Multi-Post Sign Calculations

SR 93 (I-75)

FPID 444008-4-52-01

Collier County

Prepared By:

Faller, Davis & Associates, Inc.

APRIL 2024

Note to Reviewer:

The only post type that is allowed per FDOT Standards is the Steel Beam 2-post or the Steel Beam 3-post. All supports proposed in this project are the 2-post steel beam. All calculations show “OK” for 2-post steel beams within this calculation set. All other calculations for other types of support posts should be ignored.

Multi- Column Ground Sign Post Design

SUBJECT Standard Plans Index 700-020
PROJECT # 444008-4-52-01
DESIGNED BY KF_____ DATE 03/28/24_____
CHECKED BY _____ DATE _____

GENERAL INFORMATION:

References:

1. AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 1st Edition. [LRFD LTS-1]
2. FDOT Structures Manual Volume 3
3.FDOT Standard Plans for Road and Bridge Construction, Index 700-020.

Reference:H:\60800\44400845201\signing\Mathcad\LRFD Equation Module.xmcd(R)

DESIGN REQUIREMENTS:

Main Panel Dimensions

$L_{panel} := 12 \cdot ft$ $D_{panel} := 6.5 \cdot ft$

Top Panel Dimensions and Location

$L_{top.panel} := 0 \cdot ft$ $D_{top.panel} := 0 \cdot ft$

TopJustification := Left / Center / Right

Bottom Panel Dimensions and Location

$L_{bot.panel} := 0 \cdot ft$ $D_{bot.panel} := 0 \cdot ft$

BottomJustification := Left / Center / Right

Ground Slope and Sign Height

$Run_{Rise} := 7.91 \cdot \frac{ft}{ft}$ *ground slope*

$H_{clear.min.sign} := 8.52 \cdot ft$ *Clearance from the ground to the bottom of the sign*

LRFD Extreme Event I Wind Speed

$V_{wind} := 110 \cdot mph$ *FDOT Structures Manual, Vol. 3 For Ground Signs, Use 110 mph for the entire state*

$z_{panel} := 0ft$ *Height of Main Sign Panel for Wind Load Calculation; Input 0 to use height from the ground line.*

Roadside Design Guide 4.3.2:

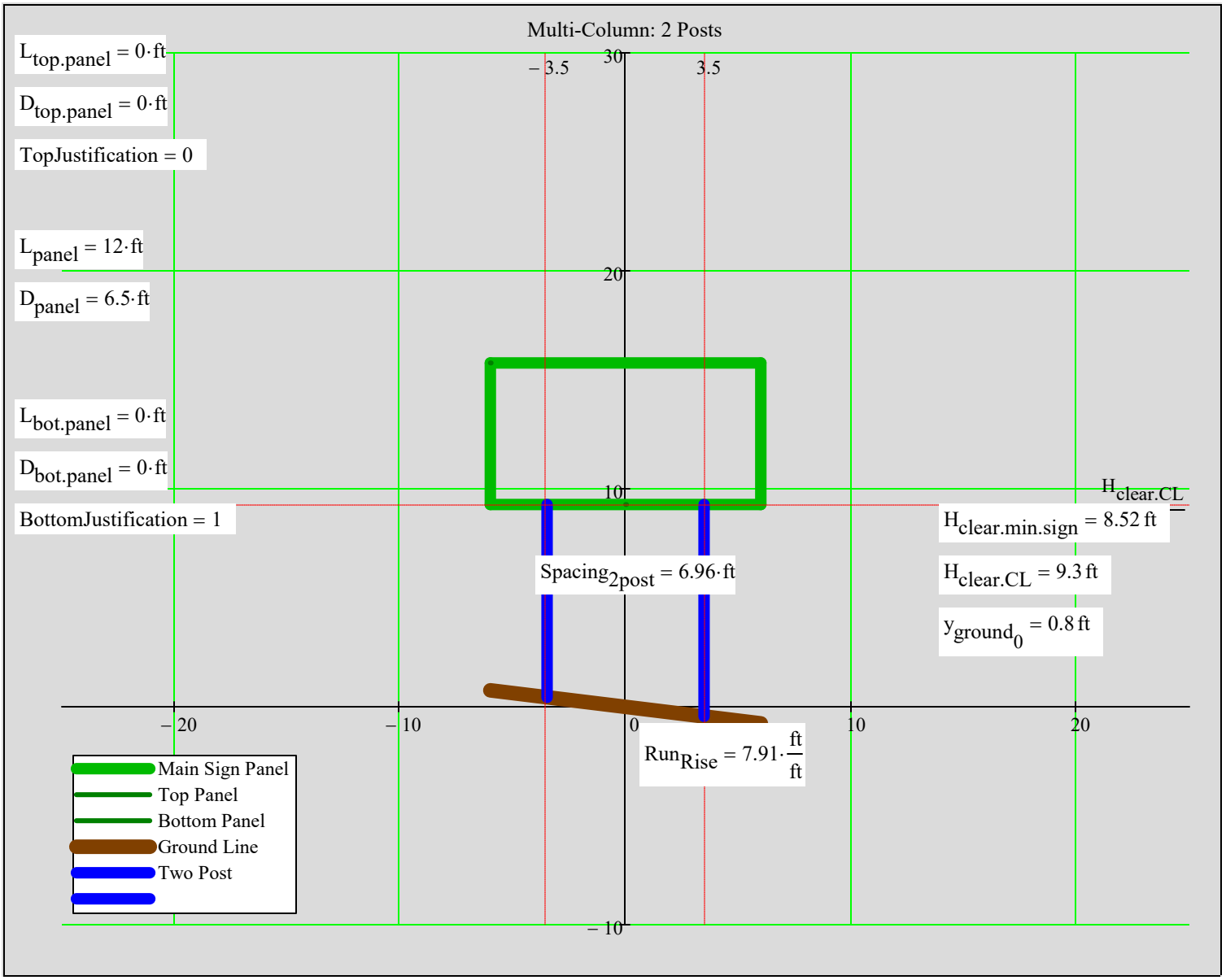
- *The hinge should be at least 7 ft, above the ground so that no portion of the sign or upper section of the support is likely to penetrate the windshield of an impacting vehicle.*
- *No supplementary signs should be attached below the hinges if such placement is likely to interfere with the breakaway action of the support post or if the supplemental sign is likely to strike the windshield of an impacting vehicle.*

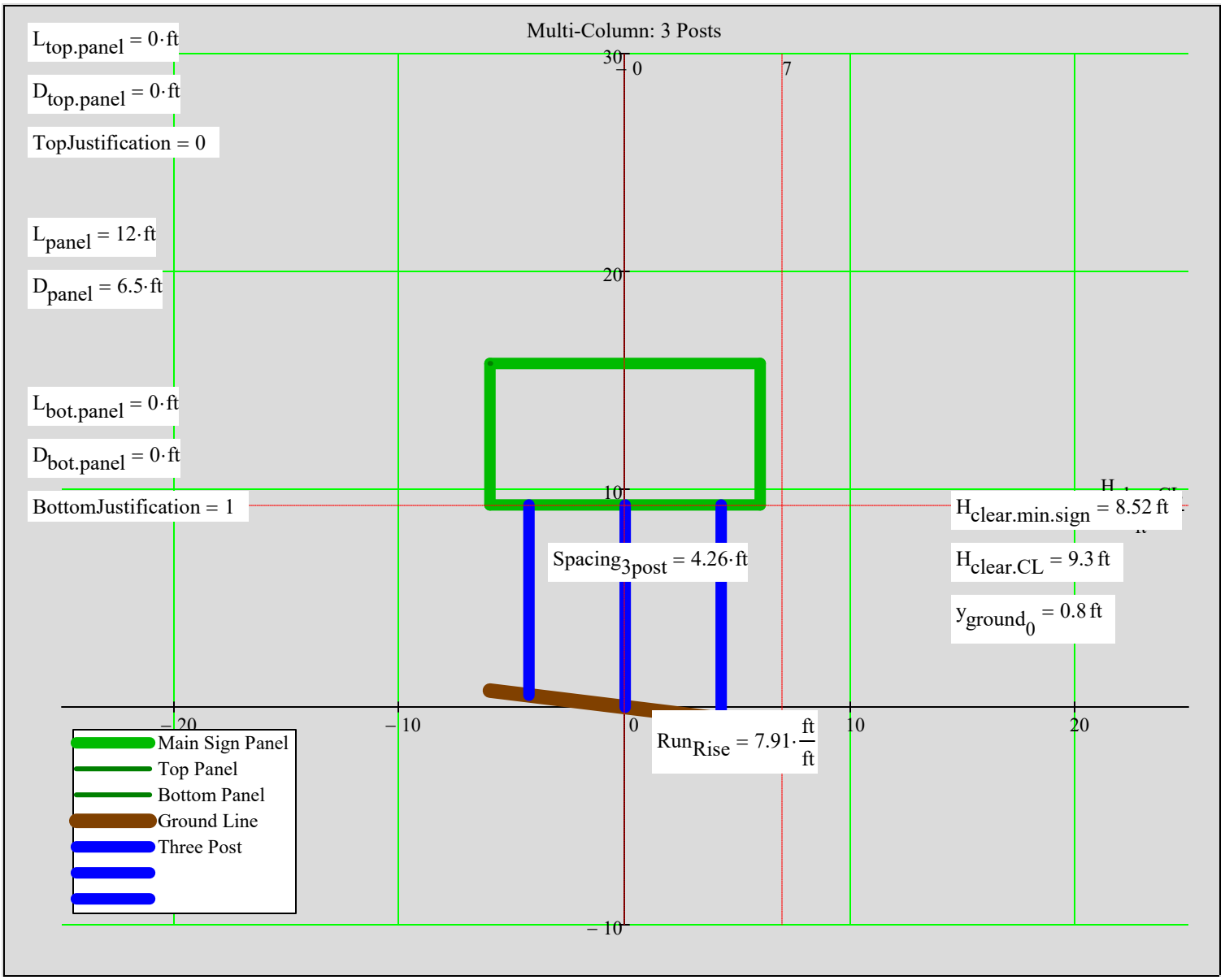
MUTCD 2A.18:

- *Directional signs on freeways and expressways shall be installed with a minimum height of 7 feet,measured vertically from the bottom of the sign to the elevation of the near edge of the pavement.*
- *Where large signs having an area exceeding 50 square feet are installed on multiple breakaway posts, the clearance from the ground to the bottom of the sign shall be at least 7 feet.*

Post and Panel Geometry

Post and Panel Geometry





CheckPanelDims = "OK"

CheckTopPanelDims = "OK"

CheckBotPanelDims = "OK"

CheckMaxPanelWidth2Post = "OK"

CheckMaxClearHeight = "OK "

CheckMinClearHeight = "OK "

Post and Panel Loads

Post and Panel Loads

Post Design: Steel W-Beam

Post Material and Section Properties

$F_{y.stbeam} := 36 \cdot ksi$ $E_{steel} := 29000 \cdot ksi$

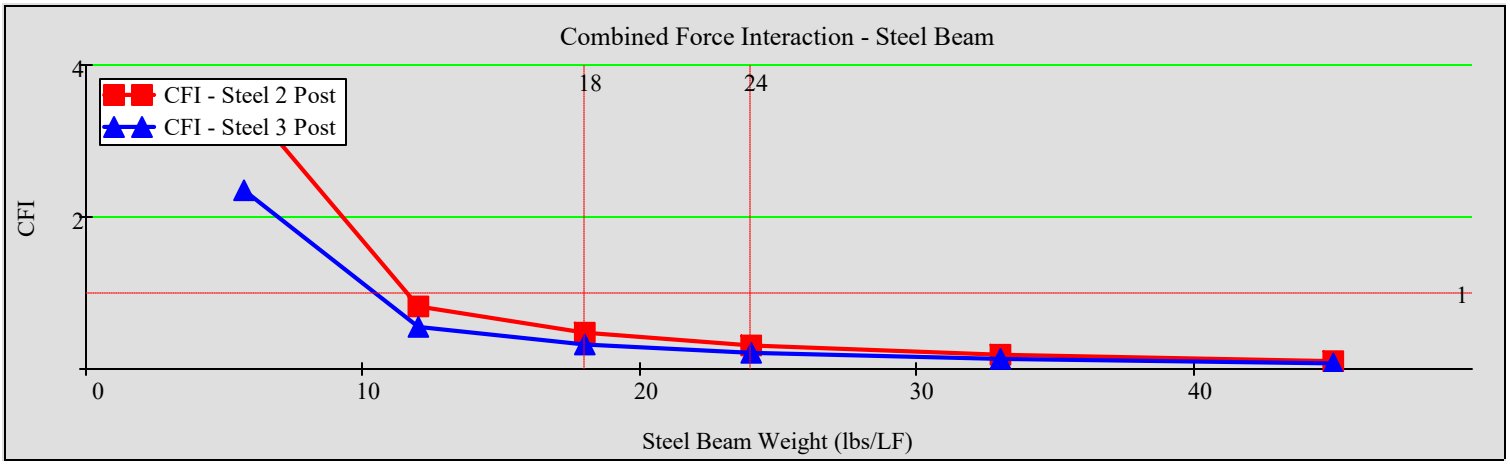
Steel I Beam Designations *S3x5.7* *W6x12* *W8x18* *W8x24* *W10x33* *W12x45*

$Prop_{stbeam} :=$

5.7	12.0	18.0	24.0	33.0	45.0	Wt per Length (lbf/ft)
2.33	4.0	5.25	6.5	7.96	8.0	Flange Width (in)
0.26	0.28	0.33	0.40	0.435	0.575	Flange Thickness (in)
3.0	6.03	8.14	7.93	9.73	12.1	d (in)
0.17	0.23	0.23	0.245	0.29	0.335	Web Thickness (in)
1.66	3.55	5.26	7.08	9.71	13.1	A (in3)
1.67	7.31	15.2	20.9	35.0	57.7	S (in3)
1.94	8.30	17.0	23.1	38.8	64.2	Z (in3)
2.5	22.1	61.9	82.7	171.0	348	I (in4)
0.447	2.99	7.97	18.3	36.6	50.0	Iy (in4)
0.0433	0.0903	0.172	0.346	0.583	1.26	J (in4)
0.838	24.7	122	259	791	1650	Cw(in6)

The order of Steel Beams need to be in ascending order of the Section Strength

Steel Beam Post Design



$WtPerFt_{stbeam} = \begin{pmatrix} 5.7 \\ 12 \\ 18 \\ 24 \\ 33 \\ 45 \end{pmatrix} \cdot \frac{lbf}{ft}$ $CFI_{2Post.stbeam} = \begin{pmatrix} 3.54 \\ 0.82 \\ 0.48 \\ 0.31 \\ 0.19 \\ 0.11 \end{pmatrix}$

Smallest 2 Post Steel Beam that Satisfies Strength Requirements

SteelBeam2Post = "W 6 x 12"

CheckMaxPanelWidth2Post = "OK"

CheckCFI2PostStBeam = "OK"

CheckBreakaway2PostStBeam = "OK"

$$WtPerFt_{stbeam} = \begin{pmatrix} 5.7 \\ 12 \\ 18 \\ 24 \\ 33 \\ 45 \end{pmatrix} \cdot \frac{lbf}{ft} \qquad CFI_{3Post.stbeam} = \begin{pmatrix} 2.35 \\ 0.55 \\ 0.33 \\ 0.21 \\ 0.13 \\ 0.07 \end{pmatrix}$$

Smallest 3 Post Steel Beam that Satisfies Strength Requirements

SteelBeam3Post = "W 6 x 12"

CheckCFI3PostStBeam = "OK"

CheckBreakaway3PostStBeam = "OK"

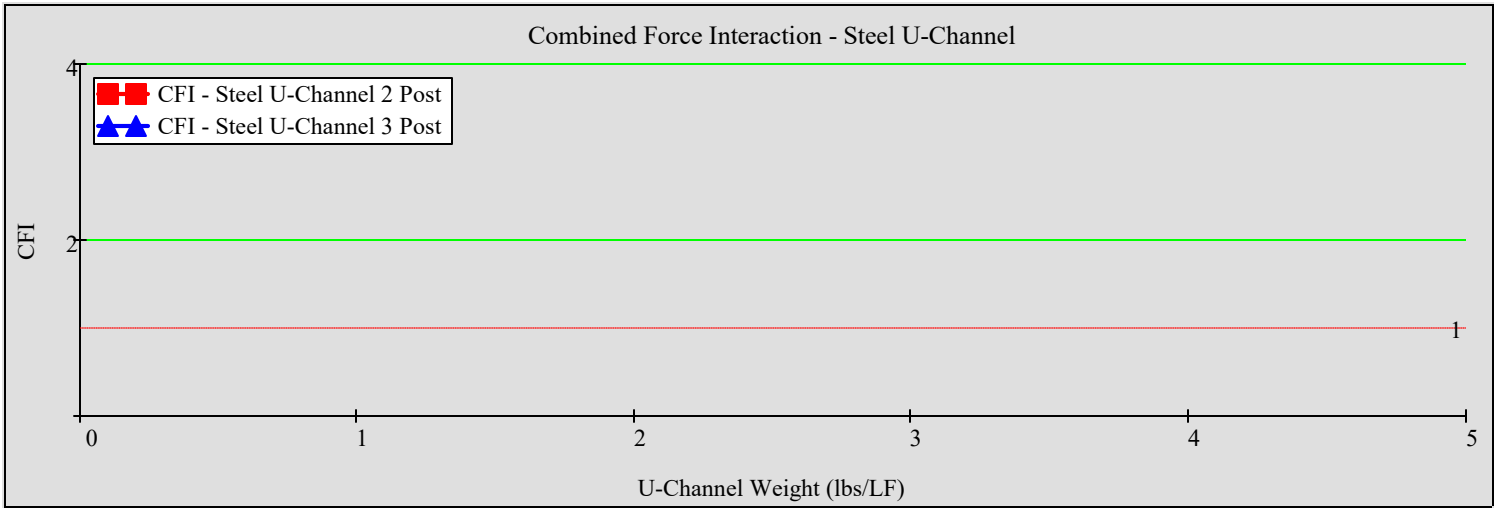
Post Design: Steel U-Channel

$F_{y.steel.uchan} := 60 \cdot ksi$

$$Prop_{uchan} := \begin{pmatrix} 2 & 2.5 & 3 & 4 \\ 3.125 & 3.125 & 3.5 & 3.5 \\ 1.25 & 1.25 & 1.625 & 1.671 \\ 0.11 & 0.13 & 0.14 & 0.19 \\ 0.59 & 0.74 & 0.92 & 1.24 \\ 0.23 & 0.31 & 0.43 & 0.56 \\ 0.26 & 0.35 & 0.48 & 0.62 \\ 0.18 & 0.24 & 0.40 & 0.50 \end{pmatrix} \begin{pmatrix} \text{Wt per Length (lbf/ft)} \\ \text{Overall Width (in)} \\ \text{Flange Width (in)} \\ \text{Flange Thickness (in)} \\ \text{A (in3)} \\ \text{S (in3)} \\ \text{Z (in3)} \\ \text{Iy (in4)} \end{pmatrix}$$

The order of Steel U-Channels need to be in ascending order of the Section Strength

Steel U-Channel Post Design



$$WtPerFt_{uchan} = \begin{pmatrix} 2 \\ 2.5 \\ 3 \\ 4 \end{pmatrix} \cdot \frac{lbf}{ft} \qquad CFI_{2Post.uchan} = \begin{pmatrix} 13.53 \\ 9.84 \\ 8.20 \\ 5.87 \end{pmatrix}$$

Smallest 2 Post U-Channel that Satisfies Strength Requirements

SteelUChannel2Post = "N/A"

CheckMaxPanelWidth2Post = "OK"

CheckCFI2PostUchan = "NG"

CheckBreakaway2PostUchan = "OK"

$$WtPerFt_{uchan} = \begin{pmatrix} 2 \\ 2.5 \\ 3 \\ 4 \end{pmatrix} \cdot \frac{lbf}{ft} \qquad CFI_{3Post.uchan} = \begin{pmatrix} 9.37 \\ 7.35 \\ 5.69 \\ 4.07 \end{pmatrix}$$

Smallest 3 Post U-Channel that Satisfies Strength Requirements

SteelUChannel3Post = "N/A"

CheckCFI3PostUchan = "N/A"

CheckBreakaway3PostUchan = "OK"

Post Design: Aluminum Beam (6061-T6 Alloy)

Post Material and Section Properties

$F_{cy} := 35 \cdot ksi$ $F_{ty} := 35 \cdot ksi$ $C_t := 141$ $F_{tu} := 38 \cdot ksi$ $k_t := 1.0$ $E_{aluminum} := 10100 \cdot ksi$

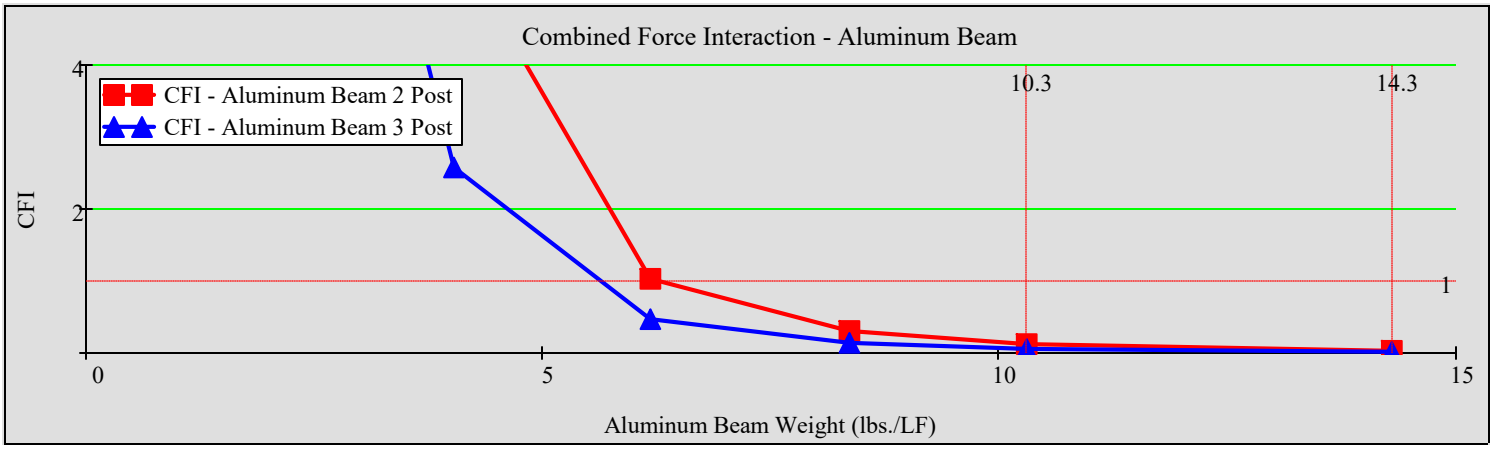
Aluminum I-Beam Designations *4x2.79* *8x6.18* *10x10.3* *3x2.03* *6x4.03* *8x8.36* *12x14.3*

$Prop_{albeam} :=$

2.03	2.79	4.03	6.18	8.36	10.3	14.3	Wt per Length (lbf/ft)
2.5	3	4	5	5.5	6	7	Flange Width (in)
0.26	0.29	0.29	0.35	0.44	0.5	0.62	Flange Thickness (in)
3	4	6	8	9	10	12	d (in)
0.15	0.17	0.19	0.23	0.27	0.29	0.31	Web Thickness (in)
1.73	2.38	3.43	5.26	7.11	8.75	12.1	A (in3)
1.81	3.36	7.33	14.9	22.7	31.2	52.9	S (in3)
1.25	1.68	2.53	3.37	3.79	4.22	5.11	r (in)
2.71	6.71	22.0	59.7	102	156	317	I (in4)
0.679	1.31	3.10	7.30	12.2	18.0	35.5	Iy (in4)
0.0374	0.0608	0.0888	0.188	0.386	0.620	1.26	J (in4)
1.27	4.5	25.3	107	224	407	1149	Cw (in6)

The order of Aluminum Beams need to be in ascending order of the Section Modulus

Aluminum Beam Post Design



$WtPerFt_{albeam} = \begin{pmatrix} 2.03 \\ 2.79 \\ 4.03 \\ 6.18 \\ 8.36 \\ 10.3 \\ 14.3 \end{pmatrix} \cdot \frac{lbf}{ft}$ $CFI_{2Post.albeam} = \begin{pmatrix} 59.06 \\ 19.86 \\ 5.73 \\ 1.03 \\ 0.30 \\ 0.13 \\ 0.03 \end{pmatrix}$

Smallest 2 Post Aluminum Beam that Satisfies Strength Requirements

AlBeam2Post = "I 9 x 8.36"

CheckMaxPanelWidth2Post = "OK"

CheckCFI2PostAlBeam = "OK"

CheckBreakaway2PostAlBeam = "OK"

$WtPerFt_{albeam} = \begin{pmatrix} 2.03 \\ 2.79 \\ 4.03 \\ 6.18 \\ 8.36 \\ 10.3 \\ 14.3 \end{pmatrix} \cdot \frac{lbf}{ft}$ $CFI_{3Post.albeam} = \begin{pmatrix} 26.19 \\ 8.82 \\ 2.58 \\ 0.47 \\ 0.14 \\ 0.06 \\ 0.02 \end{pmatrix}$

Smallest 3 Post Aluminum Beam that Satisfies Strength Requirements

AlBeam3Post = "I 8 x 6.18"

CheckCFI3PostAlBeam = "OK"

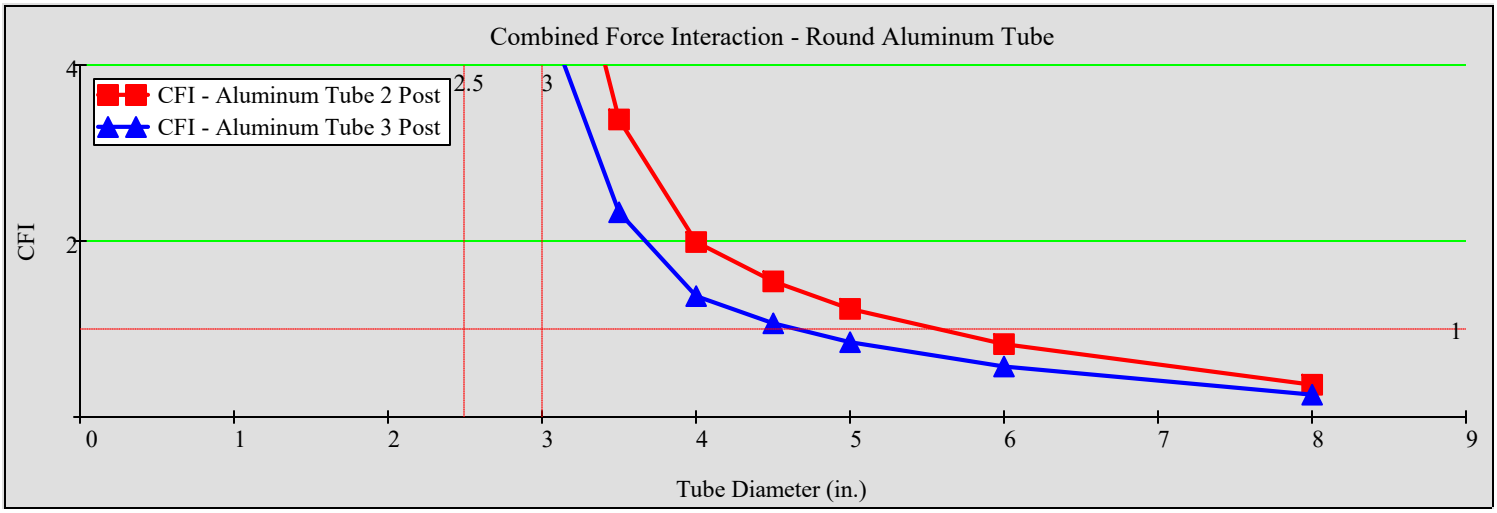
CheckBreakaway3PostAlBeam = "NG"

Post Design: Aluminum Round Tube (6061-T6 Alloy)

$$AlTube := \begin{pmatrix} 2 & 2.5 & 3 & 3.5 & 4 & 4.5 & 5 & 6 & 8 \\ 0.125 & 0.125 & 0.125 & 0.188 & 0.25 & 0.25 & 0.25 & 0.25 & 0.313 \end{pmatrix} \begin{pmatrix} \text{Outside Diameter (in)} \\ \text{Wall Thickness (in)} \end{pmatrix}$$

The order of Aluminum Round Tubes needs to be in ascending order of the Section Strength

Aluminum Round Tube Post Design



$$OD_{tube} = \begin{pmatrix} 2 \\ 2.5 \\ 3 \\ 3.5 \\ 4 \\ 4.5 \\ 5 \\ 6 \\ 8 \end{pmatrix} \cdot in \qquad CFI_{2Post.tube} = \begin{pmatrix} 16.62 \\ 10.12 \\ 6.8 \\ 3.38 \\ 1.99 \\ 1.54 \\ 1.23 \\ 0.83 \\ 0.37 \end{pmatrix}$$

Smallest 2 Post Aluminum Tube that Satisfies Strength Requirements

AlTube2Post = "OD = 6 in, t = 1/4 in"

CheckMaxPanelWidth2Post = "OK"

CheckCFI2PostTube = "OK"

CheckBreakaway2PostTube = "NG, posts too strong"

Note: for aluminum tube the only acceptable breakaway sizes are 3 inch OD and smaller with no more than 2 posts in a 7 foot path.

$$OD_{tube} = \begin{pmatrix} 2 \\ 2.5 \\ 3 \\ 3.5 \\ 4 \\ 4.5 \\ 5 \\ 6 \\ 8 \end{pmatrix} \cdot in \qquad CFI_{3Post.tube} = \begin{pmatrix} 11.39 \\ 6.95 \\ 4.68 \\ 2.33 \\ 1.38 \\ 1.07 \\ 0.85 \\ 0.58 \\ 0.26 \end{pmatrix}$$

Smallest 3 Post Aluminum Tube that Satisfies Strength Requirements

AlTube3Post = "OD = 5 in, t = 1/4 in"

CheckCFI3PostTube = "OK"

CheckBreakaway3PostTube = "NG, posts too strong"

Note: for aluminum tube the only acceptable breakaway sizes are 3 inch OD and smaller with no more than 2 posts in a 7 foot path.

Foundation Design

Soil Properties, Shaft Properties and Phi Factor for Overturning

$SoilType := 1$ *(0 for clay, 1 for sand)*

$\gamma_{soil} := 105 \cdot pcf$

$\phi_{soil} := 30 \cdot deg$ *(for sand)*

$c_{soil} := 1.0 \cdot ksf$ *(for clay)*

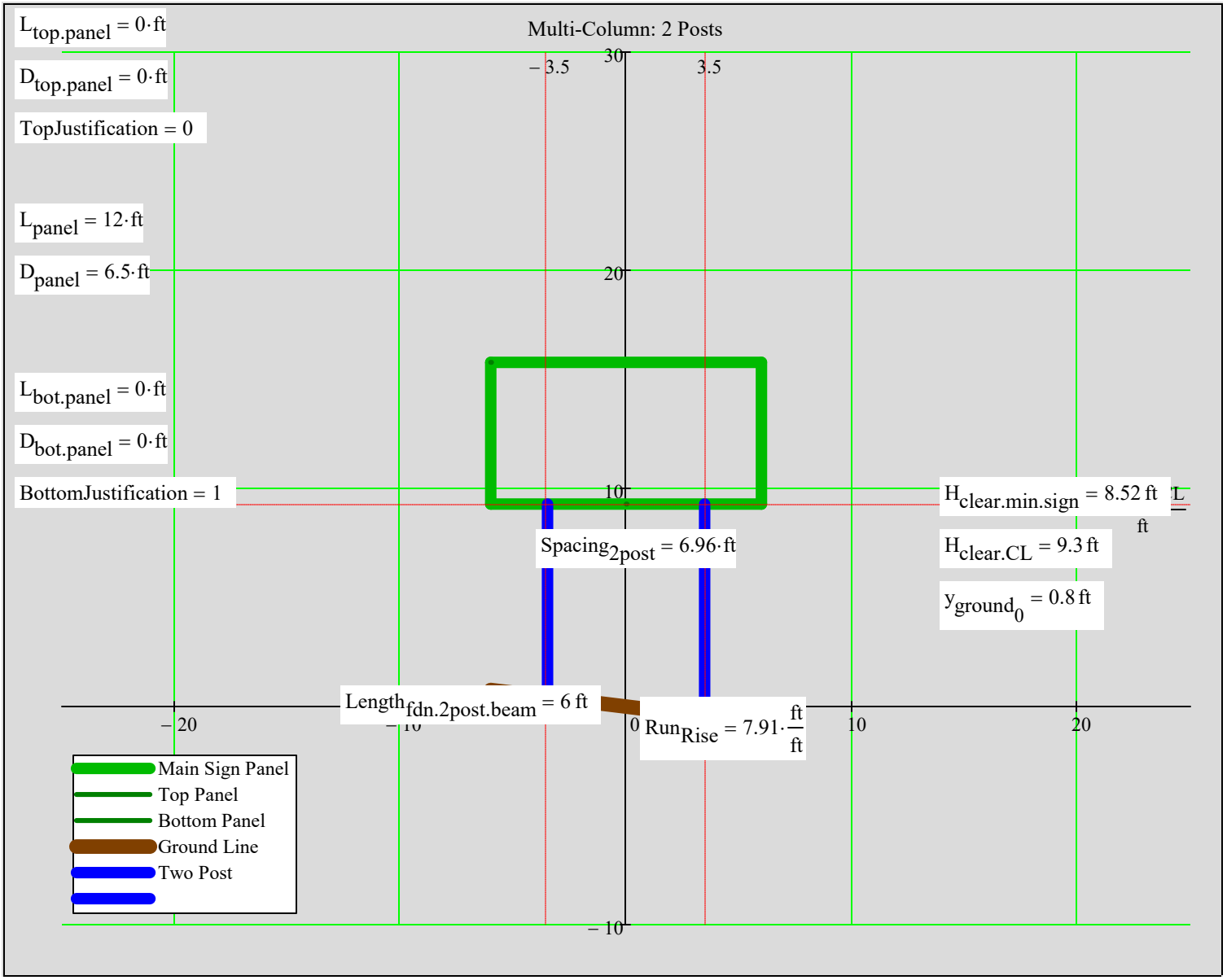
$Dia_{fdn} := 2.0 \cdot ft$

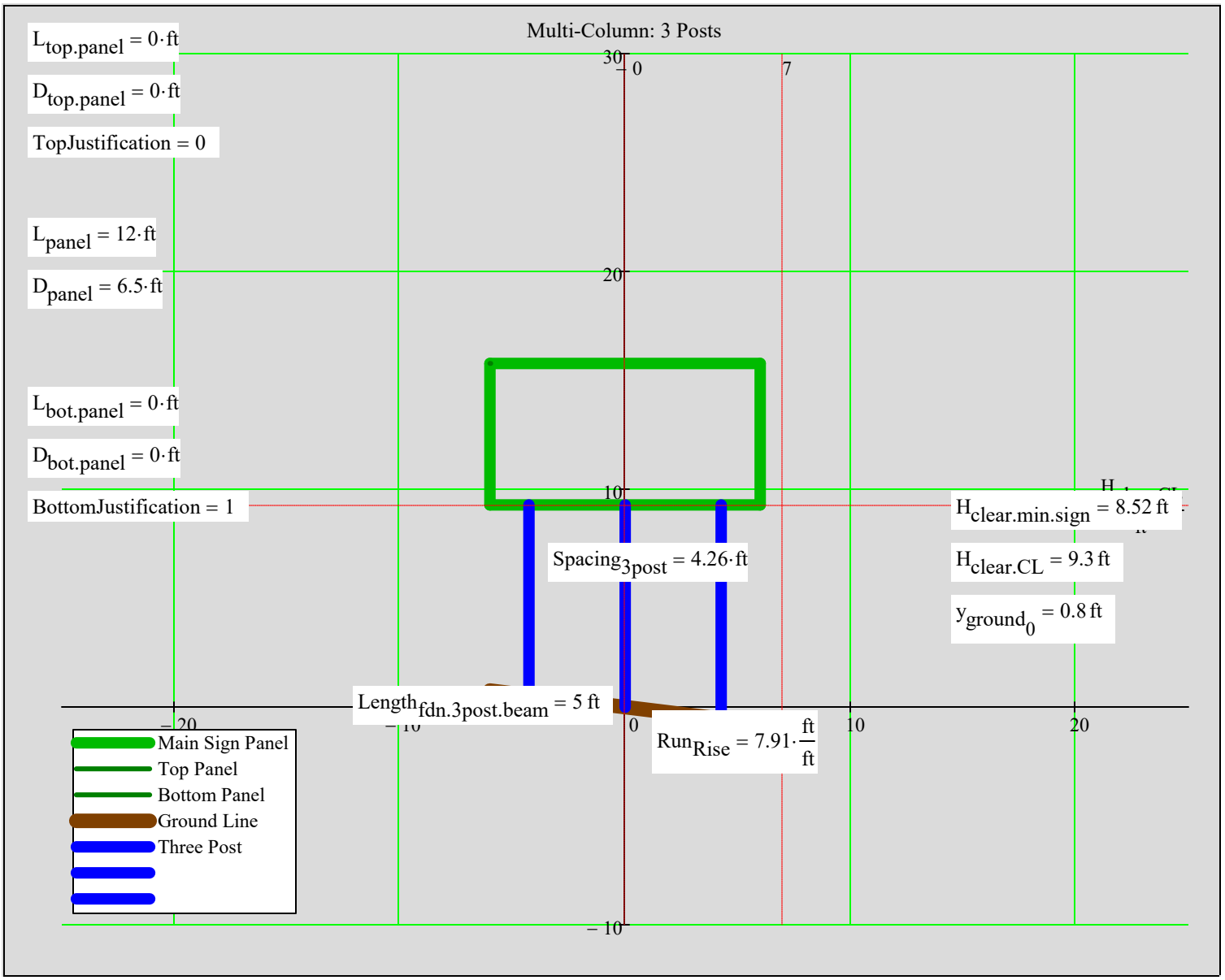
$Offset := 0.5 \cdot ft$

$\phi_{ot} := 0.6$

Foundation Design for Round Piles for Steel & Aluminum Beams and Direct Burial U-Channel and Aluminum Tubes

DESIGN SUMMARY:





Panel and Supplemental Panel Checks

CheckTopPanelDims = "OK"

CheckPanelDims = "OK"

CheckBotPanelDims = "OK"

CheckMaxPanelWidth2Post = "OK"

CheckMaxClearHeight = "OK "

CheckMinClearHeight = "OK "

Design Wind Speed and Number of Wind Beams

$V_{wind} = 110 \cdot mph$ #WindBeams = 2 Check#WindBeams = "OK"

Steel W-Beam Post Option $F_{y.stbeam} = 36 \cdot ksi$

CheckCFI2PostStBeam = "OK"

SteelBeam2Post = "W 6 x 12"

CheckBreakaway2PostStBeam = "OK"

CheckCFI3PostStBeam = "OK"

SteelBeam3Post = "W 6 x 12"

CheckBreakaway3PostStBeam = "OK"

$L_{post.avg} = 14.91 \cdot ft$ *Estimated Average Post Length: 2 Post 3 Post*

Aluminum I-Beam Post Option (6061-T6 Alloy)

CheckCFI2PostAlBeam = "OK") = "I 9 x 8.36"

AlBeam2Post = "I 9 x 8.36"

CheckBreakaway2PostAlBeam = "OK"

CheckCFI3PostAlBeam = "OK"

AlBeam3Post = "I 8 x 6.18"

CheckBreakaway3PostAlBeam = "NG"

$L_{post.avg} = 14.914 \cdot ft$ *Estimated Average Post Length*

Round Pile Foundation Design for Steel and Aluminum Beams

SoilType = 1 *(0 for clay, 1 for sand)* $\gamma_{soil} = 105 \cdot pcf$ $\phi_{soil} = 30 \cdot deg$ $c_{soil} = 1 \cdot ksf$

$Dia_{fdn} = 2 \cdot ft$ Offset = 0.5·ft

Shaft Length for Two Post Configuration $Length_{fdn.2post.beam} = 6 \cdot ft$ *Shaft Length for Three Post Configuration* $Length_{fdn.3post.beam} = 5 \cdot ft$

Steel U-Channel Post Option $F_{y.steel.uchan} = 60 \cdot ksi$

CheckCFI2PostUchan = "NG"

SteelUChannel2Post = "N/A"

CheckBreakaway2PostUchan = "OK"

CheckCFI3PostUchan = "N/A"

SteelUChannel3Post = "N/A"

CheckBreakaway3PostUchan = "OK"

$L_{uchannel.avg} = 18.78 \cdot ft$ *Est. Average Post Length: 2 Post 3 Post*

Aluminum Tube Post Option (6061-T6 Alloy)

CheckCFI2PostTube = "OK"

AlTube2Post = "OD = 6 in, t = 1/4 in"

CheckBreakaway2PostTube = "NG, posts too strong"

CheckCFI3PostTube = "OK"

AlTube3Post = "OD = 5 in, t = 1/4 in"

CheckBreakaway3PostTube = "NG, posts too strong"

$L_{post.avg} = 14.91 \cdot ft$ *Estimated Average Post Length*