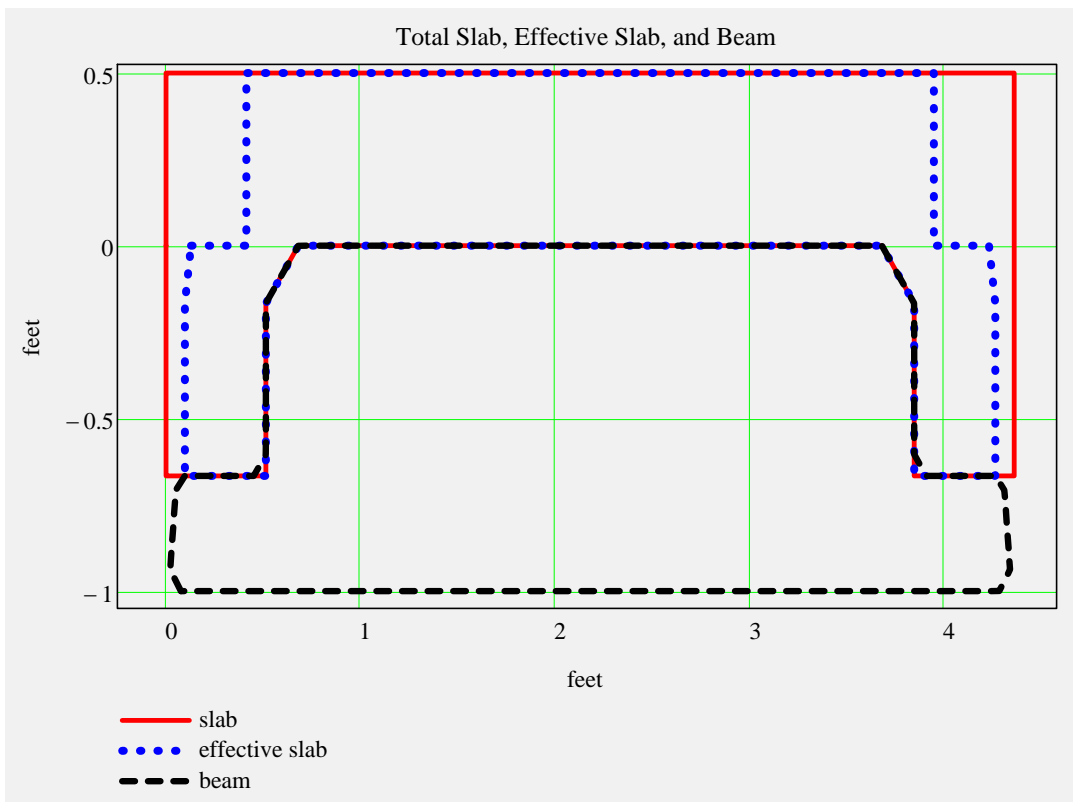
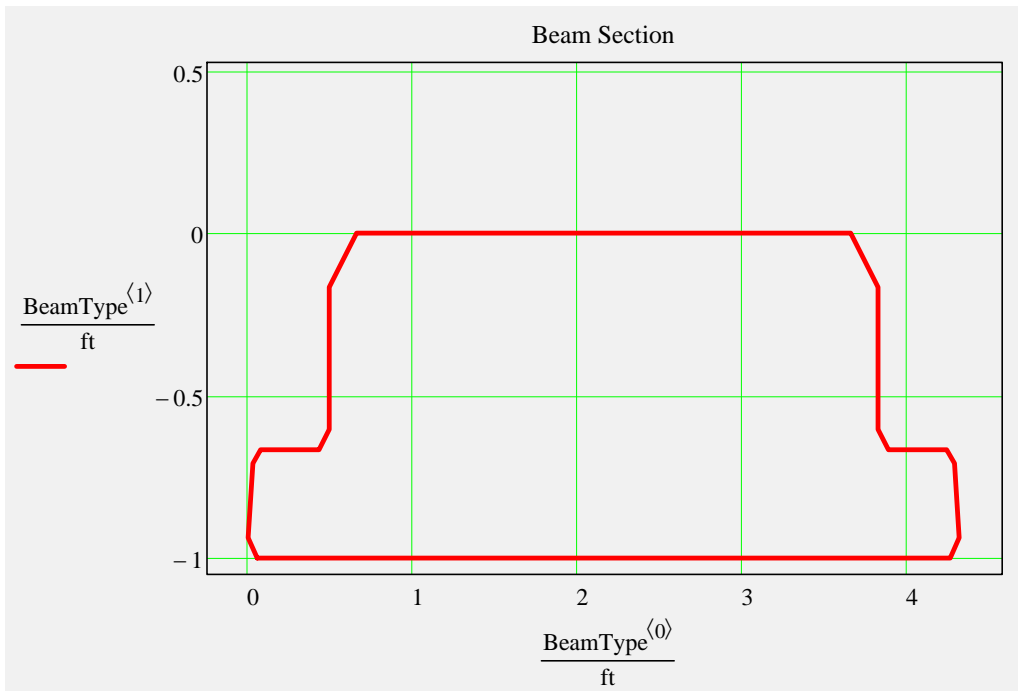
$\text{gshear} = 0.62$

$\text{gmom.fatigue} := \text{if}(\text{user_gmom.fatigue} \neq 0, \text{user_gmom.fatigue}, \text{tmp_gmom.fatigue})$

$\text{gmom.fatigue} = 0.28$



Section Views



Non-Composite Dead Load Input:

$$w_{\text{slab}} = 0.434 \cdot \frac{\text{kip}}{\text{ft}} \quad w_{\text{beam}} = 0.543 \cdot \frac{\text{kip}}{\text{ft}} \quad w_{\text{forms}} = 0 \cdot \frac{\text{kip}}{\text{ft}}$$

$$\text{Add_}w_{\text{noncomp}} := 0.0 \cdot \frac{\text{kip}}{\text{ft}}$$

additional non composite dead load (positive or negative)
note: not saved to data file, may be saved to Mathcad worksheet.

$$w_{\text{noncomposite}} := w_{\text{slab}} + w_{\text{beam}} + w_{\text{forms}} + \text{Add_}w_{\text{noncomp}}$$

$$w_{\text{noncomposite}} = 0.977 \cdot \frac{\text{kip}}{\text{ft}}$$

$$w_{\text{bnoncomposite}} := w_{\text{slab}} + w_{\text{forms}} + \text{Add_}w_{\text{noncomp}}$$

$$w_{\text{bnoncomposite}} = 0.434 \cdot \frac{\text{kip}}{\text{ft}}$$

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

$$\text{EndDiaphragmA} := 0 \cdot \text{kip} \quad \text{begin bridge}$$

$$\text{IntDiaphragmB} := 0 \cdot \text{kip}$$

input load is per beam

$$\text{DistB} := 0 \cdot \text{ft}$$

$$\text{EndDiaphragmE} := 0 \cdot \text{kip} \quad \text{end bridge}$$

$$\text{IntDiaphragmC} := 0 \cdot \text{kip}$$

Longitudinal Distance B, C, & D - Measured from CL Bearing at begin bridge

$$\text{DistC} := 0 \cdot \text{ft}$$

$$\text{IntDiaphragmD} := 0 \cdot \text{kip}$$

$$\text{DistD} := 0 \cdot \text{ft}$$

Composite Dead Load Input:

$$w_{\text{future.ws}} = 0.044 \cdot \frac{\text{kip}}{\text{ft}} \quad w_{\text{barrier}} = 0.215 \cdot \frac{\text{kip}}{\text{ft}}$$

$$\text{Add_}w_{\text{comp}} := 0.0 \cdot \frac{\text{kip}}{\text{ft}}$$

additional composite dead load (positive or negative)
note: not saved to data file, may be saved to Mathcad worksheet

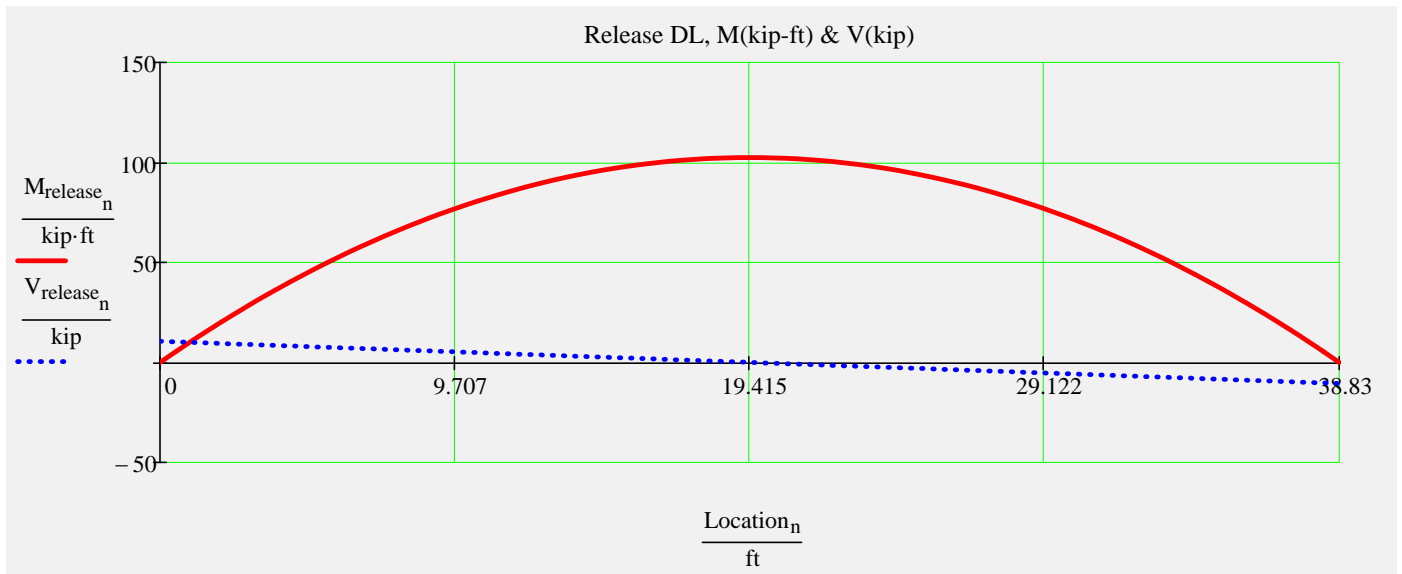
$$w_{\text{composite}} := w_{\text{future.ws}} + w_{\text{barrier}} + \text{Add_}w_{\text{comp}}$$

$$w_{\text{composite}} = 0.259 \cdot \frac{\text{kip}}{\text{ft}}$$

$$w_{\text{comp.str}} := w_{\text{barrier}} + \text{Add_}w_{\text{comp}}$$

$$w_{\text{comp.str}} = 0.215 \cdot \frac{\text{kip}}{\text{ft}}$$

Release Dead Load Moments and Shear

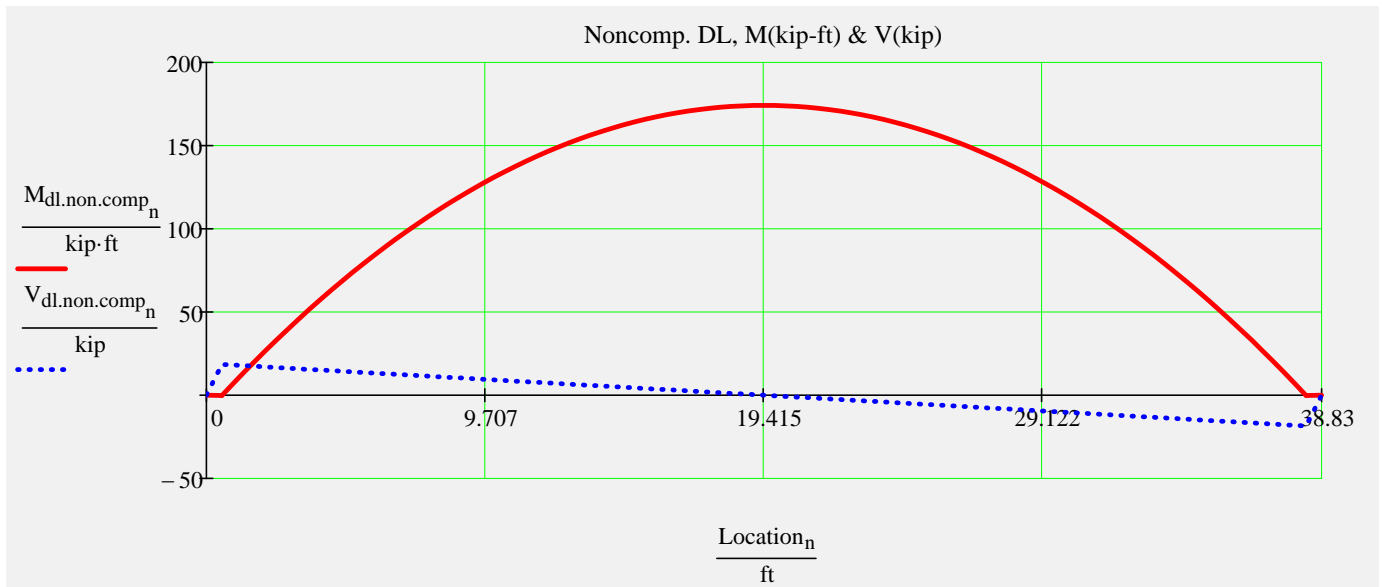


$$\max(M_{\text{release}}) = 102.4 \cdot \text{kip} \cdot \text{ft}$$

$$\max(V_{\text{release}}) = 10.6 \cdot \text{kip}$$



Noncomposite Dead Load Moments and Shear

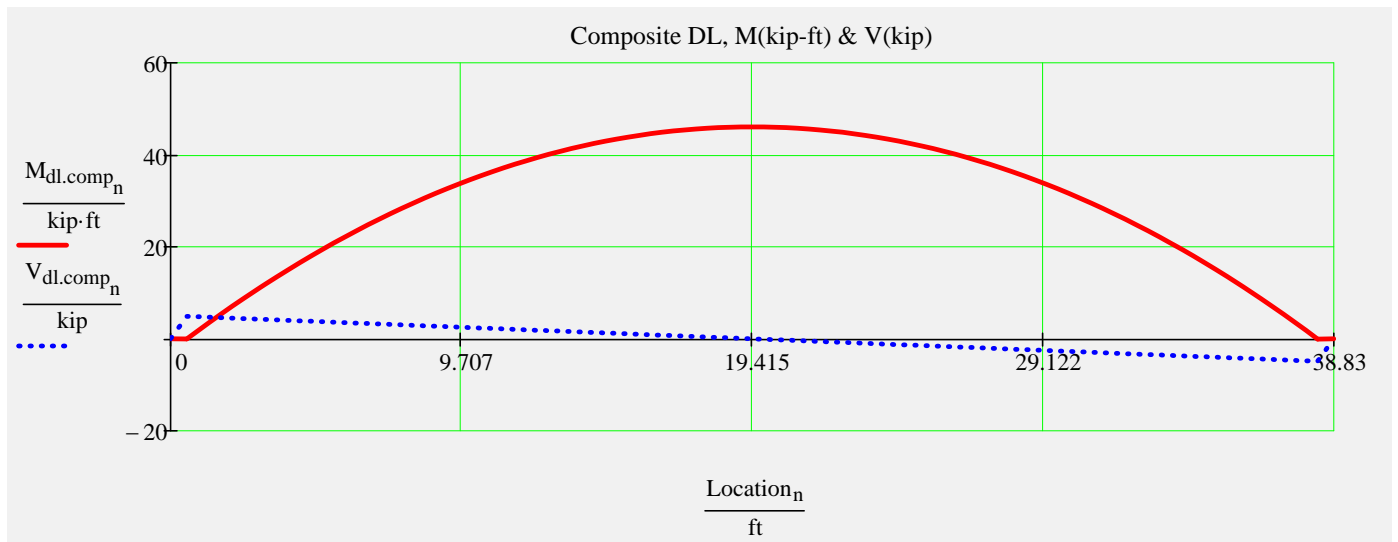


$$\max(M_{\text{dl.non.comp}}) = 174.2 \cdot \text{kip} \cdot \text{ft}$$

$$\max(V_{\text{dl.non.comp}}) = 18.4 \cdot \text{kip}$$



Composite Dead Load Moments and Shear

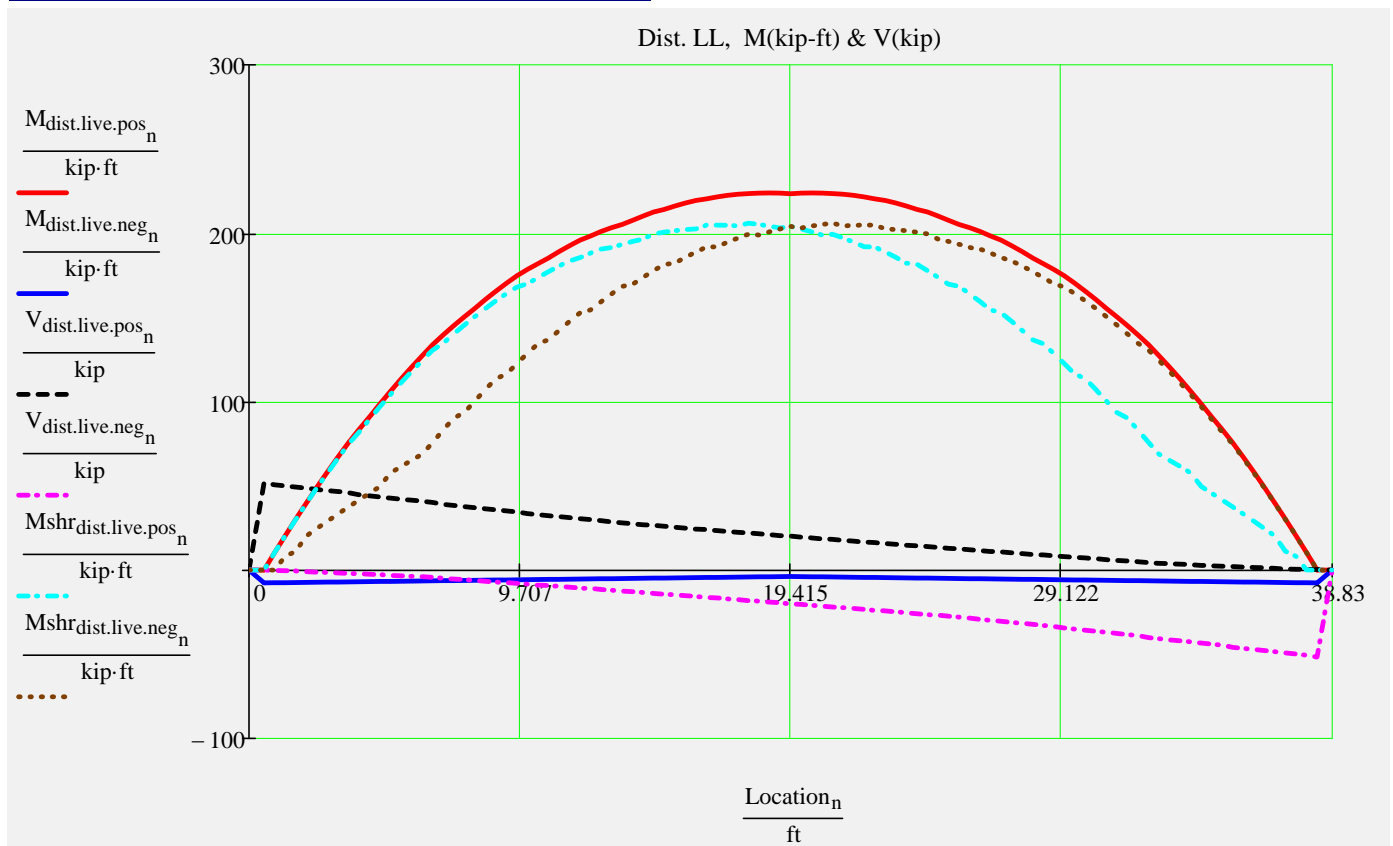


$$\max(M_{dl.comp}) = 46.1 \cdot \text{kip} \cdot \text{ft}$$

$$\max(V_{dl.comp}) = 4.9 \cdot \text{kip}$$



Distributed Live Load Moments and Shear



$$\max(M_{dist.live.pos}) = 223.9 \cdot \text{kip} \cdot \text{ft}$$

$$\min(M_{dist.live.neg}) = -7.7 \cdot \text{kip} \cdot \text{ft}$$

Beam End Reactions... with IM factor only

$$\text{Reaction}_{LL} = 52.82 \cdot \text{kip}$$

$$\max(V_{dist.live.pos}) = 51.8 \cdot \text{kip}$$

$$\max(M_{shr_{dist.live.pos}}) = 205.9 \cdot \text{kip} \cdot \text{ft}$$

$$\text{Reaction}_{DL} = 24 \cdot \text{kip}$$

Prestress Strand Layout Input

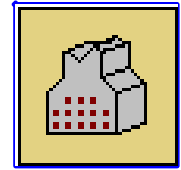
Instructions:

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 :=

Strand Pattern Generator:



Recalculate Worksheet

Read Strand Data

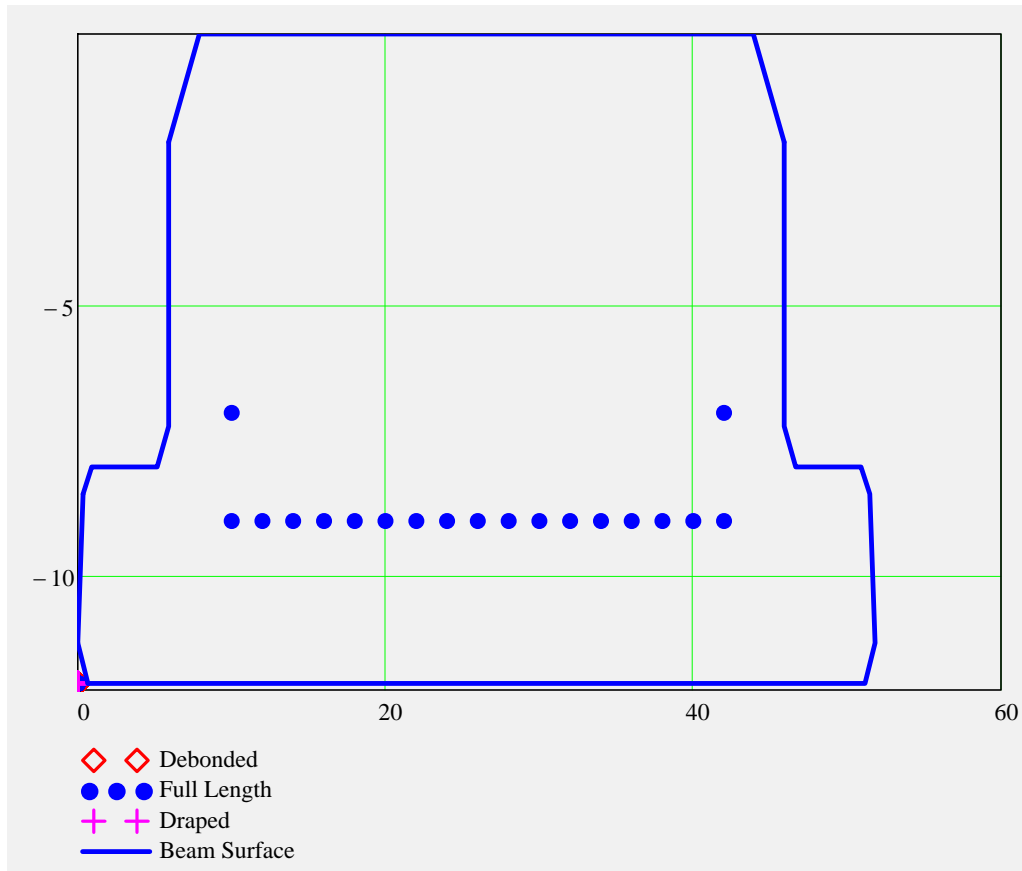
Collapsed Region for Custom Strand Sizes...

▾ 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

Partially Stressed Tendons ("Strand N")

PartialPS_{force} = 40·kip *partial prestress total force*

PartialPS_{force} := if (BeamTypeTog = "II", 20·kip, PartialPS_{force})

PartialPS_{force} = 40·kip

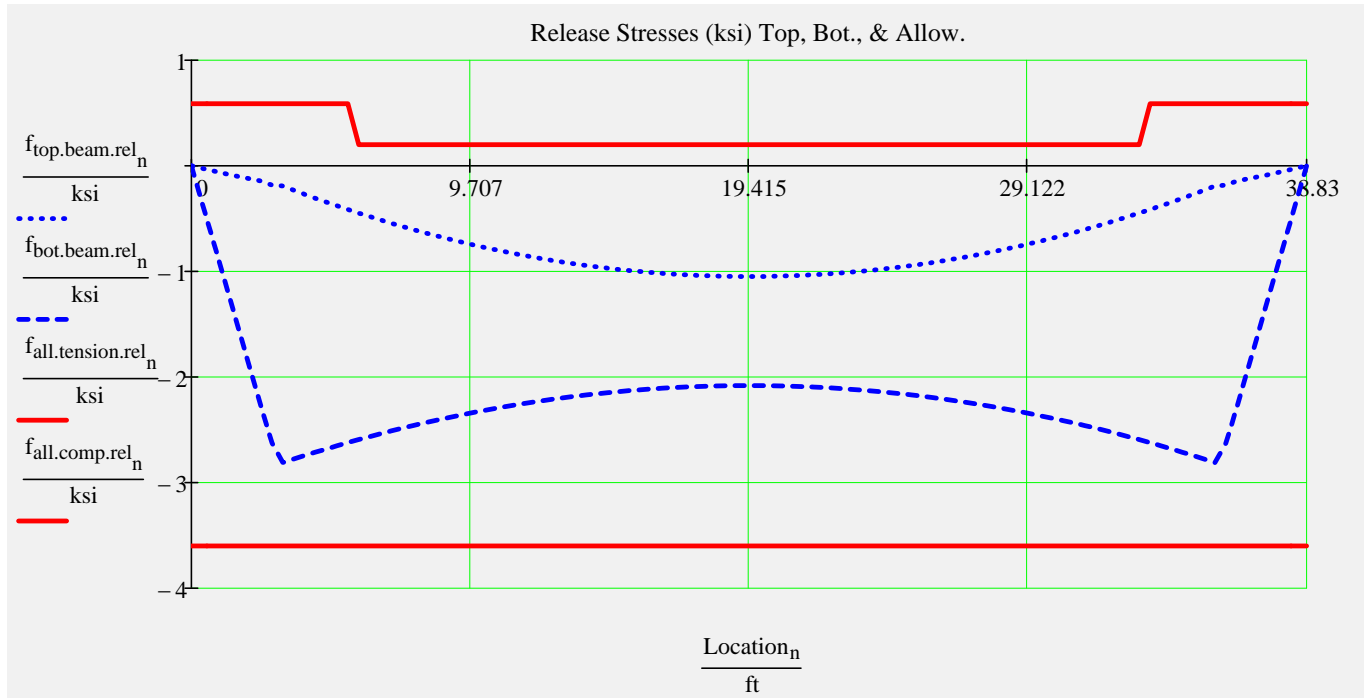
PartialPS_{location} = 1.4375in *centroid location of partial prestress from the top of the beam*

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

PartialPS_{location} = 3·in

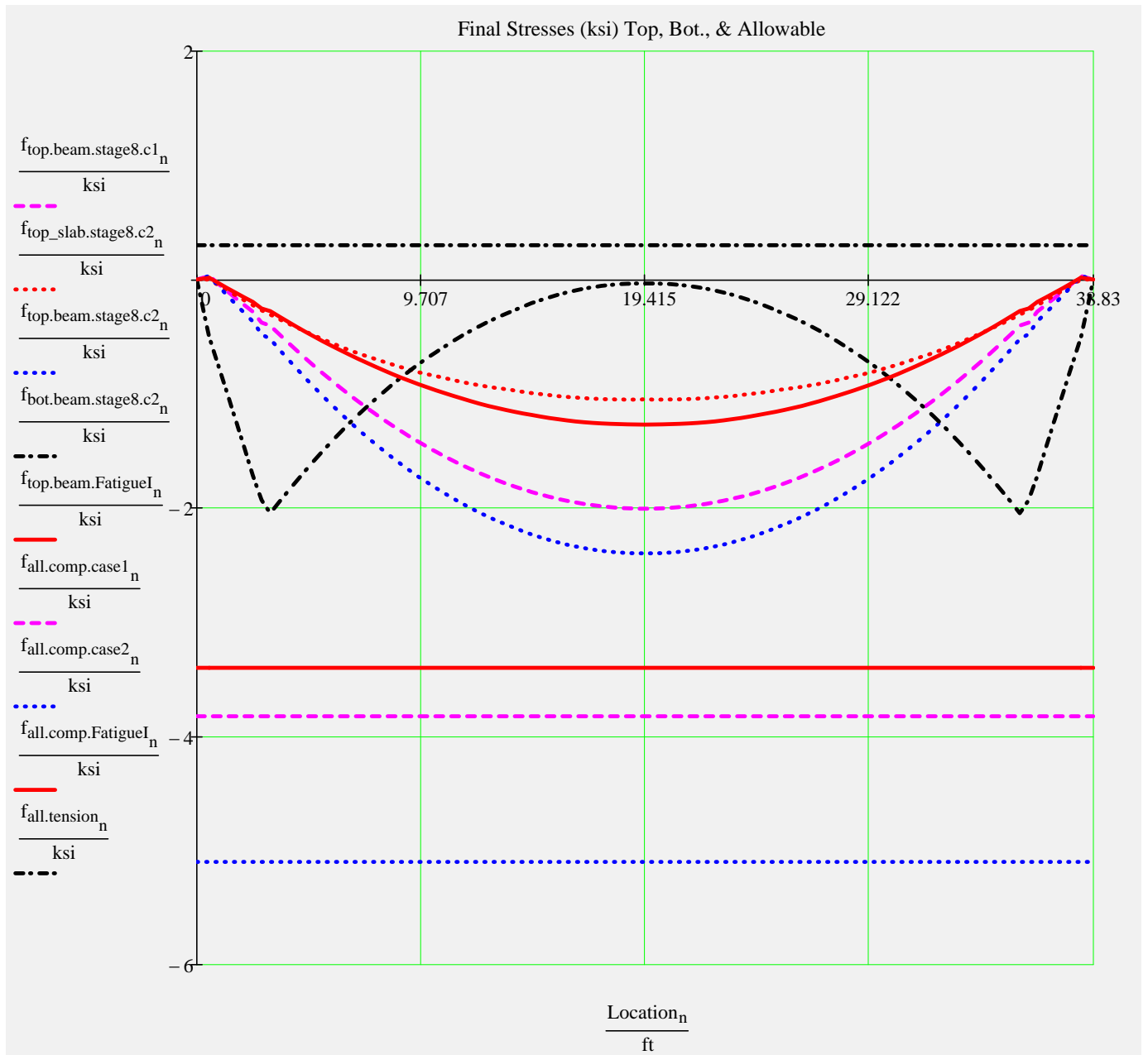
Section Properties & Strand Profile Properties

Release Stresses



▢ Prestress Force

Final Stresses



Release Checks & Final Checks for Capacity Ratio (CR)

Stress Checks

$$\min(CR_{f_{tension.rel}}) = 10$$

Check_ $f_{tension.rel}$ = "OK"

[\(Release tension\)](#)

$$\min(CR_{f_{comp.rel}}) = 1.28$$

Check_ $f_{comp.rel}$ = "OK"

[\(Release compression\)](#)

$$\min(CR_{f_{tension.stage8}}) = 10$$

Check_ $f_{tension.stage8}$ = "OK"

[\(Service III, PS + DL + LL*0.8\)](#)

$$\min(CR_{f_{comp.stage8.c1}}) = 1.91$$

Check_ $f_{comp.stage8.c1}$ = "OK"

[\(Service I, PS + DL\)](#)

$$\min(CR_{f_{comp.stage8.c2}}) = 2.13$$

Check_ $f_{comp.stage8.c2}$ = "OK"

[\(Service I, PS + DL + LL\)](#)

$$\min(CR_{f_{comp.FatigueI}}) = 2.68$$

Check_ $f_{comp.FatigueI}$ = "OK"

[\(Fatigue I, \(PS + DL\)*0.5 + 1.5 Fatigue Truck\)](#)

Strand Pattern Checks

CheckPattern0 = "OK"

check 0 - no debonded tendon in outside row

CheckPattern1 = "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)*

CheckPattern2 = "OK"

check 2 - less than 40% debonded tendons in any row

CheckPattern3 = "OK"

check 3 - less than 40% of debonded tendons terminated at same section

(LRFD 5.11.4.3)

CheckPattern4 = "OK"

check 4 - more than half beam depth debond length

(SDG 4.3.1)

Section and Strand Properties Summary

Section and Strand Properties Summary

$$A_{\text{beam}} = 521.75 \cdot \text{in}^2$$

Concrete area of beam

$$I_{\text{beam}} = 6355.6223 \cdot \text{in}^4$$

Gross Moment of Inertia of Beam about CG

$$y_{\text{comp}} = -3.37 \cdot \text{in}$$

Dist. from top of beam to CG of gross composite section

$$I_{\text{comp}} = 22691.6954 \cdot \text{in}^4$$

Gross Moment of Inertia Composite Section about CG

$$A_{\text{deck}} = 337.77 \cdot \text{in}^2$$

Concrete area of deck slab

$$A_{\text{ps}} = 4.1 \cdot \text{in}^2$$

total area of strands

$$d_{\text{b.ps}} = 0.6 \cdot \text{in}$$

diameter of Prestressing strand

$$\text{min}(\text{PrestressType}) = 0$$

0 - low lax 1 - stress relieved

$$f_{\text{py}} = 243 \cdot \text{ksi}$$

tendon yield strength

$$f_{\text{pj}} = 203 \cdot \text{ksi}$$

prestress jacking stress

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

$$A_{\text{ps.row}}^T = (3.7 \ 0.4 \ 0.2) \cdot \text{in}^2$$

$$d_{\text{ps.row}} =$$

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|----|----|----|----|----|----|----|----|----|-----|
| 0 | -9 | -9 | -9 | -9 | -9 | -9 | -9 | -9 | -9 | -9 |
| 1 | -7 | -7 | -7 | -7 | -7 | -7 | -7 | -7 | -7 | -7 |
| 2 | -3 | -3 | -3 | -3 | -3 | -3 | -3 | -3 | -3 | ... |

·in

TotalNumberOfTendons = 19

StrandSize = "0.6 in low lax"

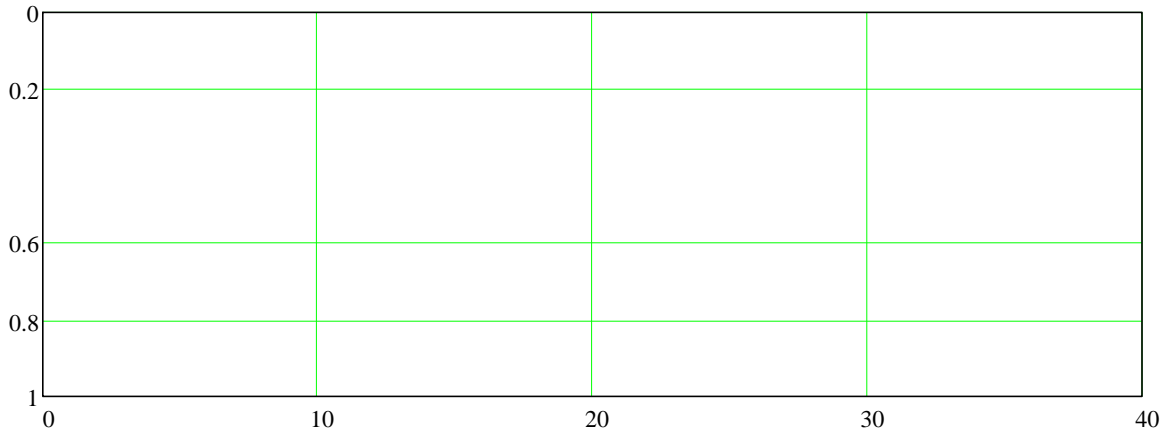
NumberOfDebondedTendons = 0

StrandArea = $0.22 \cdot \text{in}^2$

NumberOfDrapedTendons = 0

JackingForce_{per.strand} = 43.94·kip

Location of Depressed Strands



▣ Section and Strand Properties Summary

Prestress Losses Summary

$f_{pj} = 202.5 \cdot \text{ksi}$ Check_ $f_{pt} = \text{"OK"}$

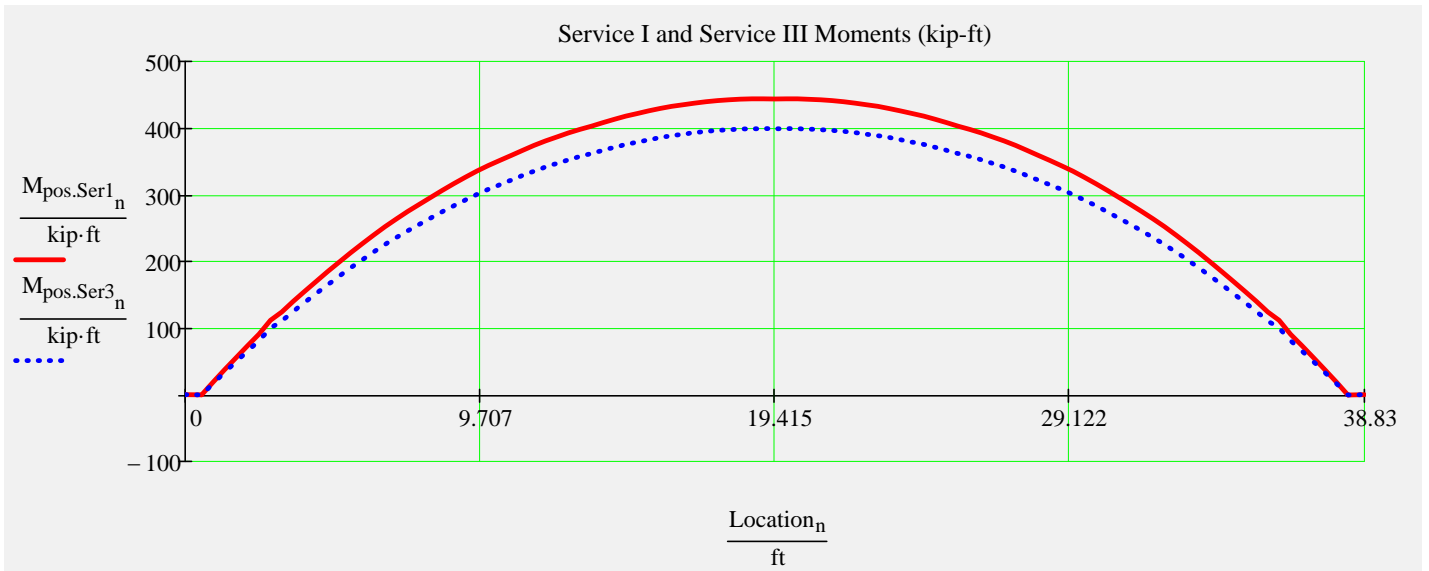
$\Delta f_{pES} = 0 \cdot \text{ksi}$ *Note: Elastic shortening losses are zero in concrete stress calculations when using transformed section properties per LRFD 5.9.5.2.3*

$\Delta f_{pT} = -21 \cdot \text{ksi}$ $\frac{\Delta f_{pT}}{f_{pj}} = -10.57 \cdot \%$

$f_{pe} = 181 \cdot \text{ksi}$ $\frac{f_{pe}}{f_{pj}} = 89.43 \cdot \%$

$0.8 \cdot f_{py} = 194 \cdot \text{ksi}$ Check_ $f_{pe} = \text{"OK"}$

Service Limit State Moments



$\max(M_{\text{pos.Ser1}}) = 443.9 \cdot \text{kip-ft}$

$\max(M_{\text{pos.Ser3}}) = 399.2 \cdot \text{kip-ft}$

Summary of Values at Midspan

$$\text{Stresses} = \begin{pmatrix} \text{"Stage"} & \text{"Top of Beam (ksi)} & \text{"Bott of Beam (ksi)} \\ 1 & -1.05 & -2.08 \\ 2 & -1.07 & -1.75 \\ 4 & -1 & -1.81 \\ 6 & -1.93 & -1.02 \\ 8 & -2.4 & -0.04 \end{pmatrix}$$

$$\text{PrestressForce} = \begin{pmatrix} \text{"Condition"} & \text{"Axial (kip)} & \text{"Moment (kip*ft)} \\ \text{"Release"} & -874.9 & -156.9 \\ \text{"Final (about composite centroid)} & -782.4 & -134 \end{pmatrix}$$

$$\text{Properties} = \begin{pmatrix} \text{"Section"} & \text{"Area (in^2)} & \text{"Inertia (in^4)} & \text{"distance to centroid from top of bm (in)} \\ \text{"Net Beam"} & 517.43 & 6327.91 & -6.37 \\ \text{"Transformed Beam (initial)} & 544.7 & 6497.53 & -6.48 \\ \text{"Transformed Beam"} & 541.74 & 6479.7 & -6.47 \\ \text{"Composite"} & 885.89 & 23557.21 & -3.43 \end{pmatrix}$$

$$\text{ServiceMoments} = \begin{pmatrix} \text{"Type"} & \text{"Value (kip*ft)} \\ \text{"Release"} & 102.4 \\ \text{"Non-composite (includes bm wt.)"} & 174.2 \\ \text{"Composite"} & 46.1 \\ \text{"Distributed Live Load"} & 223.4 \end{pmatrix}$$

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

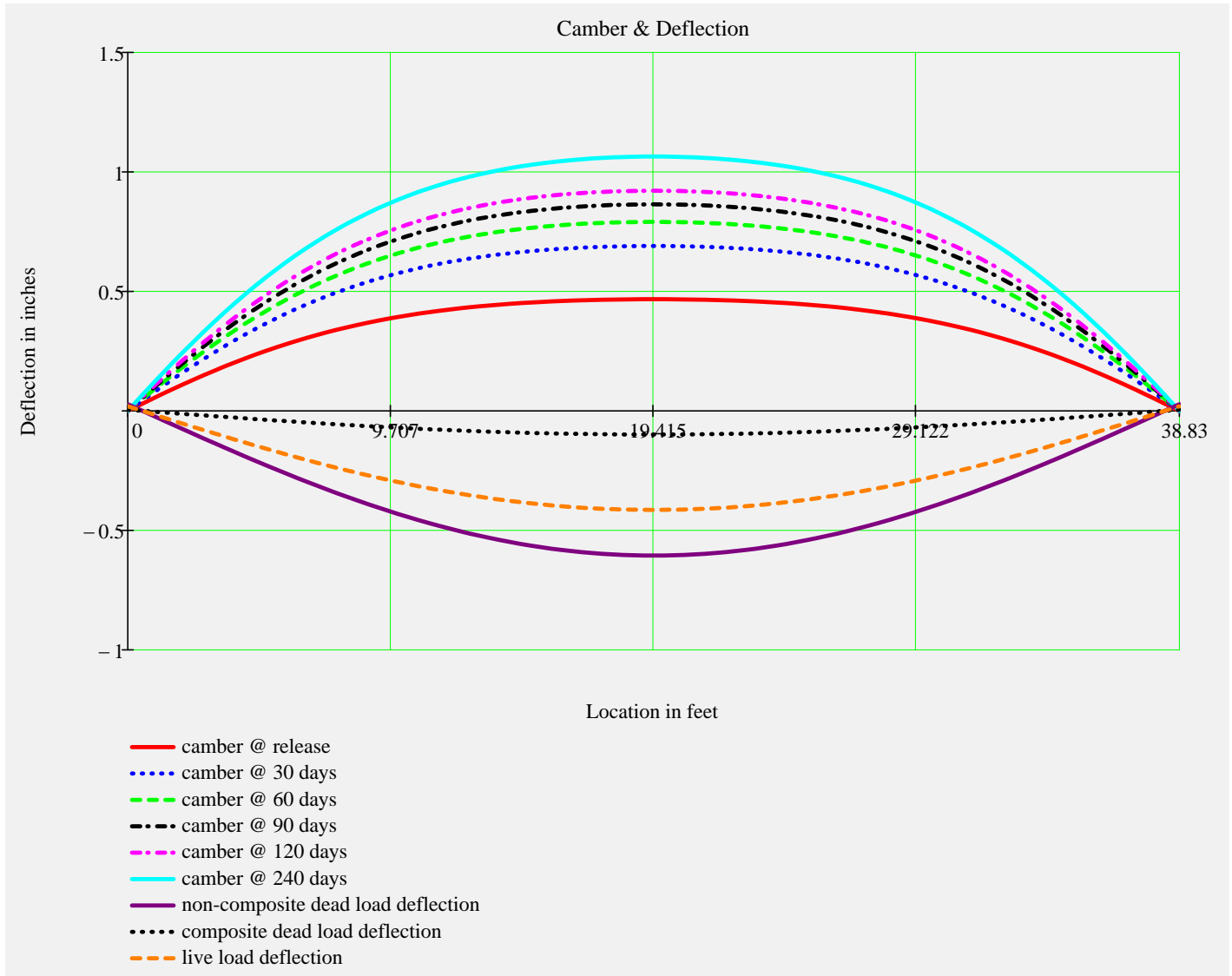
Stage 2 ---> Same as release with the addition of the remaining prestress losses applied to the transformed beam

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

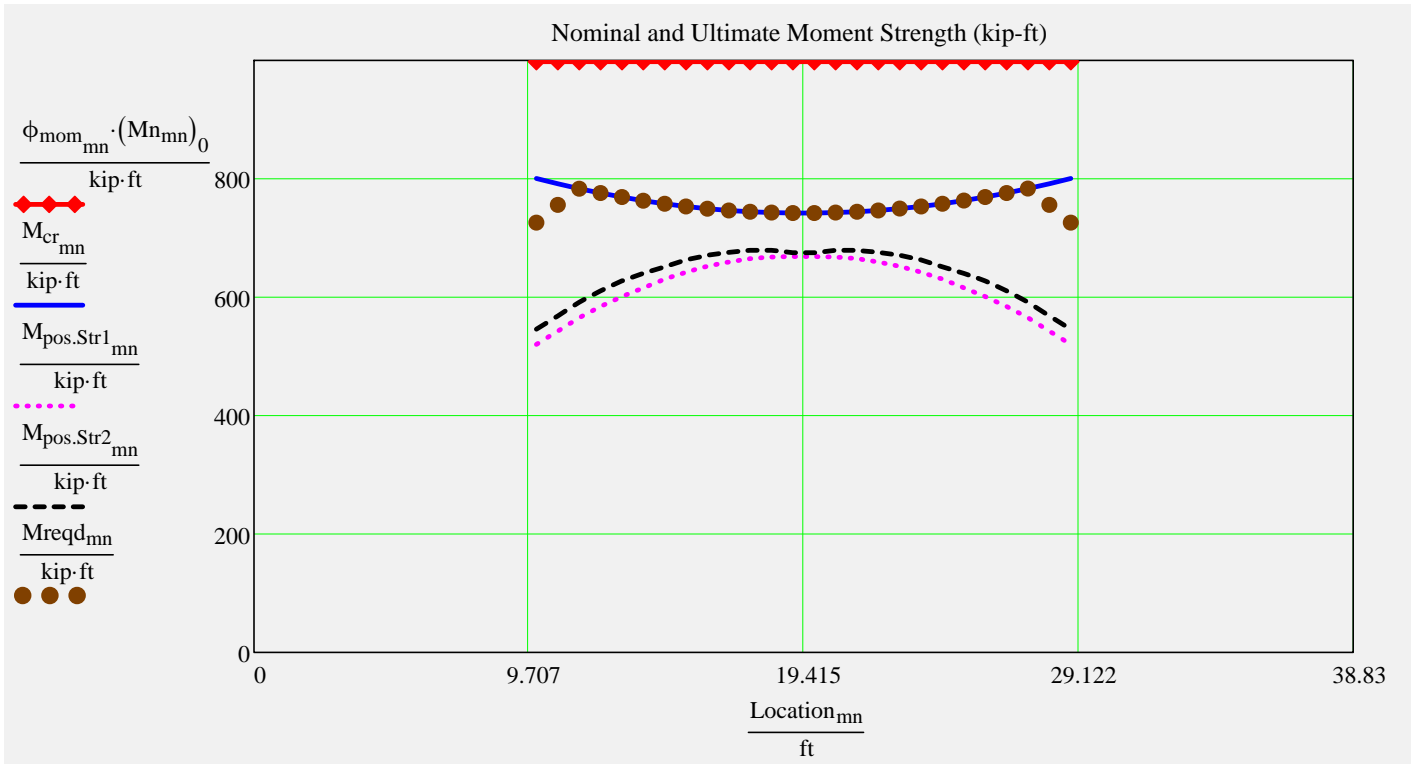
Stage 8 ---> Stage 6 with the addition of composite dead load and live loads applied to the composite section

Camber, Shrinkage, and Dead Load Deflection Components



| "Stage" | "Change in L @ Top (in)" | "Change in L @ Bot. (in)" | "Slope at End (deg)" | "midspan defl (in)" |
|---------------|--------------------------|---------------------------|----------------------|---------------------|
| "Release" | -0.0673 | -0.2276 | 0.2794 | 0.4673 |
| "30 Days" | -0.1791 | -0.439 | 0.4849 | 0.6901 |
| "60 Days" | -0.2203 | -0.517 | 0.5643 | 0.791 |
| "90 Days" | -0.2417 | -0.5576 | 0.6056 | 0.8644 |
| "120 Days" | -0.2549 | -0.5824 | 0.6309 | 0.9213 |
| "240 Days" | -0.2788 | -0.6277 | 0.677 | 1.0645 |
| "non-comp DL" | -0.0553 | 0.0473 | -0.2452 | -0.6054 |
| "comp DL" | -0.0048 | 0.012 | -0.0401 | -0.099 |
| "LL" | -0.0205 | 0.0511 | -0.171 | -0.4144 |

Strength Limit State Moments



$$CR_{Str.mom_n} := 10 \quad CR_{Str.mom_{mn}} := \frac{\phi_{mom_{mn}} \cdot (Mn_{mn})_0}{M_{reqd_{mn}}} \quad (LRFD\ 5.7.3.3.2) \quad \min(CR_{Str.mom}) = 1.27$$

$$\max(M_{reqd}) = 783.4 \cdot \text{kip-ft}$$

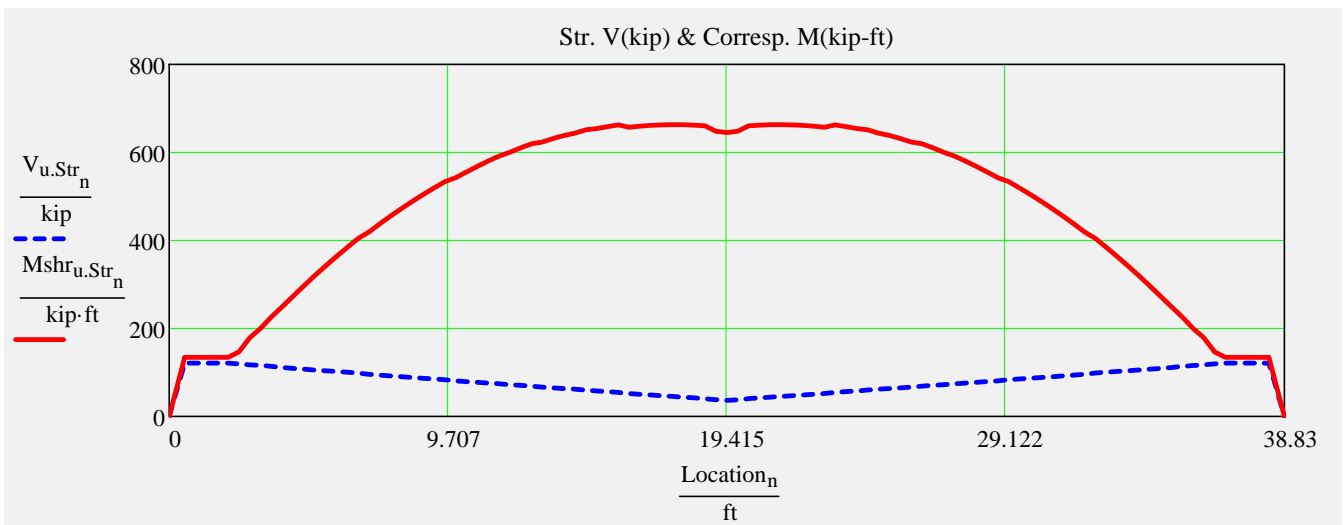
$$CheckMomentCapacity := \text{if}(\min(CR_{Str.mom}) > 0.99, "OK", "No Good!")$$

CheckMomentCapacity = "OK"

FSB only - Design Check of Transverse reinforcing Bars E

Shear Analysis

Strength Shear and Associated Moments



$$\max(V_{u.Str}) = 120.9 \cdot \text{kip}$$

$$\max(M_{shr_u.Str}) = 662.9 \cdot \text{kip-ft}$$

Design Shear, Longitudinal, Interface and Anchorage Reinforcement

Stirrup sizes and spacings assigned in input file

| <u>Location</u> | <u>spacing</u> | <u>Number of Spaces</u> | <u>area per stirrup</u> |
|-------------------|---|---|---|
| <u>A1 stirrup</u> | $\text{tmp_s} = \begin{pmatrix} 6 \\ 18 \\ 18 \\ 18 \\ 18 \\ 18 \\ 18 \\ 18 \end{pmatrix} \cdot \text{in}$ | $\text{tmp_NumberSpaces} = \begin{pmatrix} 8 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 0 \end{pmatrix}$ | $\text{tmp_A}_{\text{stirrup}} = \begin{pmatrix} 0.8 \\ 0.8 \\ 0.8 \\ 0.8 \\ 0.8 \\ 0.8 \\ 0.8 \\ 0.8 \end{pmatrix} \cdot \text{in}^2$ |
| <u>A2 stirrup</u> | | | |
| <u>A3 stirrup</u> | | | |
| <u>S1 stirrup</u> | | | |
| <u>S2 stirrup</u> | | | |
| <u>S3 stirrup</u> | | | |
| <u>S4 stirrup</u> | | | |

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.

| | <u>user_s_nspacings :=</u> | <u>user_NumberSpaces_nspacings :=</u> | <u>user_A_{stirrup}_nspacings :=</u> | <u>interface_factor_nspacings :=</u> |
|-------------------|--------------------------------------|---|--|--|
| <u>A1 stirrup</u> | -1 · in | -1 | -1 · in ² | 0.25 |
| <u>A2 stirrup</u> | -1 · in | -1 | -1 · in ² | 0.5 |
| <u>A3 stirrup</u> | -1 · in | -1 | -1 · in ² | 1 |
| <u>S1 stirrup</u> | -1 · in | -1 | -1 · in ² | 1 |
| <u>S2 stirrup</u> | -1 · in | -1 | -1 · in ² | 1 |
| <u>S3 stirrup</u> | -1 · in | -1 | -1 · in ² | 1 |
| <u>S4 stirrup</u> | -1 · in | -1 | -1 · in ² | 1 |

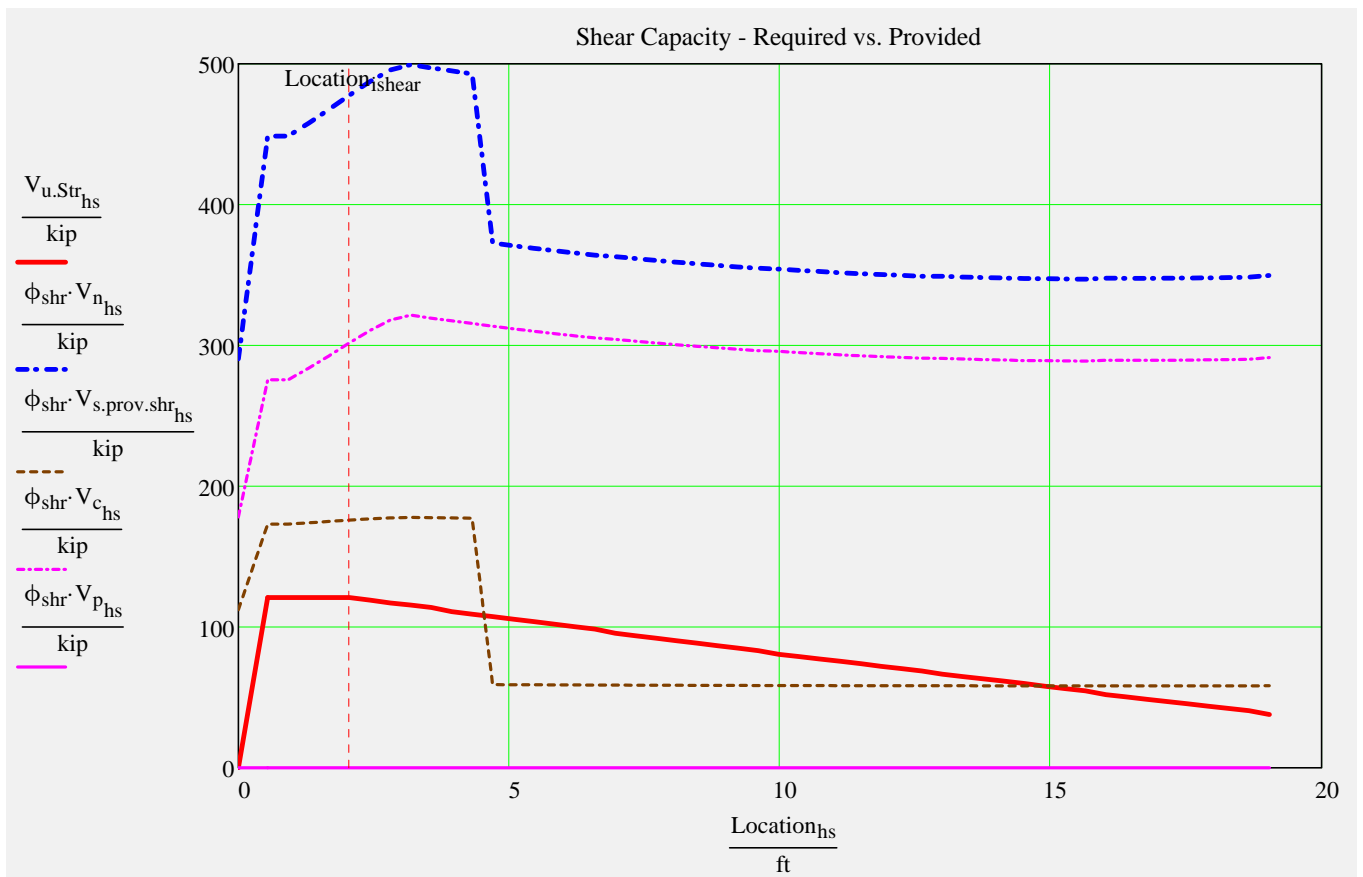
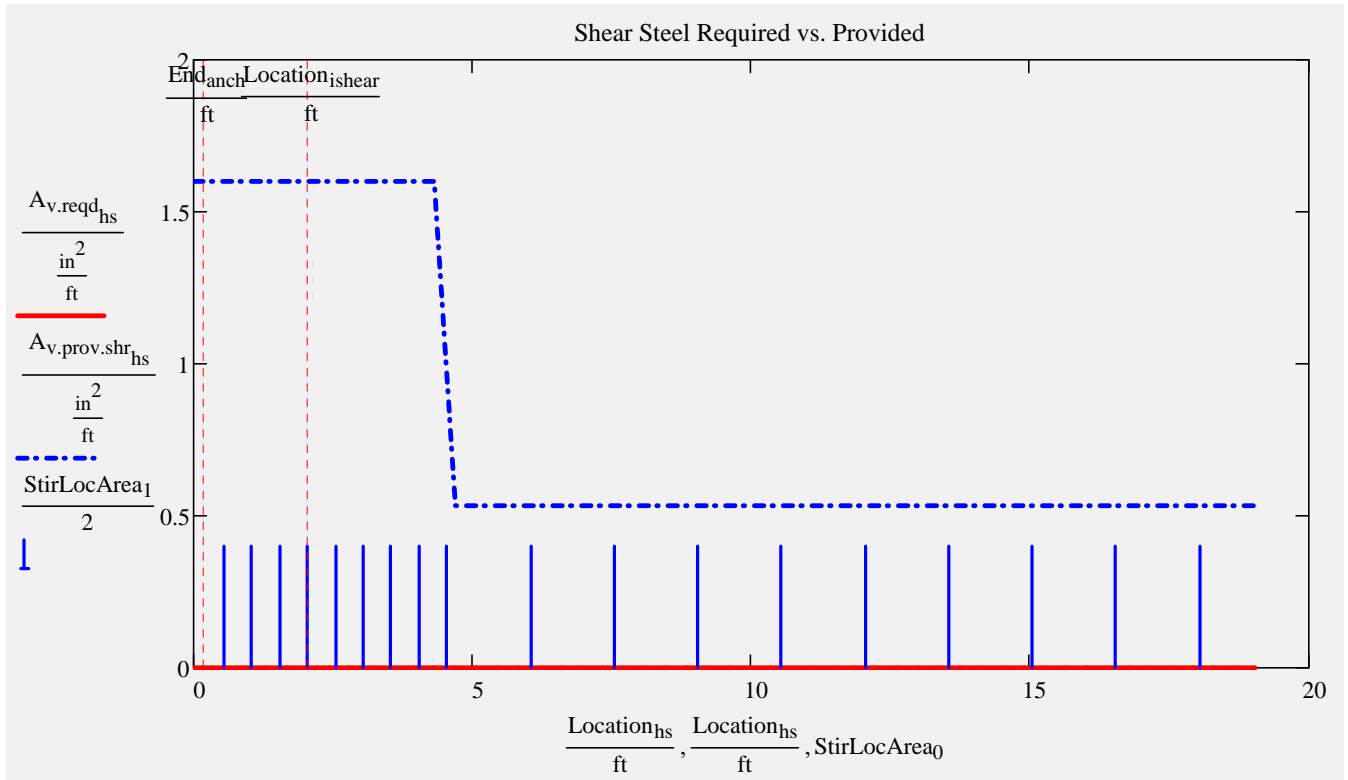
Recalculate Worksheet

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.

| | | | | |
|-------------------|---|---|---|---------------------|
| <u>A1 stirrup</u> | $s = \begin{pmatrix} 6 \\ 18 \\ 18 \\ 18 \\ 18 \\ 18 \\ 18 \\ 18 \end{pmatrix} \cdot \text{in}$ | $\text{NumberSpaces} = \begin{pmatrix} 8 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 4.92 \end{pmatrix}$ | $A_{\text{stirrup}} = \begin{pmatrix} 0.8 \\ 0.8 \\ 0.8 \\ 0.8 \\ 0.8 \\ 0.8 \\ 0.8 \\ 0.8 \end{pmatrix} \cdot \text{in}^2$ | EndCover = 6.5 · in |
| <u>A2 stirrup</u> | | | | |
| <u>A3 stirrup</u> | | | | |
| <u>S1 stirrup</u> | | | | |
| <u>S2 stirrup</u> | | | | |
| <u>S3 stirrup</u> | | | | |
| <u>S4 stirrup</u> | | | | |



Computation for Checks

CheckShearCapacity = "OK"

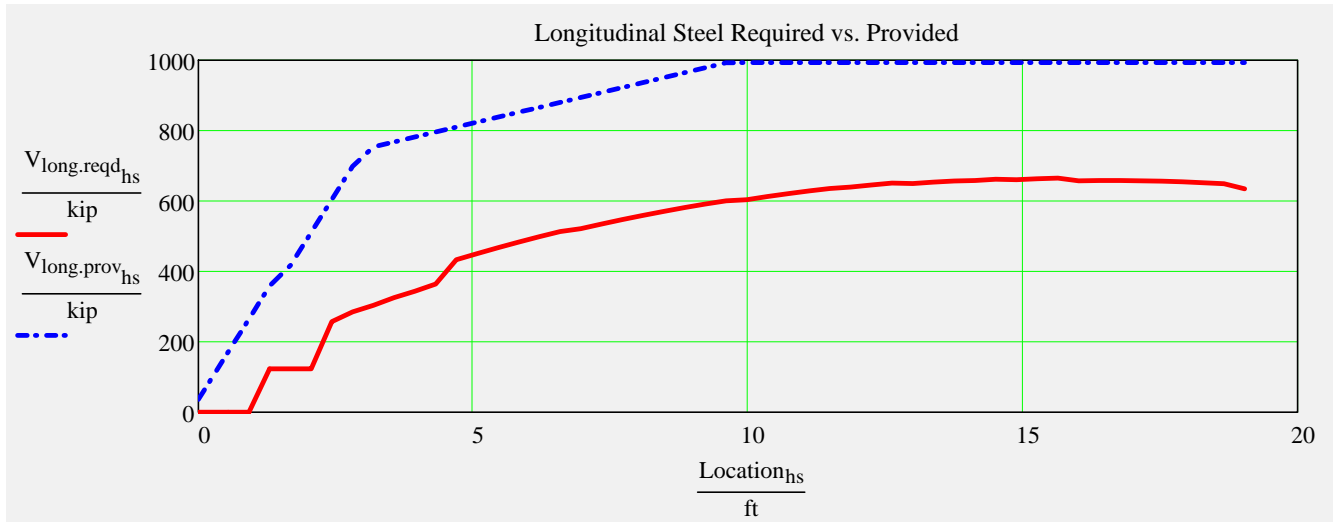
CheckMaxShearStress = "OK"

CheckStirArea = "OK"

CheckMinStirArea = "OK"

CheckMaxStirSpacing = "OK"

Longitudinal Reinforcement



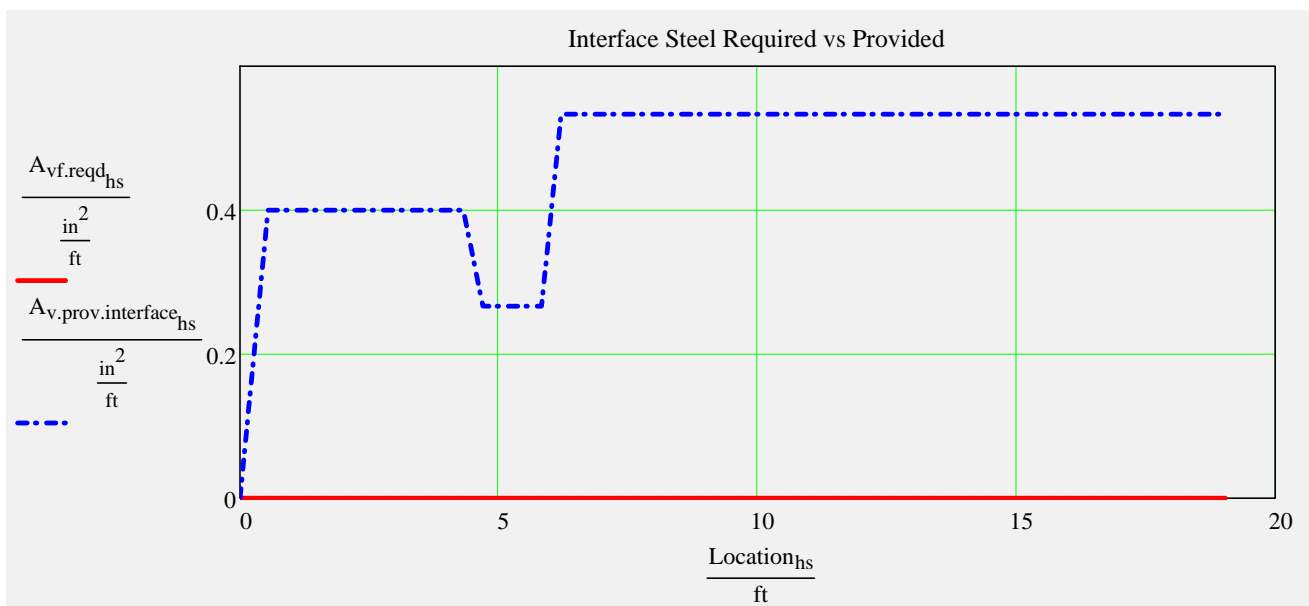
$$CR_{LongSteel}_{hs} := \text{if} \left(V_{long.reqd}_{hs} < .01kip, 100, \frac{V_{long.prov}_{hs}}{V_{long.reqd}_{hs}} \right)$$

$$\min(CR_{LongSteel}) = 1.49$$

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

CheckLongSteel = "OK"

Interface Sheer Reinforcement



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.

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

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

If max(Avf.min) or max(Avf.des) is greater than 0 in²/ft, interface steel is required.

CheckInterfaceSpacing = "OK"

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

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

CheckInterfaceSteel = "OK"

Anchorage Reinforcement and Maximum Prestressing Force

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

StandardSplittingReinforcing :=

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

CheckSplittingSteel = "N.A."

CheckMaxPrestressingForce = "OK"

Summary of Design Checks

- check0 := AcceptAASHTO
 - check1 := AcceptSDG
 - check2 := AcceptOntario
 - check3 := Check_fpt
 - check4 := Check_fpe
 - check5 := Check_ftension.rel
 - check6 := Check_fcomp.rel
 - check7 := Check_ftension.stage8
 - check8 := Check_fcomp.stage8.c1
 - check9 := Check_fcomp.stage8.c2
 - check10 := Check_fcomp.FatigueI
 - check11 := CheckMomentCapacity
 - check12 := CheckMaxCapacity
 - check13 := CheckStirArea
 - check14 := CheckShearCapacity
 - check15 := CheckMinStirArea
 - check16 := CheckMaxStirSpacing
 - check17 := CheckLongSteel
 - check18 := CheckInterfaceSpacing
 - check19 := CheckSplittingSteel
 - check20 := CheckMaxPrestressingForce
 - check21 := CheckPattern0
 - check22 := CheckPattern1
 - check23 := CheckPattern2
 - check24 := CheckPattern3
 - check25 := CheckPattern4
 - check26 := CheckInterfaceSteel
 - check27 := CheckStrandFit
 - check28 := Check_SDG1.2.Display₂
- [Link to Note- Checks, 0, 1 & 2](#)



| | | | | | |
|----------------------|------|--------|--------|------|-----|
| check ^T = | 0 | 1 | 2 | 3 | 4 |
| 0 | "OK" | "N.A." | "N.A." | "OK" | ... |

[click table to reveal scroll bar...](#)

TotalCheck = "OK"

LRFR Load Rating Analysis

FDOT Maintenance Office Bridge Load Rating Manual

Load Rating Computations

| | | Moment (Strength) or Stress (Service) | | | | | Shear (Strength) | | | | |
|------------------------------|--|---------------------------------------|------|----------|--------|-----------|------------------|----------|--------|-----------|---------|
| LRFR _{loadrating} = | | "Limit State" | "DF" | "Rating" | "Tons" | "Dim(ft)" | "DF" | "Rating" | "Tons" | "Dim(ft)" | |
| | | "Strength I(Inv)" | 0.33 | 1.84 | "N/A" | 18.50 | 0.62 | 4.64 | "N/A" | 4.15 | HL-93 |
| | | "Strength I(Op)" | 0.33 | 2.39 | "N/A" | 18.50 | 0.62 | 6.01 | "N/A" | 4.15 | HL-93 |
| | | "Service III(Inv)" | 0.33 | 1.40 | "N/A" | 18.50 | "N/A" | "N/A" | "N/A" | "N/A" | HL-93 |
| | | "Service III(Op)" | 0.33 | 1.93 | "N/A" | 18.50 | "N/A" | "N/A" | "N/A" | "N/A" | HL-93 |
| | | "Strength II" | 0.33 | 1.79 | 107.26 | 16.99 | 0.62 | 4.14 | 248.64 | 4.15 | *Permit |

*note: default permit load is FL120 per input worksheet

Longitudinal Steel Check:

CR_{LongSteel.HL93} = 1.58

CR_{LongSteel.Permit} = 1.49

CheckLongSteel_{loadrating} = "OK"

Write Data Out

LRFD Prestressed Beam Program

Project = "D30015 40 FT LR Int Bm"

DesignedBy = "GW"

Date = "07/25/2016"

filename = "C:\FDOT Structures\Programs\LRFDBeamV5.0\FSB Data Files\D30015 40 FT LR Int Bm.dat"

Comment = "FSB12x52 40 ft span"

Legend

TanHighlight = DataEntry

YellowHighlight = CheckValues

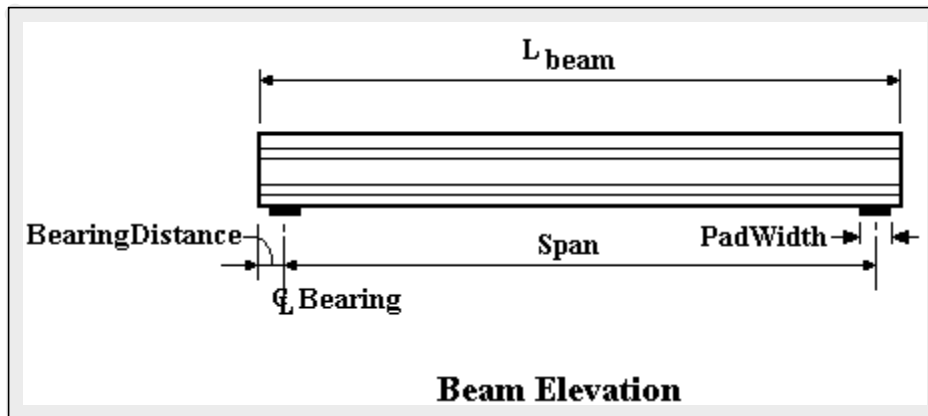
GreyHighlight = UserComments + Graphs

BlackText = ProgramEquations

Maroon Text = Code Reference

Blue Text = Commentary

Bridge Layout and Dimensions



$L_{\text{beam}} = 38.83\text{-ft}$

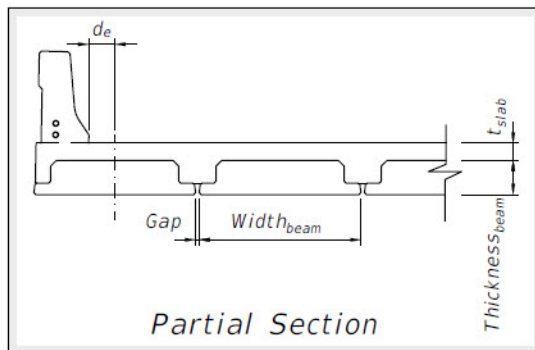
$\text{Span} = 37.75\text{-ft}$

$\text{BearingDistance} = 6.5\text{-in}$

$\text{PadWidth} = 8\text{-in}$

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.



Mild Steel:

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

Permit Loads

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

$$\text{PermitAxleLoad}^T = (13.33 \quad 53.33 \quad 53.33) \cdot \text{kip}$$

$$\text{PermitAxleSpacing}^T = (0 \quad 14 \quad 14 \quad 0) \cdot \text{ft}$$

Distribution Factors

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

calculated values:

$$\text{tmp_gmom} = 0.4 \quad \text{tmp_gshear} = 0.53 \quad \text{tmp_gmom.fatigue} = 0.24$$

user value overrides (optional):

$$\text{user_gmom} := 0.288 \quad \text{user_gshear} := 0.477 \quad \text{user_gmom.fatigue} := 0$$

value check

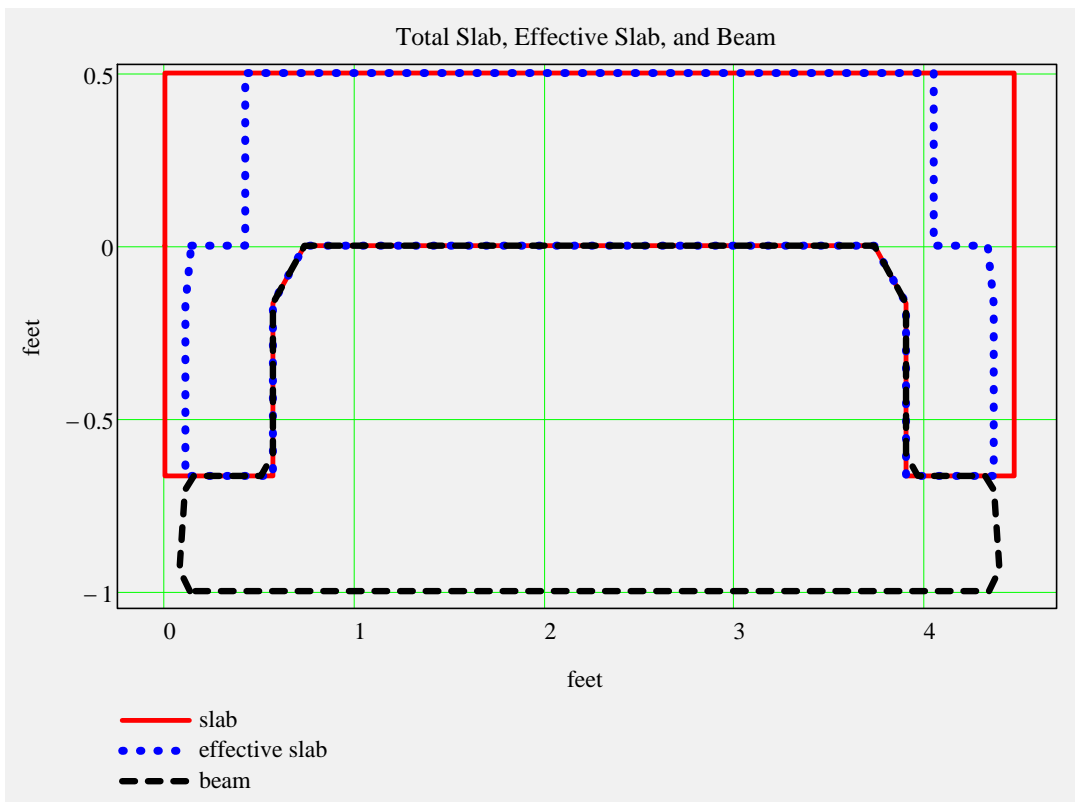
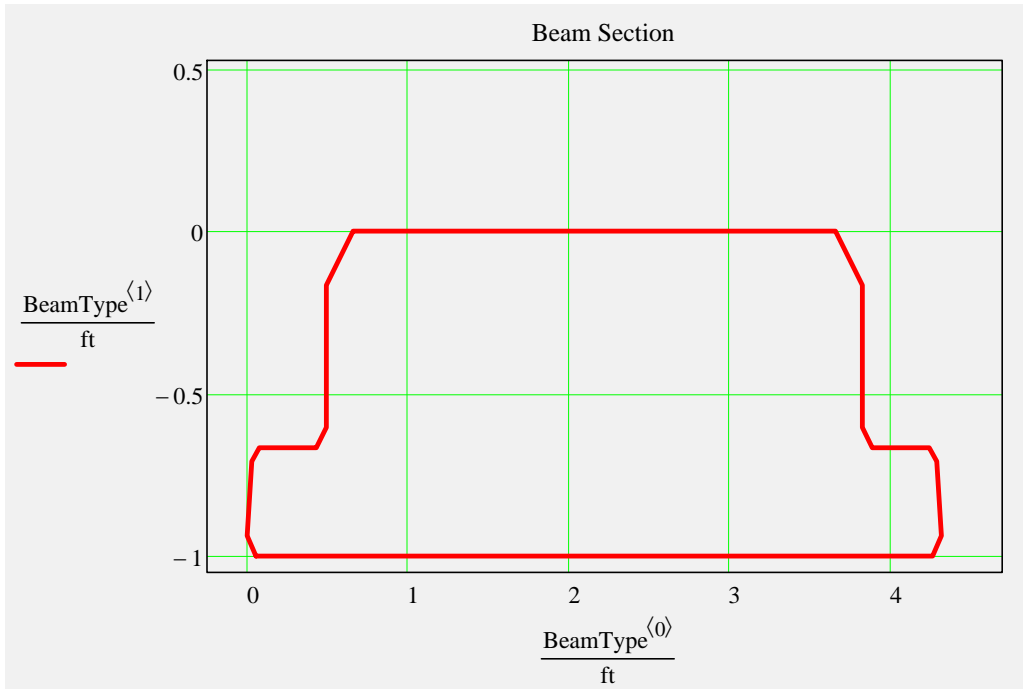
$$\text{gmom} := \text{if}(\text{user_gmom} \neq 0, \text{user_gmom}, \text{tmp_gmom}) \quad \text{gmom} = 0.29$$

$$\text{gshear} := \text{if}(\text{user_gshear} \neq 0, \text{user_gshear}, \text{tmp_gshear}) \quad \text{gshear} = 0.48$$

$$\text{gmom.fatigue} := \text{if}(\text{user_gmom.fatigue} \neq 0, \text{user_gmom.fatigue}, \text{tmp_gmom.fatigue}) \quad \text{gmom.fatigue} = 0.24$$



Section Views



Non-Composite Dead Load Input:

$$w_{\text{slab}} = 0.453 \cdot \frac{\text{kip}}{\text{ft}} \quad w_{\text{beam}} = 0.543 \cdot \frac{\text{kip}}{\text{ft}} \quad w_{\text{forms}} = 0 \cdot \frac{\text{kip}}{\text{ft}}$$

$$\text{Add_}w_{\text{noncomp}} := 0.0 \cdot \frac{\text{kip}}{\text{ft}}$$

additional non composite dead load (positive or negative)
note: not saved to data file, may be saved to Mathcad worksheet.

$$w_{\text{noncomposite}} := w_{\text{slab}} + w_{\text{beam}} + w_{\text{forms}} + \text{Add_}w_{\text{noncomp}}$$

$$w_{\text{noncomposite}} = 0.997 \cdot \frac{\text{kip}}{\text{ft}}$$

$$w_{\text{bnoncomposite}} := w_{\text{slab}} + w_{\text{forms}} + \text{Add_}w_{\text{noncomp}}$$

$$w_{\text{bnoncomposite}} = 0.453 \cdot \frac{\text{kip}}{\text{ft}}$$

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

$$\text{EndDiaphragmA} := 0 \cdot \text{kip} \quad \text{begin bridge}$$

$$\text{IntDiaphragmB} := 0 \cdot \text{kip}$$

input load is per beam

$$\text{DistB} := 0 \cdot \text{ft}$$

$$\text{EndDiaphragmE} := 0 \cdot \text{kip} \quad \text{end bridge}$$

$$\text{IntDiaphragmC} := 0 \cdot \text{kip}$$

Longitudinal Distance B, C, & D - Measured from CL Bearing at begin bridge

$$\text{DistC} := 0 \cdot \text{ft}$$

$$\text{IntDiaphragmD} := 0 \cdot \text{kip}$$

$$\text{DistD} := 0 \cdot \text{ft}$$

Composite Dead Load Input:

$$w_{\text{future.ws}} = 0.067 \cdot \frac{\text{kip}}{\text{ft}} \quad w_{\text{barrier}} = 0.215 \cdot \frac{\text{kip}}{\text{ft}}$$

$$\text{Add_}w_{\text{comp}} := 0.0 \cdot \frac{\text{kip}}{\text{ft}}$$

additional composite dead load (positive or negative)
note: not saved to data file, may be saved to Mathcad worksheet

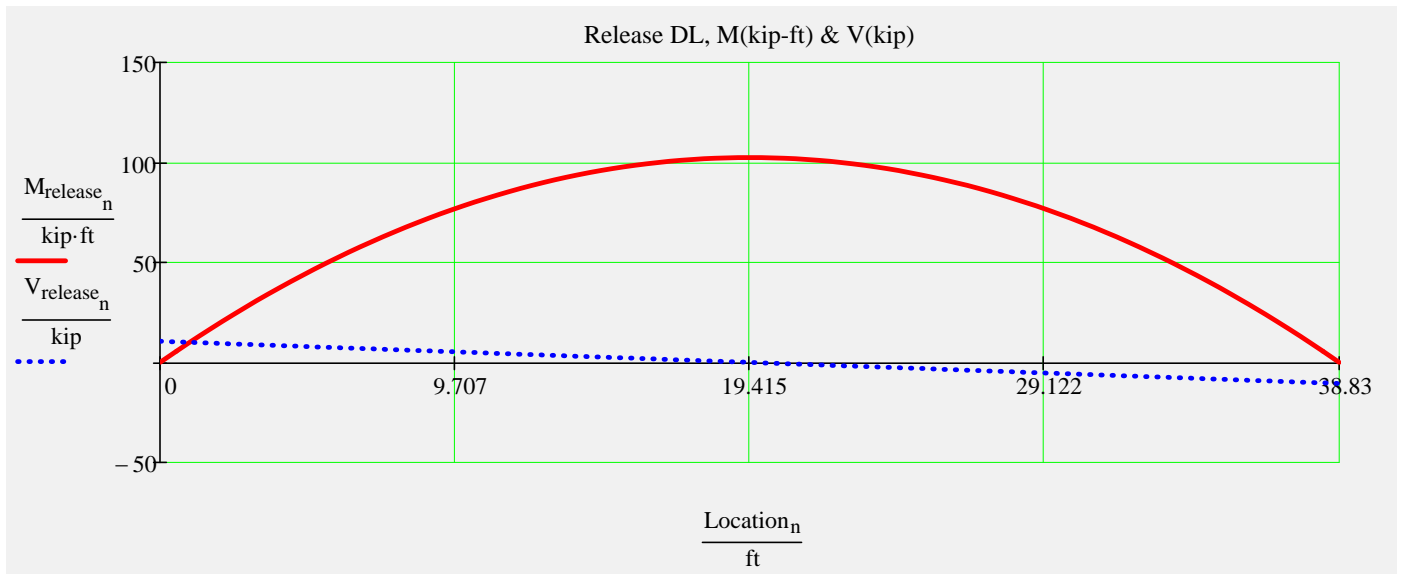
$$w_{\text{composite}} := w_{\text{future.ws}} + w_{\text{barrier}} + \text{Add_}w_{\text{comp}}$$

$$w_{\text{composite}} = 0.282 \cdot \frac{\text{kip}}{\text{ft}}$$

$$w_{\text{comp.str}} := w_{\text{barrier}} + \text{Add_}w_{\text{comp}}$$

$$w_{\text{comp.str}} = 0.215 \cdot \frac{\text{kip}}{\text{ft}}$$

Release Dead Load Moments and Shear

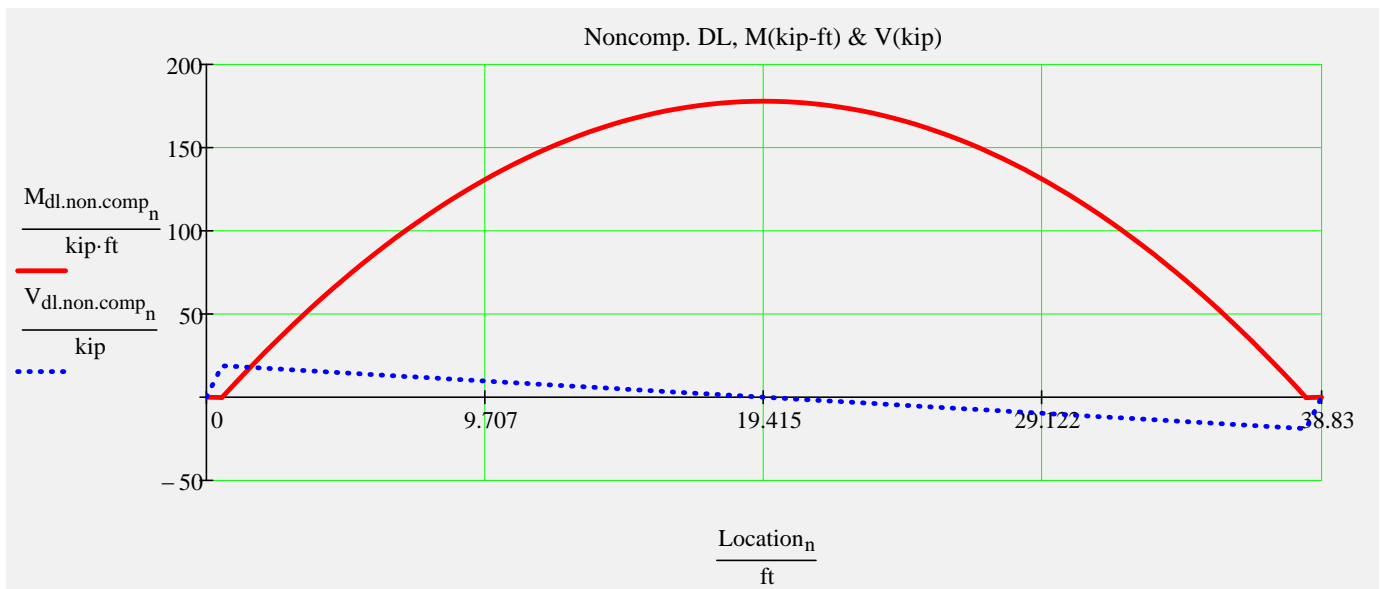


$$\max(M_{\text{release}}) = 102.4 \cdot \text{kip}\cdot\text{ft}$$

$$\max(V_{\text{release}}) = 10.6 \cdot \text{kip}$$



Noncomposite Dead Load Moments and Shear

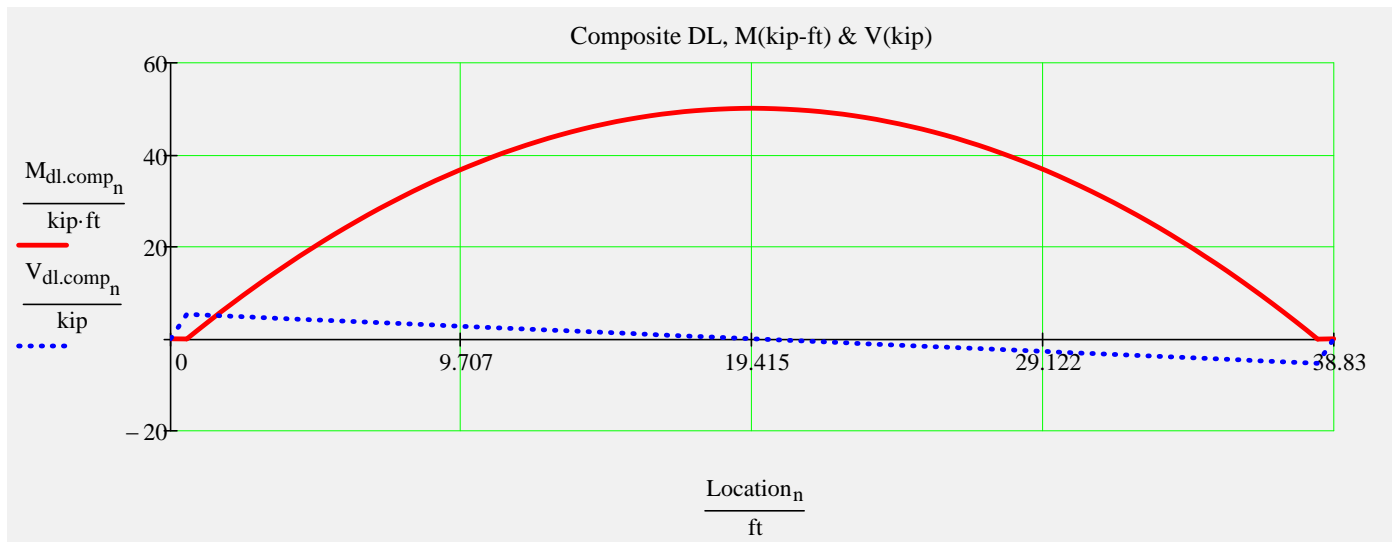


$$\max(M_{\text{dl.non.comp}}) = 177.8 \cdot \text{kip}\cdot\text{ft}$$

$$\max(V_{\text{dl.non.comp}}) = 18.8 \cdot \text{kip}$$



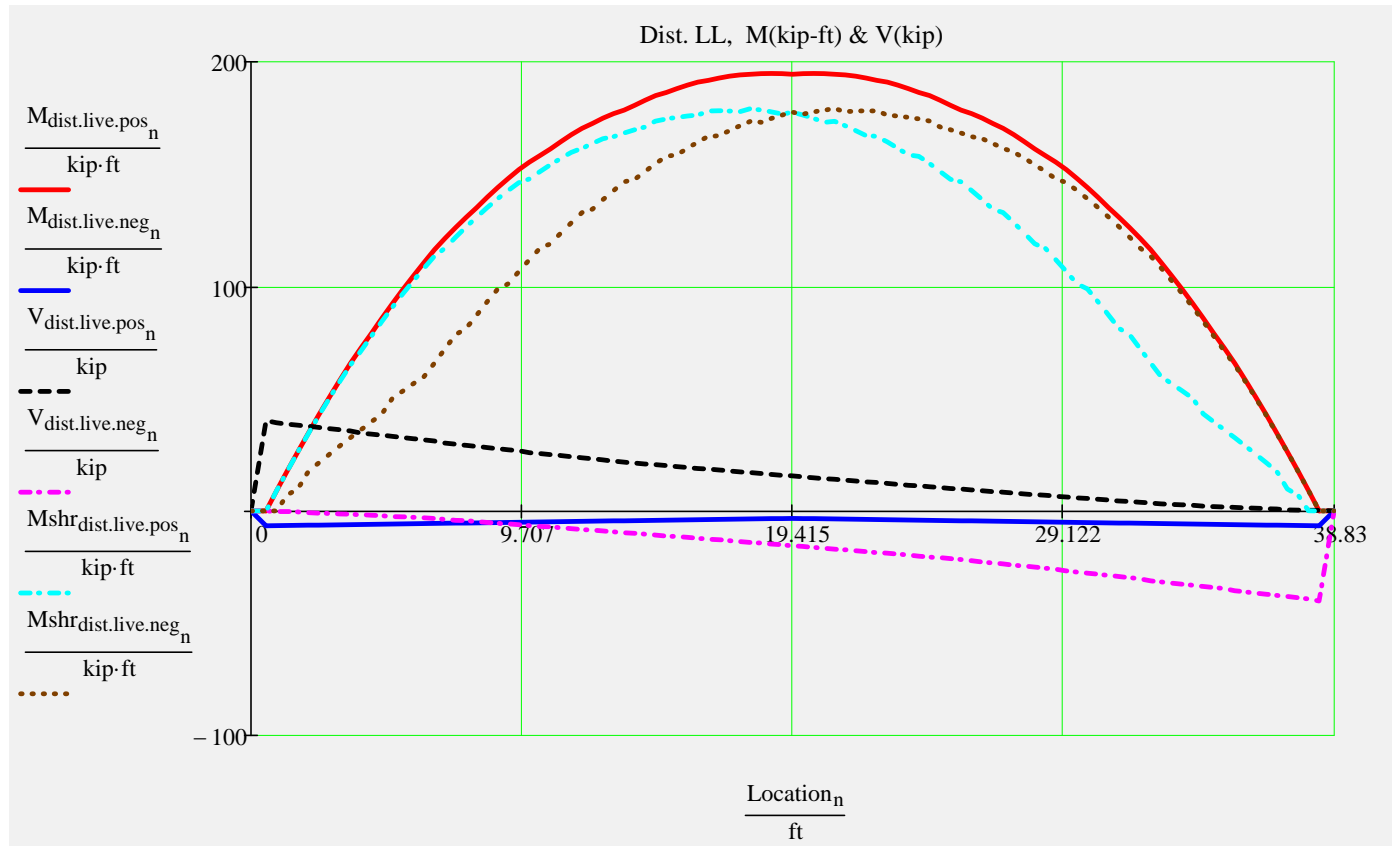
Composite Dead Load Moments and Shear



$$\max(M_{dl.comp}) = 50.1 \cdot kip \cdot ft$$

$$\max(V_{dl.comp}) = 5.3 \cdot kip$$

Distributed Live Load Moments and Shear



$$\max(M_{dist.live.pos}) = 194.8 \cdot kip \cdot ft$$

$$\min(M_{dist.live.neg}) = -6.7 \cdot kip \cdot ft$$

Beam End Reactions... with IM factor only

$$\text{Reaction}_{LL} = 40.97 \cdot kip$$

$$\max(V_{dist.live.pos}) = 40.1 \cdot kip$$

$$\max(M_{shr_{dist.live.pos}}) = 179.1 \cdot kip \cdot ft$$

$$\text{Reaction}_{DL} = 24.82 \cdot kip$$

Prestress Strand Layout Input

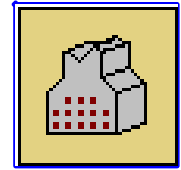
Instructions:

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 :=

Strand Pattern Generator:



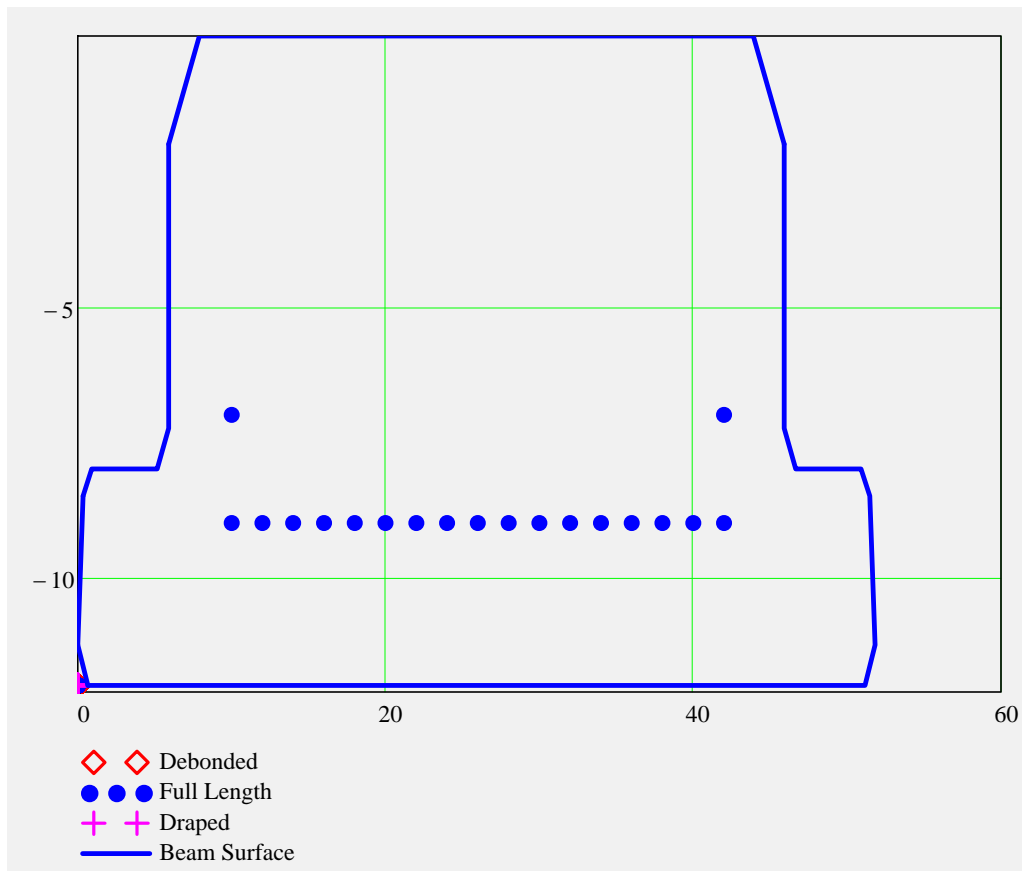
Collapsed Region for Custom Strand Sizes...

▾ Strand Multiplier

▾ Strand Data and Pattern

▾ Strand Properties

Tendon Layout



SupportLocation_{release} ≡ 0·ft

distance supports are located from the end of the beam after release; may be used to check lifting points immediately after transfer

Partially Stressed Tendons ("Strand N")

PartialPS_{force} = 40·kip *partial prestress total force*

PartialPS_{force} := if (BeamTypeTog = "II", 20·kip, PartialPS_{force})

PartialPS_{force} = 40·kip

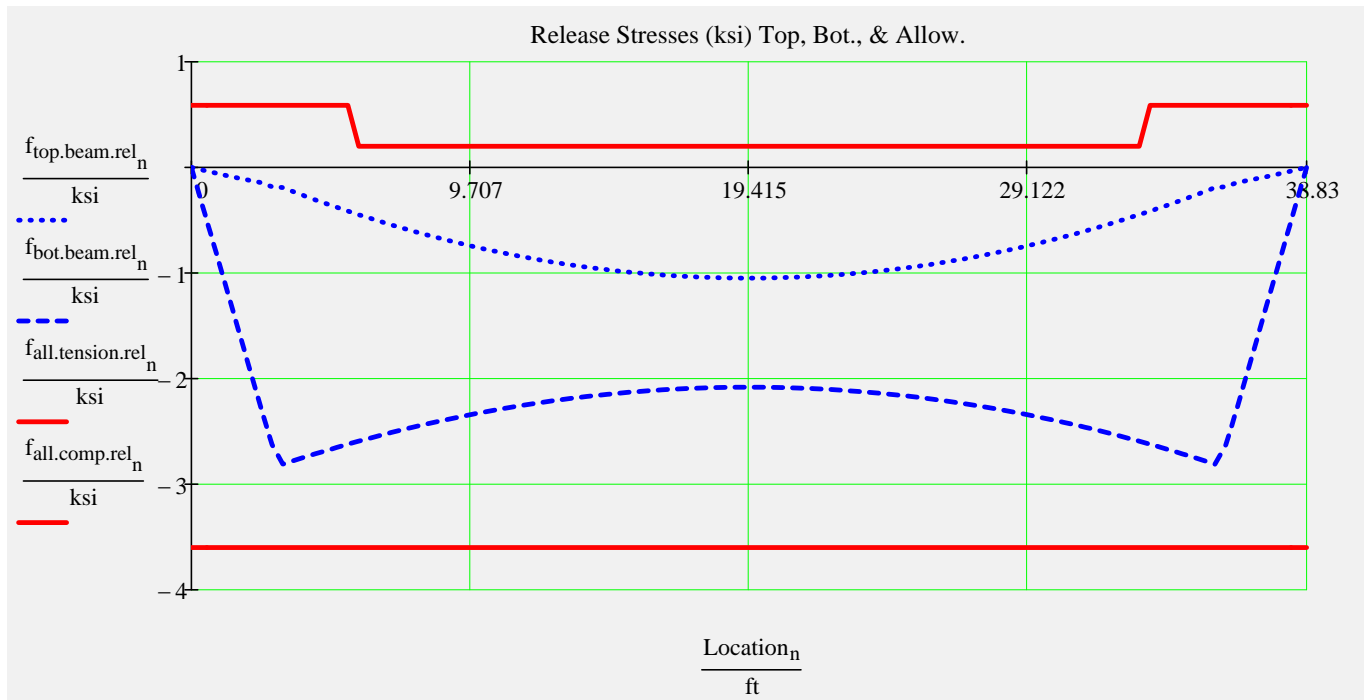
PartialPS_{location} = 1.4375in *centroid location of partial prestress from the top of the beam*

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

PartialPS_{location} = 3·in

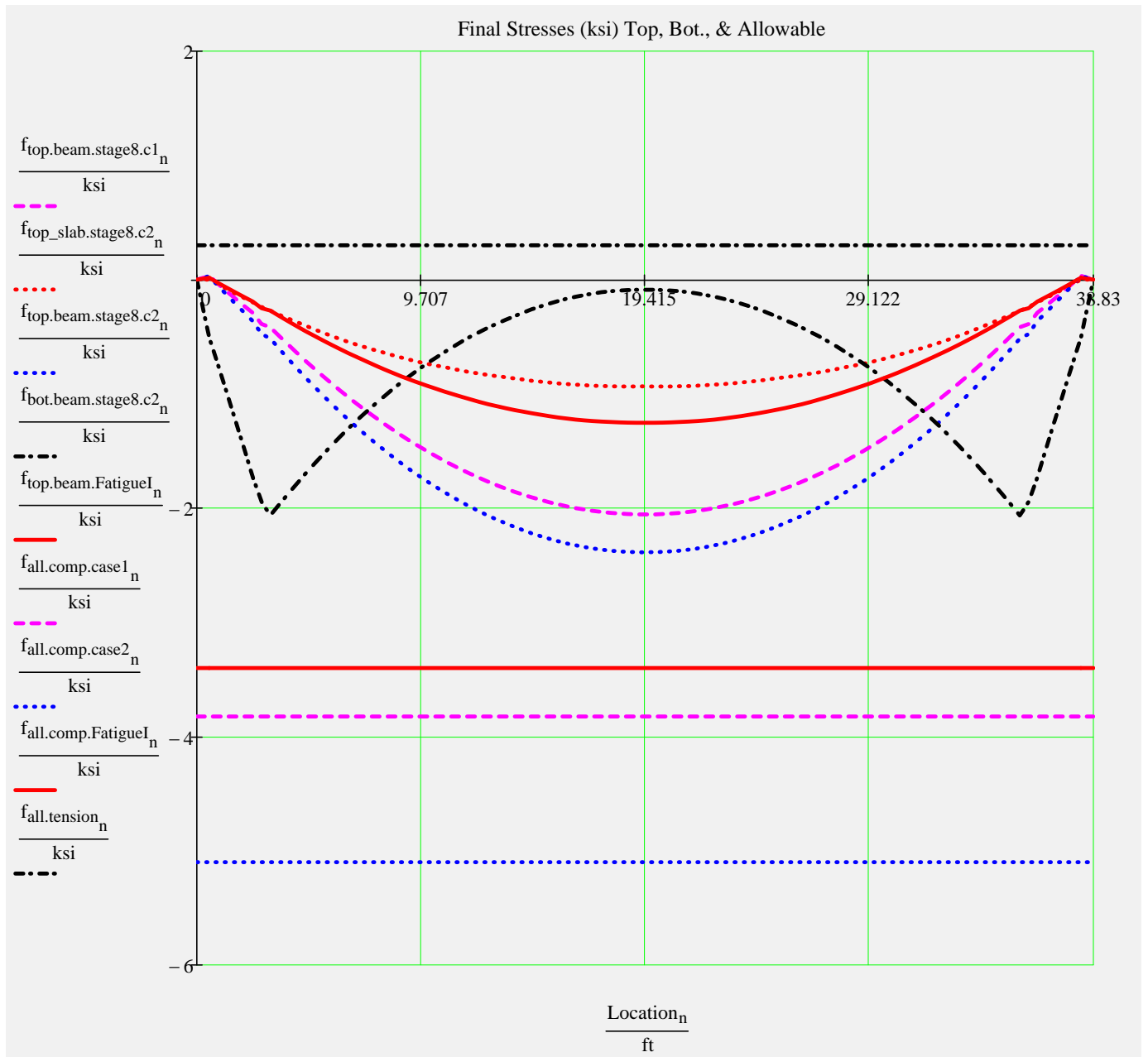
Section Properties & Strand Profile Properties

Release Stresses



Prestress Force

Final Stresses



Release Checks & Final Checks for Capacity Ratio (CR)

Stress Checks

$$\min(CR_{f_{tension.rel}}) = 10$$

Check_ $f_{tension.rel}$ = "OK"

[\(Release tension\)](#)

$$\min(CR_{f_{comp.rel}}) = 1.28$$

Check_ $f_{comp.rel}$ = "OK"

[\(Release compression\)](#)

$$\min(CR_{f_{tension.stage8}}) = 10$$

Check_ $f_{tension.stage8}$ = "OK"

[\(Service III, PS + DL + LL*0.8\)](#)

$$\min(CR_{f_{comp.stage8.c1}}) = 1.86$$

Check_ $f_{comp.stage8.c1}$ = "OK"

[\(Service I, PS + DL\)](#)

$$\min(CR_{f_{comp.stage8.c2}}) = 2.14$$

Check_ $f_{comp.stage8.c2}$ = "OK"

[\(Service I, PS + DL + LL\)](#)

$$\min(CR_{f_{comp.FatigueI}}) = 2.71$$

Check_ $f_{comp.FatigueI}$ = "OK"

[\(Fatigue I, \(PS + DL\)*0.5 + 1.5 Fatigue Truck\)](#)

Strand Pattern Checks

CheckPattern0 = "OK"

check 0 - no debonded tendon in outside row

CheckPattern1 = "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)*

CheckPattern2 = "OK"

check 2 - less than 40% debonded tendons in any row

CheckPattern3 = "OK"

check 3 - less than 40% of debonded tendons terminated at same section

(LRFD 5.11.4.3)

CheckPattern4 = "OK"

check 4 - more than half beam depth debond length

(SDG 4.3.1)

Section and Strand Properties Summary

Section and Strand Properties Summary

$$A_{\text{beam}} = 521.75 \cdot \text{in}^2$$

Concrete area of beam

$$I_{\text{beam}} = 6355.6223 \cdot \text{in}^4$$

Gross Moment of Inertia of Beam about CG

$$y_{\text{comp}} = -3.32 \cdot \text{in}$$

Dist. from top of beam to CG of gross composite section

$$I_{\text{comp}} = 23021.7546 \cdot \text{in}^4$$

Gross Moment of Inertia Composite Section about CG

$$A_{\text{deck}} = 352.89 \cdot \text{in}^2$$

Concrete area of deck slab

$$A_{\text{ps}} = 4.1 \cdot \text{in}^2$$

total area of strands

$$d_{\text{b.ps}} = 0.6 \cdot \text{in}$$

diameter of Prestressing strand

$$\text{min}(\text{PrestressType}) = 0$$

0 - low lax 1 - stress relieved

$$f_{\text{py}} = 243 \cdot \text{ksi}$$

tendon yield strength

$$f_{\text{pj}} = 203 \cdot \text{ksi}$$

prestress jacking stress

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

$$A_{\text{ps.row}}^T = (3.7 \ 0.4 \ 0.2) \cdot \text{in}^2$$

$$d_{\text{ps.row}} =$$

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|----|----|----|----|----|----|----|----|----|-----|
| 0 | -9 | -9 | -9 | -9 | -9 | -9 | -9 | -9 | -9 | -9 |
| 1 | -7 | -7 | -7 | -7 | -7 | -7 | -7 | -7 | -7 | -7 |
| 2 | -3 | -3 | -3 | -3 | -3 | -3 | -3 | -3 | -3 | ... |

·in

TotalNumberOfTendons = 19

StrandSize = "0.6 in low lax"

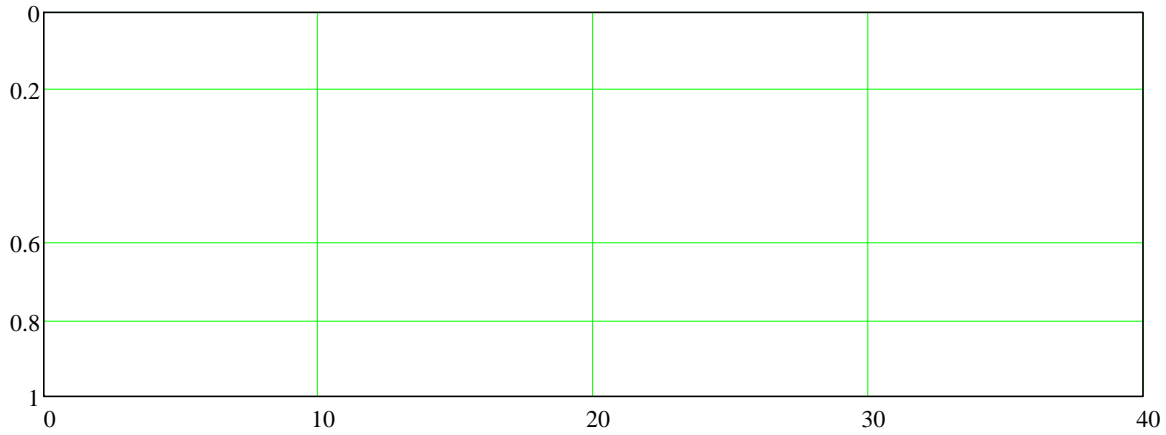
NumberOfDebondedTendons = 0

StrandArea = 0.22·in²

NumberOfDrapedTendons = 0

JackingForce_{per.strand} = 43.94·kip

Location of Depressed Strands



▣ Section and Strand Properties Summary

Prestress Losses Summary

$f_{pj} = 202.5 \cdot \text{ksi}$ Check_ $f_{pt} = \text{"OK"}$

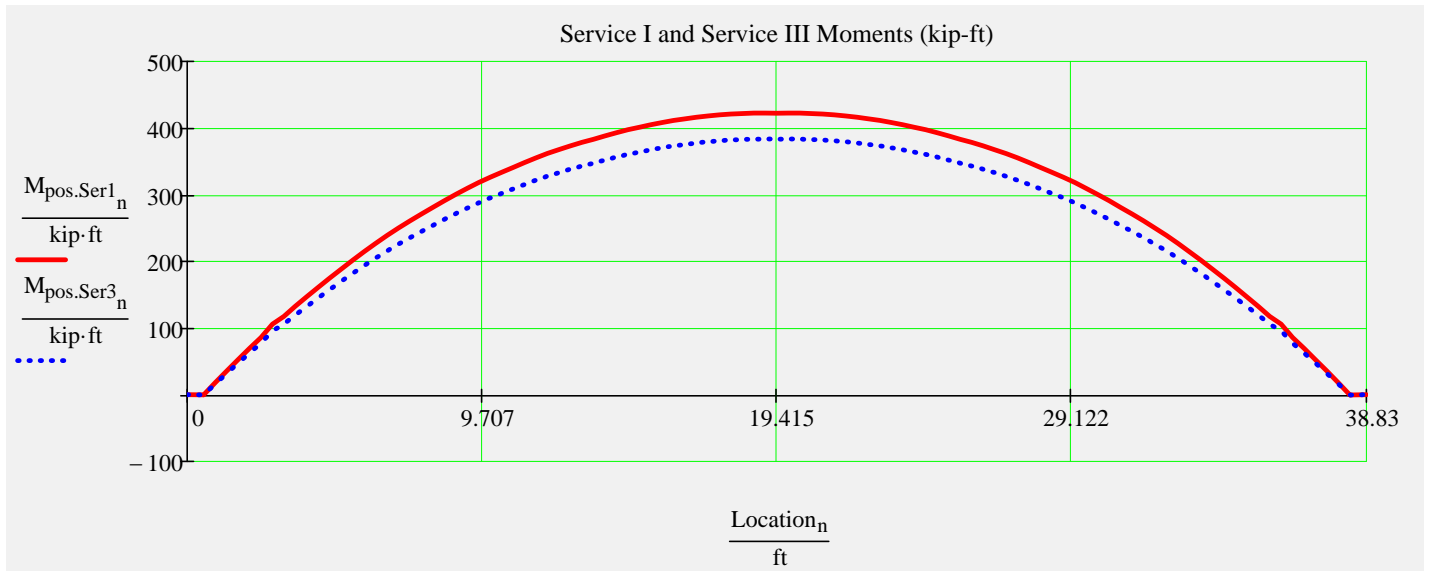
$\Delta f_{pES} = 0 \cdot \text{ksi}$ *Note: Elastic shortening losses are zero in concrete stress calculations when using transformed section properties per LRFD 5.9.5.2.3*

$\Delta f_{pT} = -21 \cdot \text{ksi}$ $\frac{\Delta f_{pT}}{f_{pj}} = -10.57 \cdot \%$

$f_{pe} = 181 \cdot \text{ksi}$ $\frac{f_{pe}}{f_{pj}} = 89.43 \cdot \%$

$0.8 \cdot f_{py} = 194 \cdot \text{ksi}$ Check_ $f_{pe} = \text{"OK"}$

Service Limit State Moments



$\max(M_{\text{pos.Ser1}}) = 422.6 \cdot \text{kip} \cdot \text{ft}$

$\max(M_{\text{pos.Ser3}}) = 383.6 \cdot \text{kip} \cdot \text{ft}$

Summary of Values at Midspan

$$\text{Stresses} = \begin{pmatrix} \text{"Stage"} & \text{"Top of Beam (ksi)} & \text{"Bott of Beam (ksi)} \\ 1 & -1.05 & -2.08 \\ 2 & -1.07 & -1.75 \\ 4 & -1 & -1.81 \\ 6 & -1.97 & -0.98 \\ 8 & -2.39 & -0.09 \end{pmatrix}$$

$$\text{PrestressForce} = \begin{pmatrix} \text{"Condition"} & \text{"Axial (kip)} & \text{"Moment (kip*ft)} \\ \text{"Release"} & -874.9 & -156.9 \\ \text{"Final (about composite centroid)} & -782.4 & -134 \end{pmatrix}$$

$$\text{Properties} = \begin{pmatrix} \text{"Section"} & \text{"Area (in^2)} & \text{"Inertia (in^4)} & \text{"distance to centroid from top of bm (in)} \\ \text{"Net Beam"} & 517.43 & 6327.91 & -6.37 \\ \text{"Transformed Beam (initial)"} & 544.7 & 6497.53 & -6.48 \\ \text{"Transformed Beam"} & 541.74 & 6479.7 & -6.47 \\ \text{"Composite"} & 901.17 & 23899.8 & -3.39 \end{pmatrix}$$

$$\text{ServiceMoments} = \begin{pmatrix} \text{"Type"} & \text{"Value (kip*ft)} \\ \text{"Release"} & 102.4 \\ \text{"Non-composite (includes bm wt.)"} & 177.8 \\ \text{"Composite"} & 50.1 \\ \text{"Distributed Live Load"} & 194.4 \end{pmatrix}$$

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

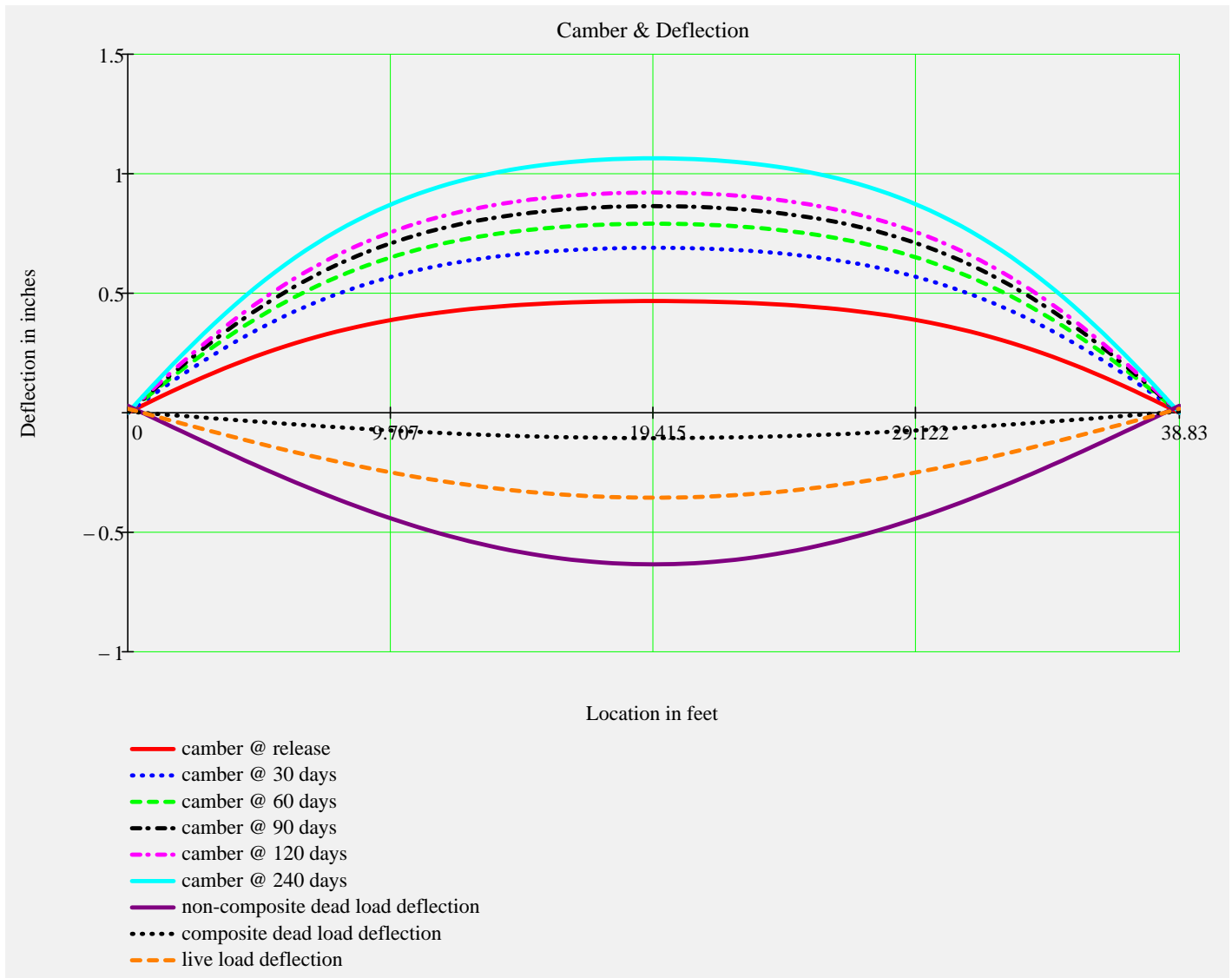
Stage 2 ---> Same as release with the addition of the remaining prestress losses applied to the transformed beam

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

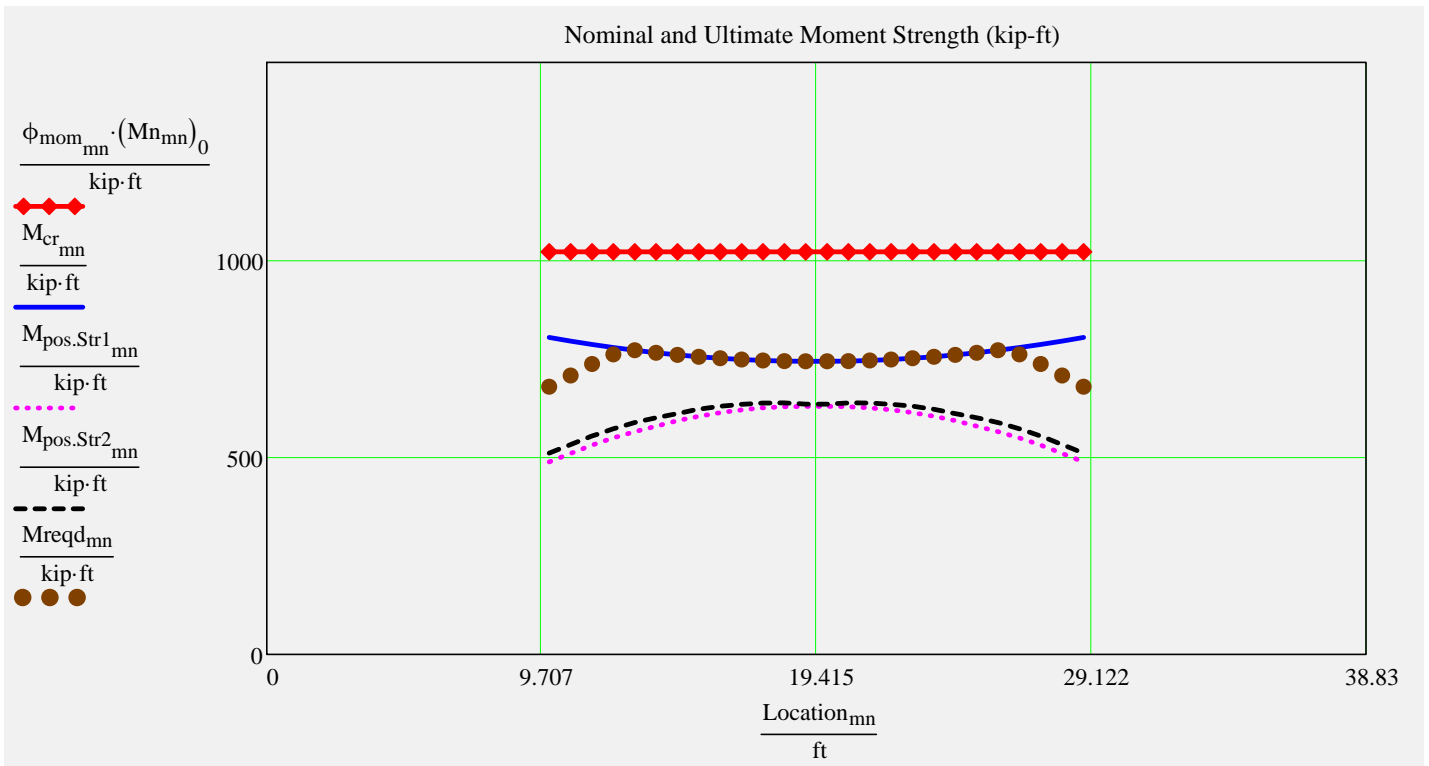
Stage 8 ---> Stage 6 with the addition of composite dead load and live loads applied to the composite section

Camber, Shrinkage, and Dead Load Deflection Components



| "Stage" | "Change in L @ Top (in)" | "Change in L @ Bot. (in)" | "Slope at End (deg)" | "midspan defl (in)" |
|---------------|--------------------------|---------------------------|----------------------|---------------------|
| "Release" | -0.0673 | -0.2276 | 0.2794 | 0.4673 |
| "30 Days" | -0.1791 | -0.439 | 0.4849 | 0.6901 |
| "60 Days" | -0.2203 | -0.517 | 0.5643 | 0.791 |
| "90 Days" | -0.2417 | -0.5576 | 0.6056 | 0.8644 |
| "120 Days" | -0.2549 | -0.5824 | 0.6309 | 0.9213 |
| "240 Days" | -0.2788 | -0.6277 | 0.677 | 1.0645 |
| "non-comp DL" | -0.058 | 0.0496 | -0.2569 | -0.6343 |
| "comp DL" | -0.0051 | 0.0129 | -0.043 | -0.1062 |
| "LL" | -0.0173 | 0.0441 | -0.1467 | -0.3554 |

Strength Limit State Moments



$$CR_{Str.mom_n} := 10 \quad CR_{Str.mom_{mn}} := \frac{\phi_{mom_{mn}} \cdot (Mn_{mn})_0}{Mreqd_{mn}} \quad (LRFD\ 5.7.3.3.2) \quad \min(CR_{Str.mom}) = 1.32$$

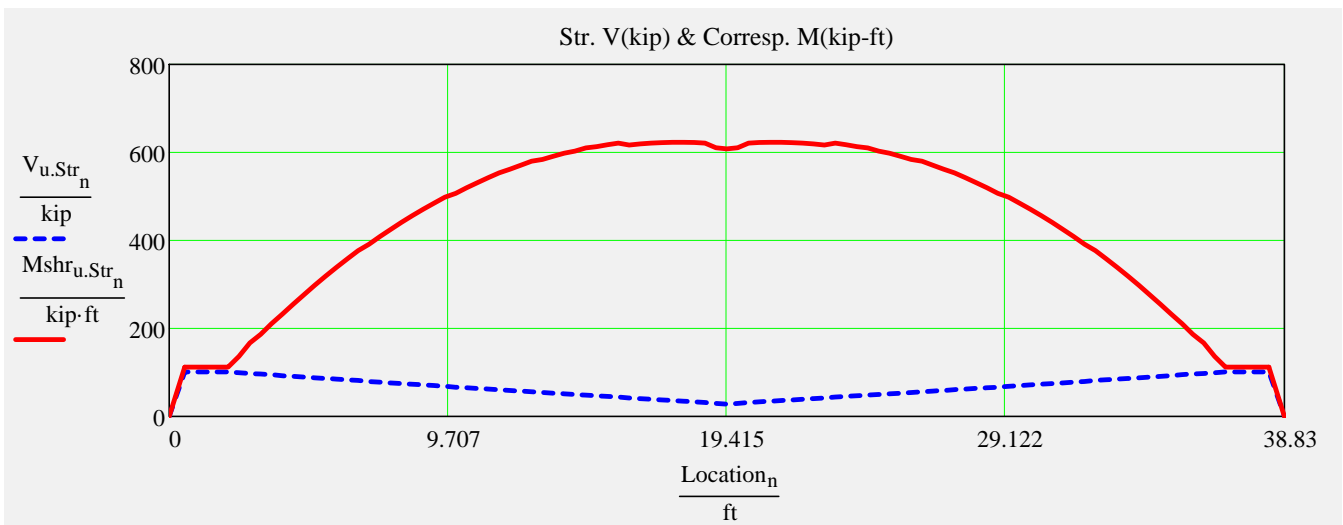
$$\max(Mreqd) = 770.5 \cdot \text{kip}\cdot\text{ft} \quad \text{CheckMomentCapacity} := \text{if}(\min(CR_{Str.mom}) > 0.99, \text{"OK"}, \text{"No Good!"})$$

CheckMomentCapacity = "OK"

FSB only - Design Check of Transverse reinforcing Bars E

Shear Analysis

Strength Shear and Associated Moments



$$\max(V_{u.Str}) = 100.9 \cdot \text{kip}$$

$$\max(M_{shr_{u.Str}}) = 623.0 \cdot \text{kip}\cdot\text{ft}$$

Design Shear, Longitudinal, Interface and Anchorage Reinforcement

Stirrup sizes and spacings assigned in input file

Location

spacing

Number of Spaces

area per stirrup

A1 stirrup

A2 stirrup

A3 stirrup

S1 stirrup

S2 stirrup

S3 stirrup

S4 stirrup

$$\text{tmp_s} = \begin{pmatrix} 6 \\ 18 \\ 18 \\ 18 \\ 18 \\ 18 \\ 18 \end{pmatrix} \cdot \text{in}$$

$$\text{tmp_NumberSpaces} = \begin{pmatrix} 8 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 0 \end{pmatrix}$$

$$\text{tmp_A}_{\text{stirrup}} = \begin{pmatrix} 0.8 \\ 0.8 \\ 0.8 \\ 0.8 \\ 0.8 \\ 0.8 \\ 0.8 \end{pmatrix} \cdot \text{in}^2$$

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.

A1 stirrup

A2 stirrup

A3 stirrup

S1 stirrup

S2 stirrup

S3 stirrup

S4 stirrup

user_sns spacings :=

$$\begin{pmatrix} -1 \\ -1 \\ -1 \\ -1 \\ -1 \\ -1 \\ -1 \end{pmatrix} \cdot \text{in}$$

user_NumberSpacesns spacings :=

$$\begin{pmatrix} -1 \\ -1 \\ -1 \\ -1 \\ -1 \\ -1 \\ -1 \end{pmatrix}$$

user_A_{stirrup}ns spacings :=

$$\begin{pmatrix} -1 \\ -1 \\ -1 \\ -1 \\ -1 \\ -1 \\ -1 \end{pmatrix} \cdot \text{in}^2$$

interface_factorns spacings :=

$$\begin{pmatrix} 0.25 \\ 0.5 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{pmatrix}$$

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

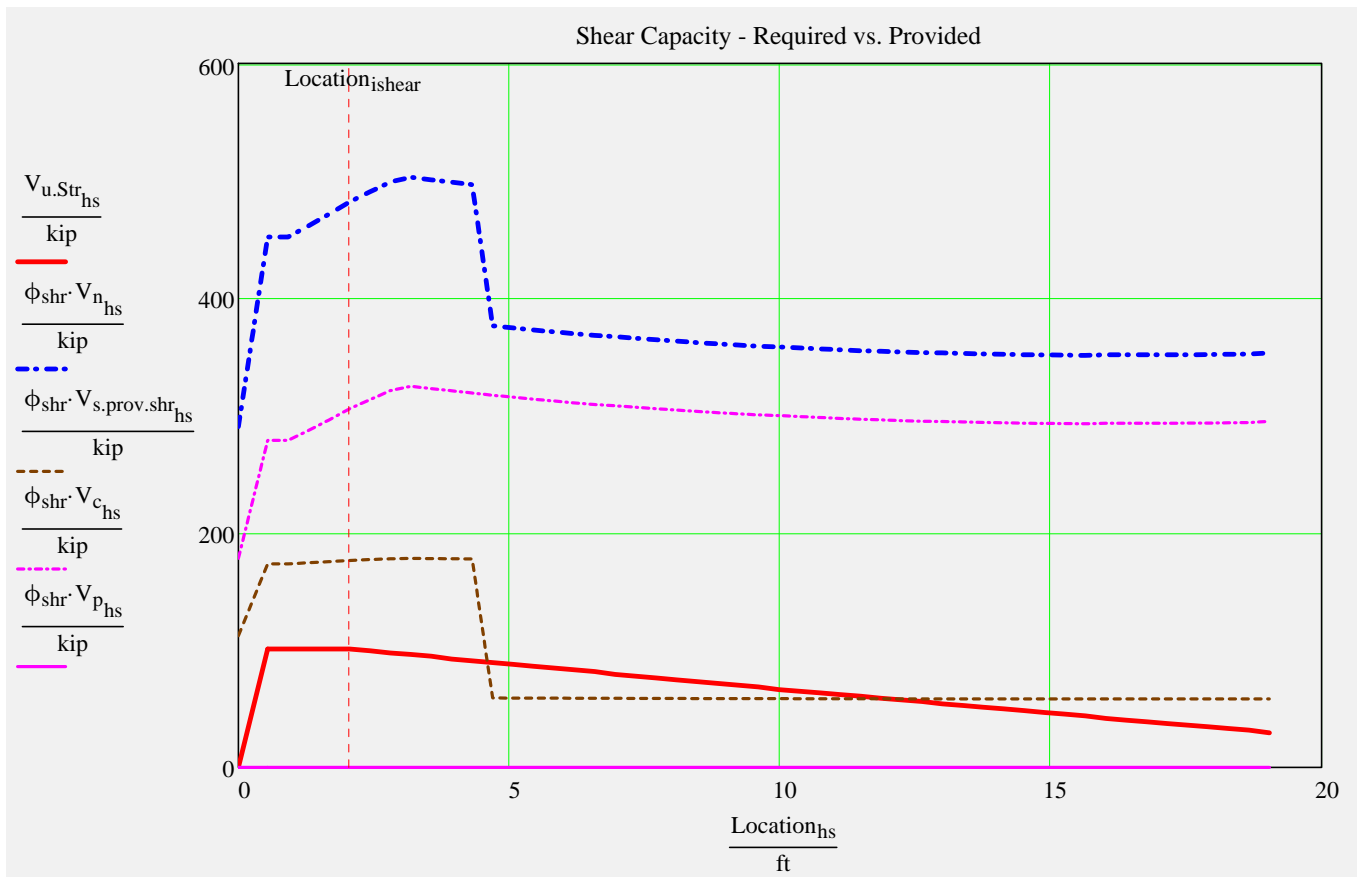
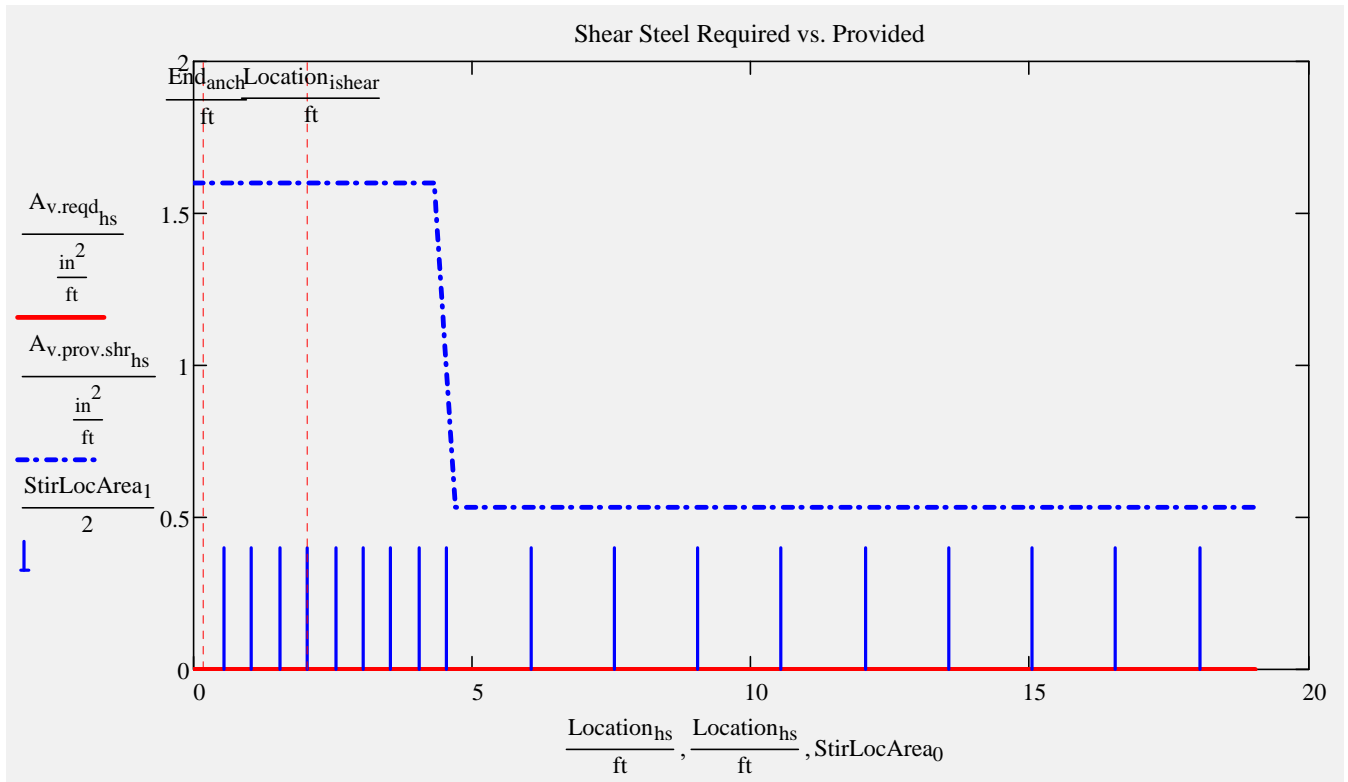
S4 stirrup

$$s = \begin{pmatrix} 6 \\ 18 \\ 18 \\ 18 \\ 18 \\ 18 \\ 18 \end{pmatrix} \cdot \text{in}$$

$$\text{NumberSpaces} = \begin{pmatrix} 8 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 4.92 \end{pmatrix}$$

$$A_{\text{stirrup}} = \begin{pmatrix} 0.8 \\ 0.8 \\ 0.8 \\ 0.8 \\ 0.8 \\ 0.8 \\ 0.8 \end{pmatrix} \cdot \text{in}^2$$

EndCover = 6.5 in



Computation for Checks

CheckShearCapacity = "OK"

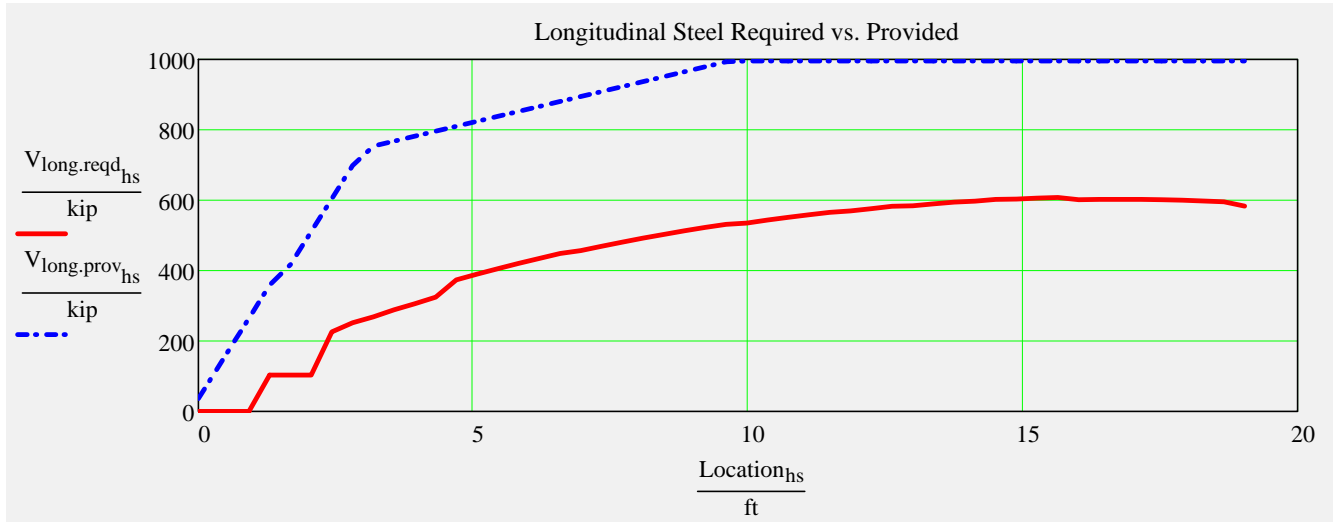
CheckMaxShearStress = "OK"

CheckStirArea = "OK"

CheckMinStirArea = "OK"

CheckMaxStirSpacing = "OK"

Longitudinal Reinforcement

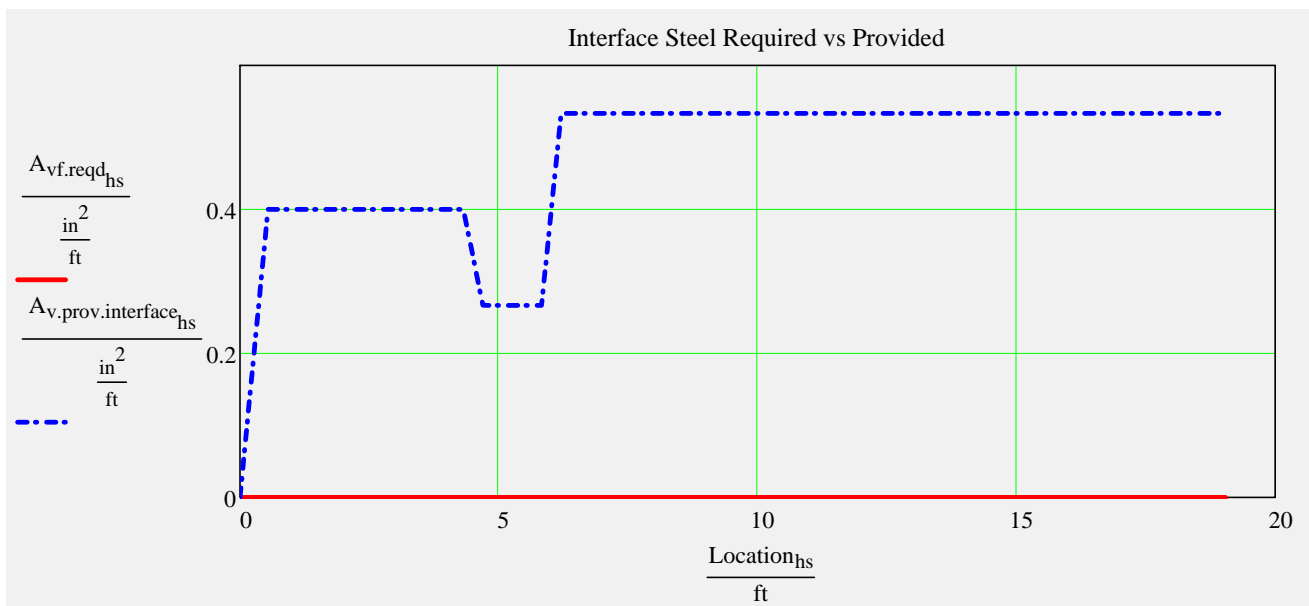


$$CR_{LongSteel}_{hs} := \text{if} \left(V_{long.reqd}_{hs} < .01kip, 100, \frac{V_{long.prov}_{hs}}{V_{long.reqd}_{hs}} \right) \quad \min(CR_{LongSteel}) = 1.64$$

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

CheckLongSteel = "OK"

Interface Sheer Reinforcement



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.

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

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

If max(Avf.min) or max(Avf.des) is greater than 0 in²/ft, interface steel is required.

CheckInterfaceSpacing = "OK"

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

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

Anchorage Reinforcement and Maximum Prestressing Force

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

StandardSplittingReinforcing :=

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

CheckSplittingSteel = "N.A."

CheckMaxPrestressingForce = "OK"

Summary of Design Checks

- check0 := AcceptAASHTO check1 := AcceptSDG check2 := AcceptOntario
- check3 := Check_fpt check4 := Check_fpe check5 := Check_ftension.rel
- check6 := Check_fcomp.rel check7 := Check_ftension.stage8 check8 := Check_fcomp.stage8.c1
- check9 := Check_fcomp.stage8.c2 check10 := Check_fcomp.FatigueI check11 := CheckMomentCapacity
- check12 := CheckMaxCapacity check13 := CheckStirArea check14 := CheckShearCapacity
- check15 := CheckMinStirArea check16 := CheckMaxStirSpacing check17 := CheckLongSteel
- check18 := CheckInterfaceSpacing check19 := CheckSplittingSteel check20 := CheckMaxPrestressingForce
- check21 := CheckPattern0 check22 := CheckPattern1 check23 := CheckPattern2
- check24 := CheckPattern3 check25 := CheckPattern4 check26 := CheckInterfaceSteel
- check27 := CheckStrandFit check28 := Check_SDG1.2.Display₂ [Link to Note- Checks, 0, 1 & 2](#)



| | | | | | |
|----------------------|------|--------|--------|------|-----|
| check ^T = | 0 | 1 | 2 | 3 | 4 |
| 0 | "OK" | "N.A." | "N.A." | "OK" | ... |

click table to reveal scroll bar...

TotalCheck = "OK"

LRFR Load Rating Analysis

FDOT Maintenance Office Bridge Load Rating Manual

Load Rating Computations

| | | Moment (Strength) or Stress (Service) | | | | | Shear (Strength) | | | | |
|------------------------------|--------------------|---------------------------------------|----------|--------|-----------|-------|------------------|--------|-----------|---------|--|
| LRFR _{loadrating} = | "Limit State" | "DF" | "Rating" | "Tons" | "Dim(ft)" | "DF" | "Rating" | "Tons" | "Dim(ft)" | | |
| | "Strength I(Inv)" | 0.29 | 2.15 | "N/A" | 18.50 | 0.48 | 6.02 | "N/A" | 4.15 | HL-93 | |
| | "Strength I(Op)" | 0.29 | 2.78 | "N/A" | 18.50 | 0.48 | 7.81 | "N/A" | 4.15 | HL-93 | |
| | "Service III(Inv)" | 0.29 | 1.54 | "N/A" | 18.50 | "N/A" | "N/A" | "N/A" | "N/A" | HL-93 | |
| | "Service III(Op)" | 0.29 | 2.16 | "N/A" | 18.50 | "N/A" | "N/A" | "N/A" | "N/A" | HL-93 | |
| | "Strength II" | 0.29 | 2.09 | 125.24 | 16.99 | 0.48 | 5.39 | 323.14 | 4.15 | *Permit | |

*note: default permit load is FL120 per input worksheet

Longitudinal Steel Check:

CR_{LongSteel.HL93} = 1.73

CR_{LongSteel.Permit} = 1.64

CheckLongSteel_{loadrating} = "OK"

Write Data Out