LUC-23 - BrR Load Rating Background Calcs

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Checker: F. Getz **Date:** 11/04/2022

This sheet is give the load rating assumptions and inputs.

This sheet is in accordance with AISC Manual for Steel Construction, 15th Ed.

User inputs are highlighted in - Yellow Sheet assumption are highlighted in - Blue

Sheet checks are highlighted in - Green Inputs from other files are highlighted in purple - Purple

Diaphragm Weights

1958 Interior Diaphragm

$Angle_{wt} := 6.1 \cdot plf$

$Angle_{Length} := (7 \cdot ft + 3 \cdot in) + 2 \cdot \left[(36 \cdot in)^2 + (7 \cdot ft + 3 \cdot in)^2 \right]^{0.5} = 22.942\,ft$

$Int_{1958\_wt} := Angle_{wt} \cdot Angle_{Length} = 0.14 \cdot kip$

1958 End Diaphragm

$Angle_{wt} := 8.2 \cdot plf$

$Angle_{Length} := \left(\frac{7 \cdot ft + 3 \cdot in}{\cos(3.175 \cdot deg)} \right) + 2 \cdot \left[(36 \cdot in)^2 + \left(\frac{1}{2} \cdot \frac{7 \cdot ft + 3 \cdot in}{\cos(3.175 \cdot deg)} \right)^2 \right]^{0.5} = 16.681\,ft$

$End_{1958\_wt} := Angle_{wt} \cdot Angle_{Length} + \left(\frac{3}{8} \cdot in \right) \cdot (8 \cdot in) \cdot (12 \cdot in) \cdot 490 \cdot pcf = 0.147 \cdot kip$

2022 End Diaphragm

$Channel_{wt} := 42.7 \cdot plf$

$Channel_{Length} := \frac{7 \cdot ft + 3 \cdot in}{\cos(3.175 \cdot deg)} = 7.261\,ft$

$Stiffener\_vol := \left(\frac{1}{2} \cdot in \right) \cdot \left(8 \frac{1}{4} \cdot in \right) \cdot (34 \cdot in)$

$End_{2022\_wt} := Channel_{wt} \cdot Channel_{Length} + 2 \cdot Stiffener\_vol \cdot 490 \cdot pcf = 0.39 \cdot kip$

2022 Interior Diaphragm

$Angle_{wt} := 8.5 \cdot plf$

$Angle_{Length} := (6 \cdot ft + 0 \cdot in) + 2 \cdot \left[(36 \cdot in)^2 + (6 \cdot ft + 0 \cdot in)^2 \right]^{0.5} = 19.416\,ft$

$Stiffener\_vol := \left(\frac{3}{8} \cdot in \right) \cdot (7.87 \cdot in) \cdot (34 \cdot in)$

$Filler\_PL\_Vol := \left(\frac{3}{8} \cdot in \right) \cdot (12 \cdot in) \cdot (4 \cdot in)$

$Int_{2022\_wt} := Angle_{wt} \cdot Angle_{Length} + (2 \cdot Stiffener\_vol + Filler\_PL\_Vol) \cdot 490 \cdot pcf = 0.227 \cdot kip$

Designer: C. Baker **Date:** 6/27/2023

Checker: R. Brinkman **Date:** 6/29/2023

$\gamma_{conc} := 150 \cdot pcf$

$\gamma_{steel} := 490 \cdot pcf$

$Total\_Span\_Length := 2 \cdot (52 \cdot ft + 86.5 \cdot ft) = 277\ ft$

Program defines the loads from CL to CL of Bearings
So use this for determine loads

BR-2-15

ODOT Standard Drawing - BR-2-15

$HSS4x3x0\_25_{wt} := 10.48 \cdot plf$

$HSS4x4x0\_188_{wt} := 9.40 \cdot plf$

$Post_{height} := 1 \cdot ft + 6 \cdot in - 0.75 \cdot in = 17.25 \cdot in$

$BR\_Base\_Plate_{wt} := (10.5 \cdot in \cdot 10.5 \cdot in \cdot 0.75 \cdot in) \cdot \gamma_{steel} = 0.023 \cdot kip$

$Hardware\_Increase := 105 \cdot \%$

Increase by 5% to account for
bolts splice plates, etc.

$Total\_Posts\_South := (24) \cdot 2 = 48$

$$South\_BR_{wt\_total} := \left[\begin{array}{l} 2 \cdot HSS4x3x0\_25_{wt} \ldots \\ + \left(\begin{array}{l} HSS4x4x0\_188_{wt} \cdot Post_{height} \ldots \\ + BR\_Base\_Plate_{wt} \end{array} \right) \cdot \dfrac{Total\_Posts\_South}{Total\_Span\_Length} \end{array} \right] \cdot Hardware\_Increase = 0.029 \cdot klf$$

BR-2-15 - Modified

The middle barrier has tubes on both sides

$Backing\_Plate_{wt} := (8 \cdot in \cdot 3 \cdot in \cdot 0.25 \cdot in) \cdot \gamma_{steel} = 0.002 \cdot kip$

$Total\_Posts\_Middle := (22) \cdot 2 = 44$

$$Middle\_BR_{wt\_total} := \left[\begin{array}{l} 4 \cdot HSS4x3x0\_25_{wt} \ldots \\ + \left(\begin{array}{l} HSS4x4x0\_188_{wt} \cdot Post_{height} \ldots \\ + BR\_Base\_Plate_{wt} + 2 \cdot Backing\_Plate_{wt} \end{array} \right) \cdot \dfrac{Total\_Posts\_South}{Total\_Span\_Length} \end{array} \right] \cdot Hardware\_Increase = 0.051 \cdot klf$$

Fence

$Rail_{wt} := 7.93 \cdot plf$ *HSS 3.5 x 2 x 1/4*

$Post_{wt} := 17.20 \cdot plf$ *HSS 3.5 x 2 x 3/8*

$Post\_Ht := 6 \cdot ft - 0.625 \cdot in = 5.948\,ft$

$Picket_{wt} := 1 \cdot in \cdot 1 \cdot in \cdot \gamma_{steel} = 3.403 \cdot plf$

$Picket_{ht} := 4ft + 6in$

$Pickets\_Max\_Space := 4 \cdot in$

$No\_Pickets := round(Total\_Span\_Length \div Pickets\_Max\_Space, 0) = 831$

Approximate by dividing the max spacing by the total span length. Some pickets will be closer spaced, and there are pilasters but this is a good approximation

$No\_Fence\_Posts := (20) \cdot 2 = 40$

$Fence\_Base\_Plate_{wt} := (8 \cdot in \cdot 9 \cdot in \cdot 0.625 \cdot in) \cdot \gamma_{steel}$ *Same for both North and South*

$Mesh_{wt} := 2 \cdot psf$

$Mesh_{ht} := Picket_{ht} = 4.5\,ft$

$$Total\_Fence_{wt\_total} := \left[\begin{array}{l} 3 \cdot Rail_{wt} + \left(\begin{array}{l} Post_{wt} \cdot Post\_Ht \ ... \\ + Fence\_Base\_Plate_{wt} \end{array} \right) \cdot \frac{No\_Fence\_Posts}{Total\_Span\_Length} \ ... \\ + \left(Picket_{wt} \cdot Picket_{ht} \right) \cdot \frac{No\_Pickets}{Total\_Span\_Length} \ ... \\ + Mesh_{wt} \cdot Mesh_{ht} \end{array} \right] Hardware\_Increase = 0.1 \cdot klf$$

Total South Barrier

$South\_Conc\_Barrier_{wt} := [(1.5 \cdot ft \cdot 1.5 \cdot ft) + 6 \cdot in \cdot (1 \cdot ft + 8 \cdot in)] \cdot \gamma_{conc} = 0.462 \cdot klf$

$South\_Total\_Barrier_{wt} := South\_Conc\_Barrier_{wt} + South\_BR_{wt\_total} + Total\_Fence_{wt\_total} = 0.591 \cdot klf$

$South\_Program\_Conc_{wt} := 0.450 \cdot klf$

There are limitations in the program as to how to input the loads, take the program load for the concrete and then adjust the superimposed load as needed to get the total load calculated above

$South\_Add\_Load\_Program\_Input_{wt} := South\_Total\_Barrier_{wt} - South\_Program\_Conc_{wt} = 0.141 \cdot klf$

Total Middle Barrier

$Middle\_Conc\_Barrier_{wt} := [2 \cdot ft \cdot (1 \cdot ft + 1.5 \cdot in)] \cdot \gamma_{conc} = 0.337 \cdot klf$

$Middle\_Total\_Barrier_{wt} := Middle\_Conc\_Barrier_{wt} + Middle\_BR_{wt\_total} = 0.389 \cdot klf$

Total North Barrier

$North\_Conc\_Barrier_{wt} := [[1.5 \cdot ft \cdot (1 \cdot ft + 1.5 \cdot in)] + 6 \cdot in \cdot (1 \cdot ft + 3.5 \cdot in)] \cdot \gamma_{conc} = 0.35 \cdot klf$

$North\_Total\_Barrier_{wt} := North\_Conc\_Barrier_{wt} + Total\_Fence_{wt\_total} = 0.45 \cdot klf$

$North\_Program\_Conc_{wt} := 0.338 \cdot klf$

There are limitations in the program as to how to input the loads, take the program load for the concrete and then adjust the superimposed load as needed to get the total load calculated above

$North\_Add\_Load\_Program\_Input_{wt} := North\_Total\_Barrier_{wt} - North\_Program\_Conc_{wt} = 0.112 \cdot klf$

Pilaster Loads

$Abutment\_Pilaster\_Length := 5 \cdot ft + 5 \cdot in$

$Interior\_Pilaster\_Length := 3 \cdot ft$

$South\_Pilaster\_Width := 1 \cdot ft + 3.5 \cdot in$

$$South\_Abut\_Pilaster\_Load := Abutment\_Pilaster\_Length \cdot \left[(6 \cdot ft + 1 \cdot in) South\_Pilaster\_Width\, \gamma_{conc}\right] \ldots + (Abutment\_Pilaster\_Length + 4 \cdot in) \cdot \left[(7.5 \cdot in) \cdot (South\_Pilaster\_Width + 3 \cdot in) \cdot \gamma_{conc}\right] \ldots + Abutment\_Pilaster\_Length \cdot (1 \cdot ft + 3.5 \cdot in) \cdot (2 \cdot ft) \cdot \gamma_{conc} = 9.314 \cdot kip$$

$$South\_Interior\_Pilaster\_Load := Interior\_Pilaster\_Length \cdot \left[(6 \cdot ft + 1 \cdot in) South\_Pilaster\_Width\, \gamma_{conc}\right] \ldots + (Abutment\_Pilaster\_Length + 4 \cdot in) \cdot (7.5 \cdot in) \cdot (South\_Pilaster\_Width + 3 \cdot in) \cdot \gamma_{conc} \ldots + Abutment\_Pilaster\_Length \cdot (1 \cdot ft + 3.5 \cdot in) \cdot (2 \cdot ft) \cdot \gamma_{conc} = 6.466 \cdot kip$$

$North\_Pilaster\_Width := 1 \cdot ft$

$$North\_Abut\_Pilaster\_Load := Abutment\_Pilaster\_Length \cdot \left[(6 \cdot ft + 1 \cdot in) North\_Pilaster\_Width\, \gamma_{conc}\right] \ldots + (Abutment\_Pilaster\_Length + 4 \cdot in) \cdot \left[(7.5 \cdot in) \cdot (North\_Pilaster\_Width + 3 \cdot in) \cdot \gamma_{conc}\right] \ldots + Abutment\_Pilaster\_Length \cdot (1 \cdot ft + 8 \cdot in) \cdot (2 \cdot ft) \cdot \gamma_{conc} = 8.325 \cdot kip$$

$$North\_Interior\_Pilaster\_Load := Interior\_Pilaster\_Length \cdot \left[(6 \cdot ft + 1 \cdot in) North\_Pilaster\_Width\, \gamma_{conc}\right] \ldots + (Abutment\_Pilaster\_Length + 4 \cdot in) \cdot (7.5 \cdot in) \cdot (North\_Pilaster\_Width + 3 \cdot in) \cdot \gamma_{conc} \ldots + Abutment\_Pilaster\_Length \cdot (1 \cdot ft + 8 \cdot in) \cdot (2 \cdot ft) \cdot \gamma_{conc} = 6.12 \cdot kip$$

Note that the barrier load MUST be defined the full length. The The pilaster weight calculated was the total weight. Therefore subtract off the barrier weight to be used to pinput into the BrR Program

G14

$BrR\_South\_Abut\_Pilaster\_Load := South\_Abut\_Pilaster\_Load - South\_Total\_Barrier_{wt} \cdot Abutment\_Pilaster\_Length = 6.111 \cdot kip$

$BrR\_South\_Interior\_Pilaster\_Load := South\_Interior\_Pilaster\_Load - South\_Total\_Barrier_{wt} \cdot Abutment\_Pilaster\_Length = 3.263 \cdot kip$

G1

$BrR\_North\_Abut\_Pilaster\_Load := North\_Abut\_Pilaster\_Load - North\_Total\_Barrier_{wt} \cdot Abutment\_Pilaster\_Length = 5.887 \cdot kip$

$BrR\_North\_Interior\_Pilaster\_Load := North\_Interior\_Pilaster\_Load - North\_Total\_Barrier_{wt} \cdot Abutment\_Pilaster\_Length = 3.682 \cdot kip$

$Abut\_Pil\_Loc_1 := Abutment\_Pilaster\_Length \div 2 - (2 \cdot ft + 9 \cdot in - 6 \cdot in) = 0.458 \cdot ft$

$Abut\_Pil\_Loc_2 := Total\_Span\_Length - Abut\_Pil\_Loc_1 = 276.542\ ft$

$Int\_Pil\_Loc\_1 := 52 \cdot ft$

$Int\_Pil\_Loc\_2 := Int\_Pil\_Loc\_1 + 57 \cdot ft + 8 \cdot in = 109.667\ ft$

$Int\_Pil\_Loc\_3 := Total\_Span\_Length - Int\_Pil\_Loc\_2 = 167.333\ ft$

$Int\_Pil\_Loc\_4 := Total\_Span\_Length - Int\_Pil\_Loc\_1 = 225\ ft$

Lighting Load

$$Lighting\_Bump\_Out_{wt} := \begin{bmatrix} 1.5 \cdot ft \cdot (1 \cdot ft + 7 \cdot in) \ ... \\ + 2 \cdot (1 \cdot ft + 5 \cdot in) \cdot (1 \cdot ft + 7 \cdot in) \end{bmatrix} \cdot 1.5 \cdot ft \cdot \gamma_{conc} = 1.544 \cdot kip$$

$Light\_Pole_{wt} := 150 \cdot lbf$

$Total\_Light_{wt} := Lighting\_Bump\_Out_{wt} + Light\_Pole_{wt} = 1.694 \cdot kip$

$Light\_Loc\_1 := 26 \cdot ft + 10 \cdot in = 26.833\ ft$

$Light\_Loc\_2 := 79 \cdot ft + 4 \cdot in = 79.333\ ft$

$Light\_Loc\_3 := 138 \cdot ft + 6 \cdot in = 138.50\ ft$

$Light\_Loc\_4 := Total\_Span\_Length - Light\_Loc\_2 = 197.667\ ft$

$Light\_Loc\_5 := Total\_Span\_Length - Light\_Loc\_1 = 250.167\ ft$

Bar Deck Offset Location

$$Bot\_Bar\_Dist := 1.5in + \frac{5}{8}\cdot in + \frac{1}{2}\cdot\frac{5}{8}in = 2.438\cdot in$$

$$Top\_Bar\_Dist := 2.5\cdot in + \frac{1}{2}\cdot\frac{4}{8}\cdot in = 2.750\cdot in$$

$$Pier\_Bar\_Dist := 2.5\cdot in + \frac{1}{2}\cdot\frac{5}{8}\cdot in = 2.813\cdot in$$