$$
\begin{aligned}
bilat_prop\left(el_dat, w_{el_dat}, gi\right) := \;& n_t \leftarrow rows\left(el_dat\right) - 1 \\
& n_j \leftarrow rows\left(gi\right) \\
& A \leftarrow 0 \\
& B_x \leftarrow 0 \\
& I_x \leftarrow 0 \\
& \text{for } i \in 1 .. n_t \\
& \quad el \leftarrow el_dat_i \\
& \quad w_{el} \leftarrow w_{el_dat_i} \\
& \quad w_t \leftarrow w_{el} \\
& \quad w_b \leftarrow w_{el_dat_{i+1}} \\
& \quad h \leftarrow el_dat_{i+1} - el_dat_i \\
& \quad A_{trap} \leftarrow h \cdot \frac{\left(w_t + w_b\right)}{2} \\
& \quad y_{c_local} \leftarrow \text{if } A_{trap} = 0 \\
& \qquad\qquad \frac{h}{2} \\
& \qquad \text{else} \\
& \qquad\qquad \frac{\frac{1}{2} \cdot w_b \cdot h^2 + \frac{1}{6} \cdot \left(w_t - w_b\right) \cdot h^2}{A_{trap}} \\
& \quad y_{c_trap} \leftarrow y_{c_local} + el \\
& \quad I_{trap} \leftarrow \frac{w_b \cdot h^3}{12} + w_b \cdot h \cdot \left(\frac{h}{2} - y_{c_local}\right)^2 + \frac{\left(w_t - w_b\right) \cdot h^3}{36} + \frac{\left(w_t - w_b\right) \cdot h}{2} \cdot \left(\frac{h}{3} - y_{c_} \right. \\
& \quad A \leftarrow A + A_{trap} \\
& \quad B_x \leftarrow B_x + A_{trap} \cdot y_{c_trap} \\
& \quad I_x \leftarrow I_x + I_{trap} + A_{trap} \cdot y_{c_trap}{}^2 \\
& y_c \leftarrow \frac{B_x}{A} \\
& I_{xx} \leftarrow I_x - A \cdot y_c{}^2 \\
& r_x \leftarrow \sqrt{\frac{I_{xx}}{A}} \\
& c \leftarrow 0 \\
& S \leftarrow 0 \\
& k \leftarrow 0 \\
& \text{for } j \in 1 .. n_j \\
& \quad c_{j,2} \leftarrow -\left(y_c - el_dat_{\left(gi_{j,2}\right)}\right)
\end{aligned}
$$

$$
\left\|
\begin{array}{l}
\left\|
\begin{array}{l}
c_{j,1} \leftarrow concat\left(\text{"c_"}, gi_{j,1}\right) \\
S_{j,2} \leftarrow \dfrac{I_{xx}}{c_{j,2}} \\
S_{j,1} \leftarrow concat\left(\text{"S_"}, gi_{j,1}\right) \\
k_{j,2} \leftarrow -\dfrac{S_{j,2}}{A} \\
k_{j,1} \leftarrow concat\left(\text{"k_"}, gi_{j,1}\right)
\end{array}
\right. \\
k^{\langle 2 \rangle} \leftarrow reverse\left(sort\left(k^{\langle 2 \rangle}\right)\right) \\
bilat_prop \leftarrow \begin{bmatrix}
\begin{bmatrix}
\text{"A"} & A \\
\text{"I_xx"} & I_{xx} \\
\text{"r_x"} & r_x \\
\text{"y_c"} & y_c \\
\text{"top_el"} & min\left(el_dat\right) \\
\text{"bot_el"} & max\left(el_dat\right)
\end{bmatrix} \\
c \\
S \\
k
\end{bmatrix}
\end{array}
\right.
$$

$$
perim_{pts}\left(el_dat, w_{el_dat}\right) := \left\|
\begin{array}{l}
n_r \leftarrow rows\left(el_dat\right) \\
\text{for } i \in 1..n_r \\
\quad \left\|
\begin{array}{l}
el \leftarrow el_dat_i \\
w_{el} \leftarrow w_{el_dat_i} \\
x_{rght_i} \leftarrow \dfrac{w_{el}}{2} \\
y_{rght_i} \leftarrow el
\end{array}
\right. \\
x_{left} \leftarrow -reverse\left(x_{rght}\right) \\
y_{left} \leftarrow reverse\left(y_{rght}\right) \\
x_{grph} \leftarrow stack\left(0\ in, x_{rght}, x_{left}, 0\ in\right) \\
y_{grph} \leftarrow stack\left(min\left(el_dat\right), y_{rght}, y_{left}, min\left(el_dat\right)\right) \\
plstart \leftarrow \begin{bmatrix} \text{"plinewid"} \\ \text{"0"} \\ \text{"pline"} \end{bmatrix} \\
n_n \leftarrow rows\left(x_{grph}\right) - 1
\end{array}
\right.
$$

$$\begin{array}{l}
\text{for } i \in 1..n_n \\
\quad plbody_i \leftarrow concat\left(num2str\left(\frac{x_{grph_i}}{in}\right), \text{“,”}, num2str\left(\frac{-y_{grph_i}}{in}\right)\right) \\
plclose \leftarrow [\text{“c”}] \\
plcad \leftarrow stack(plstart, plbody, plclose) \\
perim_{pts} \leftarrow \left[x_{grph}\ \ y_{grph}\ \ plcad\right]^{T}
\end{array}$$

function to calculate stresses at a section due to internal and external loading in the z axis and flexure about the xx axis

$$stress_xx_z(S_prop, F_p, cg_p, M_{app}, P_{app}) := \begin{array}{l}
A \leftarrow \left(S_prop_1\right)_{1,2} \\
S \leftarrow \left(S_prop_3\right)^{\langle 2 \rangle} \\
nm \leftarrow \left(S_prop_3\right)^{\langle 1 \rangle} \\
cg_c \leftarrow \left(S_prop_1\right)_{4,2} \\
e \leftarrow cg_p - cg_c \\
f_{c_cg} \leftarrow \frac{(P_{app} - F_p)}{A} \\
f \leftarrow [\text{“f_0”}\ \ f_{c_cg}] \\
n_s \leftarrow rows(S) \\
\text{for } j \in 1..n_s \\
\quad f_{j+1,2} \leftarrow f_{c_cg} + \frac{M_{app} - F_p \cdot e}{S_j} \\
\quad f_{j+1,1} \leftarrow concat\left(\text{“f”}, substr\left(nm_j, 1, 5\right)\right) \\
stress_xx_z \leftarrow f
\end{array}$$

$A_test := 0.217\ in^2$ $x1_t := 16.5\ in$ $x2_t := 2.5\ in$ $x3_t := 10.5\ in$

$y1_t := 80.625\ in$ $y2_t := 78.625\ in$ $y3_t := 76.625\ in$ $y4_t := 74.725\ in$ $y5_t := 82.525\ in$

$$Psd_test := \begin{bmatrix}
8 & 0 & A_test & 0 & -x1_t & y1_t & -x2_t & y1_t & \text{“”} & \text{“”} & \text{“”} & \text{“”} \\
8 & 0 & A_test & 0 & x2_t & y1_t & x1_t & y1_t & \text{“”} & \text{“”} & \text{“”} & \text{“”} \\
8 & 0 & A_test & 0 & -x1_t & y2_t & -x2_t & y2_t & \text{“”} & \text{“”} & \text{“”} & \text{“”} \\
8 & 0 & A_test & 0 & x2_t & y2_t & x1_t & y2_t & \text{“”} & \text{“”} & \text{“”} & \text{“”} \\
5 & 0 & A_test & 0 & -x3_t & y3_t & -x2_t & y3_t & \text{“”} & \text{“”} & \text{“”} & \text{“”} \\
5 & 0 & A_test & 0 & x2_t & y3_t & x3_t & y3_t & \text{“”} & \text{“”} & \text{“”} & \text{“”} \\
13 & 0.3 & A_test & 0 & -0.3\ in & y4_t & -0.3\ in & y5_t & -1\ in & 4\ in & -1\ in & 28\ in \\
13 & 0.3 & A_test & 0 & 0.3\ in & y4_t & 0.3\ in & y5_t & 1\ in & 4\ in & 1\ in & 28\ in
\end{bmatrix}$$

$median(y4_t, y5$

$$Psd_test = \begin{bmatrix} 8 & 0 & 0.002\ ft^2 & 0 & -1.375\ ft & 6.719\ ft & -0.208\ ft & 6.719\ ft & \text{""} & \text{""} & \text{""} & \text{""} \\ 8 & 0 & 0.002\ ft^2 & 0 & 0.208\ ft & 6.719\ ft & 1.375\ ft & 6.719\ ft & \text{""} & \text{""} & \text{""} & \text{""} \\ 8 & 0 & 0.002\ ft^2 & 0 & -1.375\ ft & 6.552\ ft & -0.208\ ft & 6.552\ ft & \text{""} & \text{""} & \text{""} & \text{""} \\ 8 & 0 & 0.002\ ft^2 & 0 & 0.208\ ft & 6.552\ ft & 1.375\ ft & 6.552\ ft & \text{""} & \text{""} & \text{""} & \text{""} \\ 5 & 0 & 0.002\ ft^2 & 0 & -0.875\ ft & 6.385\ ft & -0.208\ ft & 6.385\ ft & \text{""} & \text{""} & \text{""} & \text{""} \\ 5 & 0 & 0.002\ ft^2 & 0 & 0.208\ ft & 6.385\ ft & 0.875\ ft & 6.385\ ft & \text{""} & \text{""} & \text{""} & \text{""} \\ 13 & 0.3 & 0.002\ ft^2 & 0 & -0.025\ ft & 6.227\ ft & -0.025\ ft & 6.877\ ft & -0.083\ ft & 0.333\ ft & -0.083\ ft & 2.333\ ft \\ 13 & 0.3 & 0.002\ ft^2 & 0 & 0.025\ ft & 6.227\ ft & 0.025\ ft & 6.877\ ft & 0.083\ ft & 0.333\ ft & 0.083\ ft & 2.333\ ft \end{bmatrix}$$

```
Pstr_prop(Psd, x) := | n_grp ← rows(Psd)
                     | A_f ← 0 in^2
                     | ycg_f ← 0 in
                     | for i ∈ 1..n_grp
                     |   | Group ← (Psd^⟨i⟩)^T
                     |   | A_mid ← Group_1 · Group_3
                     |   | y_mid ← mean(Group_6, Group_8)
                     |   | y_grp ← if Group_2 = 0
                     |   |         |  y_mid
                     |   |       else
                     |   |         |  y_end ← mean(Group_10, Group_12)
                     |   |         |  m ← (y_mid − y_end) ÷ (Group_2)
                     |   |         |  if Group_2 ≤ x ≤ (1 − Group_2)
                     |   |         |    | y_mid
                     |   |         |  else if x < Group_2
                     |   |         |    | y_end + m · x
                     |   |         |  else
                     |   |         |    | y_end + m · (1 − x)
                     |   | A_grp ← if Group_4 = 0 ∨ Group_4 ≤ x ≤ (1 − Group_4)
                     |   |         |  A_mid
                     |   |       else
                     |   |         |  0 in^2
                     |   | ycg_f ← if Group_4 = 0 ∨ Group_4 ≤ x ≤ (1 − Group_4)
                     |   |         |  (ycg_f · A_f + y_grp · A_grp) ÷ (A_f + A_grp)
                     |   |       else
                     |   |         |  ycg_f
                     |   | A_f ← A_f + A_grp
                     | Pstr_prop ← [ A_f ; ycg_f ]
```

Gr

$$Ap_test(x) := Pstr_prop(Psd_test, x)_1$$

$$cgp_test(x) := Pstr_prop(Psd_test, x)_2$$

$$Ap_test(0.5) = 0.102\ ft^2$$

```
Pstr_coord(Psd, z) := | n_grp ← rows(Psd)
                      | plist ← [0 in  0 in]
                      | for i ∈ 1 .. n_grp
                      |   | Group ← (Psd^<i>)^T
                      |   | x1m ← Group_5
                      |   | y1m ← Group_6
                      |   | x2m ← Group_7
                      |   | y2m ← Group_8
                      |   | if Group_2 = 0 ∨ Group_2 ≤ z ≤ (1 − Group_2)
                      |   |   | x1 ← x1m
                      |   |   | y1 ← y1m
                      |   |   | x2 ← x2m
                      |   |   | y2 ← y2m
                      |   | else
                      |   |   | x1e ← Group_9
                      |   |   | y1e ← Group_10
                      |   |   | x2e ← Group_11
                      |   |   | y2e ← Group_12
                      |   |   | m1_x ← (x1m − x1e) ÷ (Group_2)
                      |   |   | m1_y ← (y1m − y1e) ÷ (Group_2)
                      |   |   | m2_x ← (x2m − x2e) ÷ (Group_2)
                      |   |   | m2_y ← (y2m − y2e) ÷ (Group_2)
                      |   |   | if x < Group_2
                      |   |   |   | x1 ← x1e + m1_x · z
                      |   |   |   | y1 ← y1e + m1_y · z
                      |   |   |   | x2 ← x2e + m2_x · z
                      |   |   |   | y2 ← y2e + m2_y · z
                      |   |   | else
                      |   |   |   | x1 ← x1e + m1_x · (1 − z)
                      |   |   |   | y1 ← y1e + m1_y · (1 − z)
                      |   |   |   | x2 ← x2e + m2_x · (1 − z)
```

$$y2 \leftarrow y2e + m2_y \cdot (1 - z)$$

$$Pstr_prop \leftarrow \begin{bmatrix} A_f \\ ycg_f \end{bmatrix}$$

$w_{LL} := 0 \cdot klf \qquad f_{pi} := 179 \cdot ksi$

$M_i := \frac{(w_{DL}) \cdot L^2}{8} = (1.424 \cdot 10^3)\ kft \qquad F_{pi} := f_{pi} \cdot A_p = (1.476 \cdot 10^3)\ kip$

$stress_{i_mid} := stress_xx_z\left(S1_prop, F_{pi}, cg_{p_midspan}, M_i, 1\ kip\right)$

$stress_{i_end} := stress_xx_z\left(S1_prop, F_{pi}, cg_{p_end}, 0 \cdot kip \cdot in, 0 \cdot kip\right)$

$stress_{i_mid} = ?$ $\qquad$ $stress_{i_end} = ?$

Final conditions without live load

$w_{LL} := 0 \cdot klf \qquad f_{pe} := 149 \cdot ksi$

$M_e := \frac{(w_{DL}) \cdot L^2}{8} = (1.424 \cdot 10^3)\ kip \cdot ft \qquad F_{pe} := f_{pe} \cdot A_p = (1.229 \cdot 10^3)\ kip$

$stress_{e_mid} := stress_xx_z\left(S1_prop, F_{pe}, cg_{p_midspan}, M_e, 0\ kip\right)$

$stress_{e_end} := stress_xx_z\left(S1_prop, F_{pe}, cg_{p_end}, 0, 0\right)$

$stress_{e_mid} = ?$ $\qquad$ $stress_{e_end} = ?$

Final conditions with live load

$w_{LL} := 2 \cdot klf \qquad f_{pe} := 149 \cdot ksi$

$$M_e := \frac{(w_{DL} + w_{LL}) \cdot L^2}{8} = (4.18 \cdot 10^3)\ kip \cdot ft \qquad F_{pe} := f_{pe} \cdot A_p = (1.229 \cdot 10^3)\ kip$$

$$stress_{e_mid} := stress_xx_z\,(S1_prop, F_{pe}, cg_{p_midspan}, M_e, 0 \cdot kip)$$

$$stress_{e_end} := stress_xx_z\,(S1_prop, F_{pe}, cg_{p_end}, 0\ kip \cdot in, 0\ kip)$$

$stress_{e_mid} = ?$ $stress_{e_end} = ?$

Initial Conditions:

initial stress

$$isotrans := \begin{bmatrix} cos\left(\frac{\pi}{6}\right) & 0 & cos\left(\frac{5 \cdot \pi}{6}\right) \\ sin\left(\frac{\pi}{6}\right) & -1 & sin\left(\frac{5 \cdot \pi}{6}\right) \\ 0 & 0 & 0 \end{bmatrix}$$

final stress
before live load

$$isotrans = \begin{bmatrix} 0.866 & 0 & -0.866 \\ 0.5 & -1 & 0.5 \\ 0 & 0 & 0 \end{bmatrix}$$

final stress
before live load

$$bbox(dpt) := \left\| \begin{array}{l} xsz \leftarrow \left(max\left(dpt^{\langle 1 \rangle}\right) - min\left(dpt^{\langle 1 \rangle}\right)\right) \\ ysz \leftarrow \left(max\left(dpt^{\langle 2 \rangle}\right) - min\left(dpt^{\langle 2 \rangle}\right)\right) \\ inc \leftarrow 0.1 \\ box \leftarrow \begin{bmatrix} min\left(dpt^{\langle 1 \rangle}\right) - inc \cdot xsz & min\left(dpt^{\langle 2 \rangle}\right) - in \\ max\left(dpt^{\langle 1 \rangle}\right) + inc \cdot xsz & max\left(dpt^{\langle 2 \rangle}\right) + in \end{bmatrix} \end{array} \right.$$

$$bbox(newgraph) = ?$$

$$bb := bbox(newgraph)$$

$intpt_{iso}$

$$inpt := \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}$$