CLARK REDER ENGINEERING

STRUCTURAL SUBMITTAL PACKAGE

for

Christie Lites

Christie Lites Type G Truss

Project Location: All 50 States

Event Dates: Various

Submittal Date: 10/21/2022

Clark Reder Project Number: 22.915.05

Reviewed by:

STATE OF OHIO JEFFREY M. REDER E-67450 REGISTERED PROFESSIONAL ENGINEER 10/21/2022

Jeffrey M. Reder, P.E.

Prepared by:

Daniel Glauser E.I.T.

Table of Contents for Structural Submittal Package

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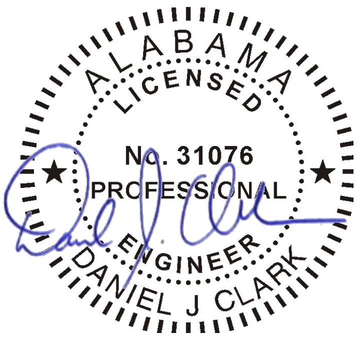		
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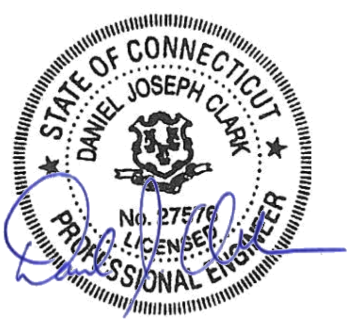		
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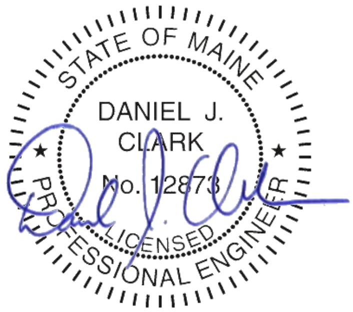


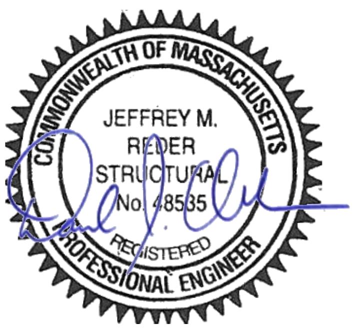
Daniel J. Clark, P.E.
P.E. # 12873

Maryland

Professional Certification: I hereby certify that these documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the State of Maryland, License # 38421,

Jeffrey M. Reder, P.E.
P.E. # 38421

Massachusetts



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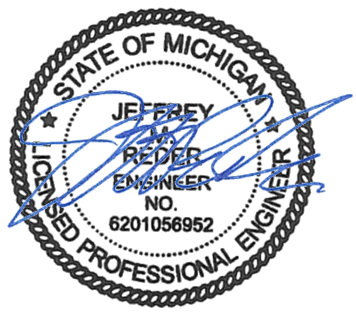

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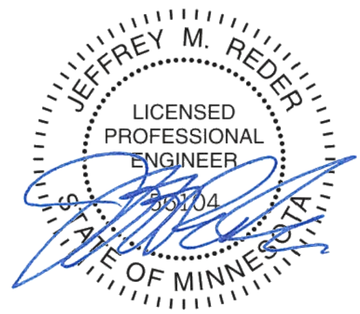

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Date: _______________ License #: 56104

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P.E. # 56104

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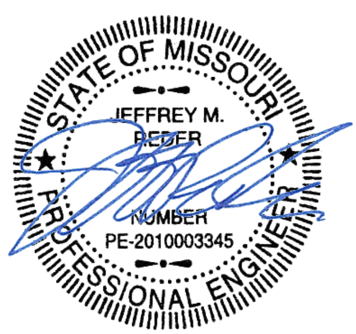
Missouri



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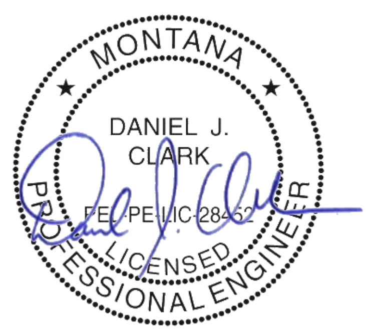

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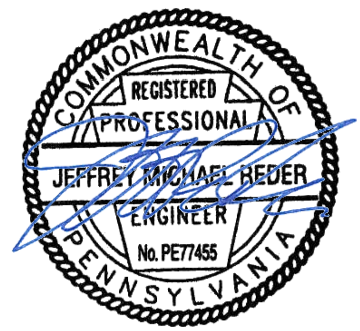

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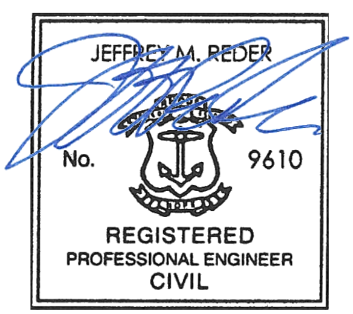

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Project Information

Project Summary

The project referenced by this submittal consists of the analysis of a Christie Lites Type G Truss. All documents were provided by Christie Lites and are included for reference.

Scope of Review

Clark Reder Engineering conducted a structural riview of the Christie Lites Type G box truss. Furthermore, load tables were created for spans of 8' up to 64' per the requirements set forth in the 2020 Aluminum Design Manual, ANSI E1.2-2021, Entertainment Technology, Design, Manufacture and Use of Aluminum Truss and Towers. The tables have been included for reference.

Conclusions

Our review has concluded that the Christie Lites Type G Truss meets the structural requirements of the 2018 International Building Code, ASCE 7-16, and ASCE 37-14.

Limitations and Exceptions

The scope of review for this submittal is limited to the items listed above. All other temporary or permanent structures on site not specifically referenced above under "Scope of Review" are the responsibility of others.

Where the items covered by this submittal are attached to existing structures, it is the responsibility of the engineer of record for those existing structures to review the impact of the elements referenced in this submittal.

GENERAL STRUCTURAL NOTES

EVENT DATE & LOCATION

1. EVENT DATE: VARIOUS
2. EVENT LOCATION: ALL 50 STATES

CODES

1. 2018 INTERNATIONAL BUILDING CODE
2. ASCE 7-16: MINIMUM DESIGN LOADS AND ASSOCIATED CRITERIA FOR BUILDINGS AND OTHER STRUCTURES
3. ASCE 37-14: DESIGN LOADS ON STRUCTURES DURING CONSTRUCTION
4. 2015 ALUMINUM DESIGN MANUAL
5. AISC 360-16: SPECIFICATION FOR STRUCTURAL STEEL BUILDINGS

REFERENCES

1. ANSI E1.2-2021 ENTERTAINMENT TECHNOLOGY, "DESIGN, MANUFACTURE AND USE OF ALUMINUM TRUSSES AND TOWERS"

DESIGN LOADS

1. DEAD LOAD: SELF-WEIGHT OF STRUCTURE
2. ALLOWABLE LOADS: REFER TO THE TWO LOADING TABLES IN THIS SUBMITTAL.

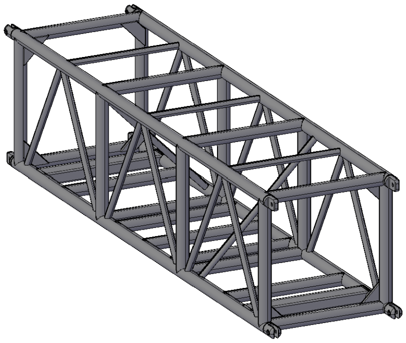
ALUMINUM

1. ALUMINUM SHALL CONFORM TO THE FOLLOWING UNLESS NOTED OTHERWISE ON THE DRAWINGS:
   A. MEMBER ALLOY: 6061-T6
   B. WELD FILLER ALLOY: 4043
2. ALL DETAILING, FABRICATION AND ERECTION SHALL CONFORM TO THE ALUMINUM ASSOCIATION ALUMINUM DESIGN MANUAL, CURRENT EDITION.
3. WELDING SHALL BE IN ACCORDANCE WITH THE AMERICAN WELDING SOCIETY LATEST EDITION.
4. FIELD CONNECTIONS SHALL BE BOLTED UNLESS SPECIFIED OTHERWISE ON THE DRAWINGS.
5. WHERE THE CONTACT OF DISSIMILAR METALS MAY CAUSE ELECTROLYSIS, MEANS SHALL BE PROVIDED TO SEPARATE THE DISSIMILAR METALS WITH A NON-CONDUCTIVE MATERIAL.

INSPECTIONS

1. ALL TRUSS UNITS AND/OR OTHER EQUIPMENT SHALL BE VISUALLY INSPECTED PRIOR TO ERECTION. DAMAGED OR CORRODED EQUIPMENT SHALL NOT BE USED. FIELD MODIFICATIONS SHALL BE APPROVED BY THE ENGINEER OF RECORD PRIOR TO INSTALLATION.

APPENDIX A



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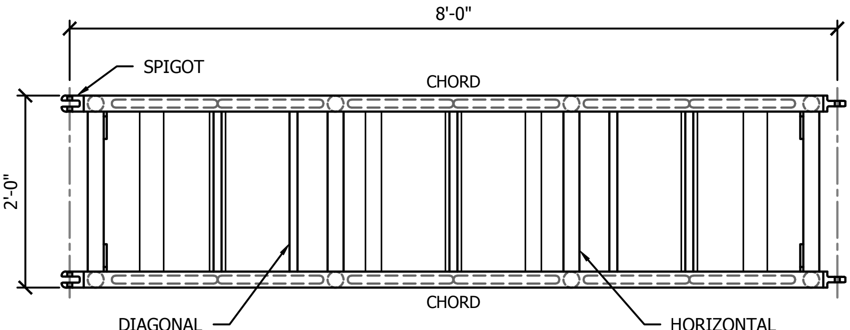
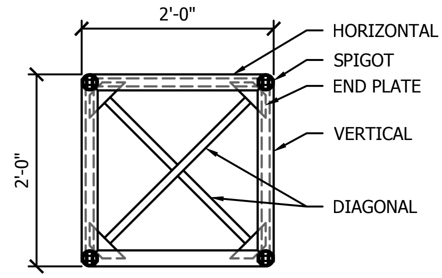
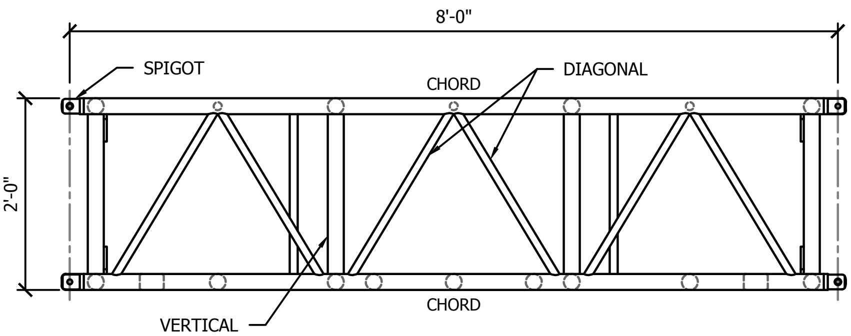


TOP VIEW



END VIEW



SIDE VIEW

CHRISTIE LITES TYPE G TRUSS 24"x24" SPIGOTED TRUSS TABLE

TRUSS SPAN	UNIFORMLY DISTRIBUTED LOAD		CENTER POINT LOAD		THIRD POINT LOAD		QUARTER POINT LOAD		FIFTH POINT LOAD	
	LOAD	DEFLECTION	LOAD	DEFLECTION	LOAD	DEFLECTION	LOAD	DEFLECTION	LOAD	DEFLECTION
8'-0"	1,201 lb/ft	0.021 in	9,606 lbs	0.034 in	4,803 lbs	0.029 in	3,202 lbs	0.027 in	2,402 lbs	0.026 in
16'-0"	593 lb/ft	0.171 in	8,781 lbs	0.254 in	4,741 lbs	0.235 in	3,160 lbs	0.218 in	2,370 lbs	0.206 in
24'-0"	390 lb/ft	0.578 in	5,750 lbs	0.573 in	4,312 lbs	0.730 in	2,875 lbs	0.678 in	2,339 lbs	0.694 in
32'-0"	263 lb/ft	1.254 in	4,203 lbs	1.025 in	3,152 lbs	1.297 in	2,101 lbs	1.206 in	1,751 lbs	1.263 in
40'-0"	162 lb/ft	1.959 in	3,250 lbs	1.613 in	2,437 lbs	2.025 in	1.625 lbs	1.888 in	1,354 lbs	1.973 in
48'-0"	108 lb/ft	2.821 in	2,594 lbs	2.344 in	1,945 lbs	2.912 in	1,297 lbs	2.722 in	1,081 lbs	2.841 in
56'-0"	73 lb/ft	3.739 in	2,107 lbs	3.224 in	1,465 lbs	3.717 in	1,054 lbs	3.713 in	842 lbs	3.733 in
64-0"	44 lb/ft	4.274 in	1,726 lbs	4.262 in	1,003 lbs	4.250 in	726 lbs	4.267 in	576 lbs	4.266 in

PARTS LIST

CHORDS	2"ϕx$\frac{3}{16}$" TUBE
DIAGONALS	1"ϕx$\frac{1}{8}$" TUBE
VERTICALS	2"ϕx$\frac{1}{8}$" TUBE
HORIZONTALS	2"ϕx$\frac{1}{8}$" TUBE
SPIGOTS	STEEL SPIGOTS
END PLATE	PL $\frac{1}{4}$"

NOTES:
1. ALL ALUMINUM IS 6061-T6
2. ALL WELD FILLER IS 4043

TABLE USAGE NOTES:
1. THE TRUSS IS SUPPORTING VERTICAL LOADS ONLY, I.E. THE TRUSS LADDERS ARE ORIENTED VERTICALLY AND NO LATERAL LOADS ARE APPLIED TO THE TRUSS.
2. THE TRUSS WAS ANALYZED AS A SIMPLE SPAN BEAM WITH SUPPORTS AT TRUSS ENDS ONLY.
3. THE TRUSS HAS BEEN ANALYZED FOR STATIC LOADS ONLY.
4. ALL LOADS ARE APPLIED CENTERED BETWEEN THE LADDERS.
5. ALL LOADS AND SUPPORTS ARE TO BE LOCATED AT THE PANEL POINTS OF THE TRUSS ONLY.
6. SELF WEIGHT HAS BEEN CONSIDERED IN THE ANALYSIS OF THE TRUSS.
7. MAXIMUM DEFLECTION LIMITED TO SPAN/180.
8. ALLOWABLE LOADS BASED ON 2020 ALUMINUM DESIGN MANUAL.

24"x24" TYPE G TRUSS

SINGLE USE

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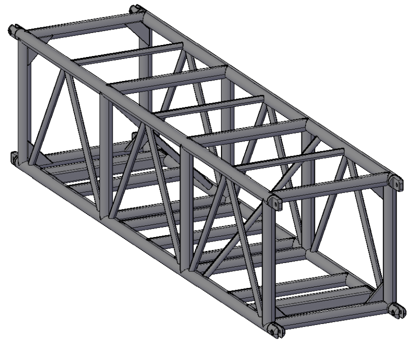
513 851 1223

TRUSS TABLE

DATE: 10/21/2022
CRE PROJECT NO: 22.915.05
DRAWN BY: DBG/TAK

ST1.1



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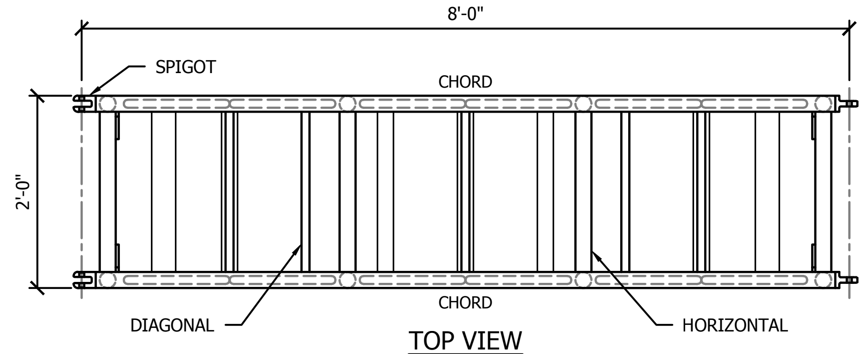
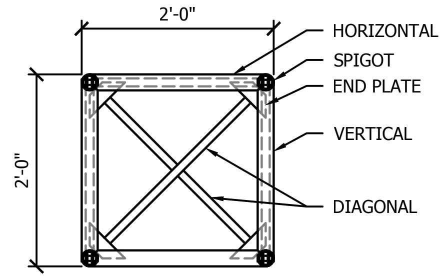
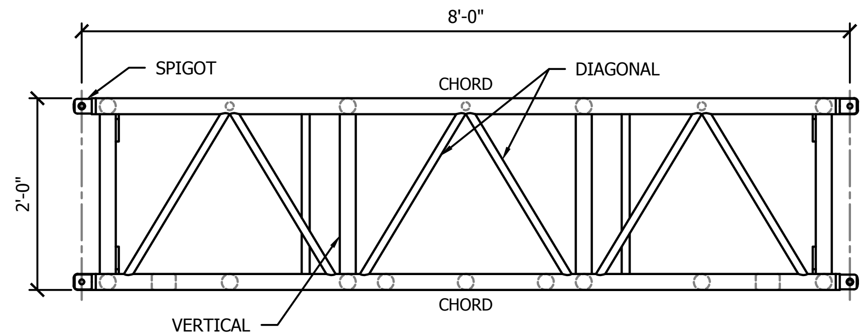


TOP VIEW



END VIEW



SIDE VIEW

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TRUSS SPAN	UNIFORMLY DISTRIBUTED LOAD		CENTER POINT LOAD		THIRD POINT LOAD		QUARTER POINT LOAD		FIFTH POINT LOAD	
	LOAD	DEFLECTION	LOAD	DEFLECTION	LOAD	DEFLECTION	LOAD	DEFLECTION	LOAD	DEFLECTION
8'-0"	1,021 lb/ft	0.018 in	8,165 lbs	0.029 in	4,083 lbs	0.025 in	2,722 lbs	0.023 in	2,041 lbs	0.022 in
16'-0"	504 lb/ft	0.146 in	7,464 lbs	0.216 in	4,029 lbs	0.200 in	2,686 lbs	0.186 in	2,015 lbs	0.176 in
24'-0"	331 lb/ft	0.495 in	4,887 lbs	0.490 in	3,666 lbs	0.624 in	2,444 lbs	0.580 in	1,988 lbs	0.594 in
32'-0"	223 lb/ft	1.076 in	3,573 lbs	0.882 in	2,679 lbs	1.113 in	1,786 lbs	1.036 in	1,489 lbs	1.084 in
40'-0"	138 lb/ft	1.691 in	2,762 lbs	1.397 in	2,072 lbs	1.747 in	1,381 lbs	1.630 in	1,151 lbs	1.703 in
48'-0"	92 lb/ft	2.451 in	2,205 lbs	2.046 in	1,653 lbs	2.528 in	1,102 lbs	2.368 in	919 lbs	2.468 in
56'-0"	64 lb/ft	3.363 in	1,791 lbs	2.840 in	1,343 lbs	3.462 in	896 lbs	3.255 in	746 lbs	3.384 in
64'-0"	44 lb/ft	4.274 in	1,468 lbs	3.792 in	1,003 lbs	4.250 in	726 lbs	4.267 in	576 lbs	4.266 in

PARTS LIST

CHORDS	2"⌀x$\frac{3}{16}$" TUBE
DIAGONALS	1"⌀x$\frac{1}{8}$" TUBE
VERTICALS	2"⌀x$\frac{1}{8}$" TUBE
HORIZONTALS	2"⌀x$\frac{1}{8}$" TUBE
SPIGOTS	STEEL SPIGOTS
END PLATE	PL $\frac{1}{4}$"

NOTES:
1. ALL ALUMINUM IS 6061-T6
2. ALL WELD FILLER IS 4043

TABLE USAGE NOTES:
1. THE TRUSS IS SUPPORTING VERTICAL LOADS ONLY, I.E. THE TRUSS LADDERS ARE ORIENTED VERTICALLY AND NO LATERAL LOADS ARE APPLIED TO THE TRUSS.
2. THE TRUSS WAS ANALYZED AS A SIMPLE SPAN BEAM WITH SUPPORTS AT TRUSS ENDS ONLY.
3. THE TRUSS HAS BEEN ANALYZED FOR STATIC LOADS ONLY.
4. ALL LOADS ARE APPLIED CENTERED BETWEEN THE LADDERS.
5. ALL LOADS AND SUPPORTS ARE TO BE LOCATED AT THE PANEL POINTS OF THE TRUSS ONLY.
6. SELF WEIGHT HAS BEEN CONSIDERED IN THE ANALYSIS OF THE TRUSS.
7. MAXIMUM DEFLECTION LIMITED TO SPAN/180.
8. ALLOWABLE LOADS BASED ON 2020 ALUMINUM DESIGN MANUAL. ALL CAPACITIES ARE REDUCED TO 0.85 PER ANSI E1.2-2012 FOR REPETITIVE USE MEMBERS

24"x24" TYPE G TRUSS

REPETITIVE USE

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TRUSS TABLE

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CRE PROJECT NO: 22.915.05
DRAWN BY: DBG/TAK

ST1.2

CLARK REDER ENGINEERING

APPENDIX B

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Christie Lites Type G Truss

Design Codes and Standards

- The Aluminum Association, Aluminum Design Manual 2020: Specifications and Guidelines for Aluminum Structures
- ANSI E1.2 - 2021 Entertainment Technology, Design, Manufacture and Use of Aluminum Trusses and Towers

Truss Description

The truss is a box truss fabricated from 6061-T-6 aluminum members. The truss is 24" deep x 24" wide. The chords and horizontals will be composed of 2 x 3/16 tubes. The diagonals will be composed of 1"X1/8" tubes. The end members are composed of forked ends. The truss will be reviewed for lengths of 8'-0", up to 64'.

Analysis Assumptions

- The truss is supporting vertical loads only, i.e. the truss diagonals are oriented vertically and no lateral loads are applied to the truss.
- The truss is analyzed as a simple span beam. Truss support points are located at truss panel points.
- The truss will be analyzed for static loads only.
- All loads are applied at the centroid of the truss between the two ladder trusses below the truss.
- All loads are applied at the panel points of the truss as to not induce local bending stresses in the chords.

Conclusions and Recommendations

The truss load capacities are outlined in the truss tables in the front of this submittal. The load capacities listed are based on the assumptions listed above and included in the charts. Values are give both for single use and repetitive use which includes a factor of 0.85 per ANSI E1.2 - 2021 The truss capacities are based on the lowest values due to truss diagonal capacity, truss chord capacity and truss connection capacity.

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6061-T6 Mechanical Properties

	Unwelded	Welded
Tension Yield Stress:	$F_{ty} := 35ksi$	$F_{tyw} := 15ksi$
Ultimate Tensile Stress:	$F_{tu} := 38ksi$	$F_{tuw} := 24ksi$
Compression Yield Stress:	$F_{cy} := 35ksi$	$F_{cyw} := 15ksi$
Shear yield stress:	$F_{sy} := 0.6 \cdot F_{ty} = 21 \cdot ksi$	$F_{syw} := 0.6 \cdot F_{tyw} = 9 \cdot ksi$
Ultimate shear stress:	$F_{su} := 24ksi$	$F_{suw} := 15ksi$
Tension coefficient:	$k_t := 1.0$	

Truss Properties

Chords - 2"x3/16

Outer diameter: $D_c := 2 \cdot in$

Wall thickness: $t_c := 0.1875 \cdot in$

Inner diameter: $ID_c := D_c - 2 \cdot t_c = 0.135\,ft$

Area of tube: $$A_c := \frac{\pi \cdot \left(D_c^{\,2} - ID_c^{\,2}\right)}{4} = 1.0677 \cdot in^2$$

Polar moment: $$J_c := \frac{\pi \cdot \left[\left(\frac{D_c}{2}\right)^4 - \left(\frac{ID_c}{2}\right)^4\right]}{2} = 0.886 \cdot in^4$$

Moment of inertia: $$I_c := \frac{\pi \cdot \left(D_c^{\,4} - ID_c^{\,4}\right)}{64} = 0.443 \cdot in^4$$

Rb over t: $$R\_t_c := \frac{\frac{D_c - t_c}{2}}{t_c} = 4.833$$

Elastic section modulus: $$S_c := \frac{\pi \cdot \left(D_c^{\,4} - ID_c^{\,4}\right)}{32 \cdot D_c} = 0.443 \cdot in^3$$

Selfweight: $wt_c := A_c \cdot \gamma_a = 1.253 \cdot plf$

Radius of gyration: $$r_c := \frac{\sqrt{D_c^{\,2} + ID_c^{\,2}}}{4} = 0.644 \cdot in$$

Plastic section modulus: $$Z_c := \frac{\left(D_c^{\,3} - ID_c^{\,3}\right)}{6} = 0.618 \cdot in^3$$

Diagonals - 1"x1/8"

Outer diameter: $D_d := 1.\cdot in$

Wall thickness: $t_d := 0.125\cdot in$

Inner diameter: $ID_d := D_d - 2\cdot t_d = 0.063\ ft$

Area of tube: $A_d := \frac{\pi\cdot\left(D_d^{\,2} - ID_d^{\,2}\right)}{4} = 0.3436\cdot in^2$

Polar moment: $J_d := \frac{\pi\cdot\left[\left(\frac{D_d}{2}\right)^4 - \left(\frac{ID_d}{2}\right)^4\right]}{2} = 0.067\cdot in^4$

Moment of inertia: $I_d := \frac{\pi\cdot\left(D_d^{\,4} - ID_d^{\,4}\right)}{64} = 0.034\cdot in^4$

Rb over t: $R\_t_d := \frac{\frac{D_d - t_d}{2}}{t_d} = 3.5$

Elastic section modulus: $S_d := \frac{\pi\cdot\left(D_d^{\,4} - ID_d^{\,4}\right)}{32\cdot D_d} = 0.067\cdot in^3$

Selfweight: $wt_d := A_d\cdot\gamma_a = 0.403\cdot plf$

Radius of gyration: $r_d := \frac{\sqrt{D_d^{\,2} + ID_d^{\,2}}}{4} = 0.313\cdot in$

Horizontals - 2"x3/16"

Outer diameter: $D_H := 2\cdot in$

Wall thickness: $t_H := 0.1875\cdot in$

Inner diameter: $ID_H := D_H - 2\cdot t_H = 0.135\ ft$

Area of tube: $A_H := \frac{\pi\cdot\left(D_H^{\,2} - ID_H^{\,2}\right)}{4} = 1.0677\cdot in^2$

Polar moment: $J_H := \frac{\pi\cdot\left[\left(\frac{D_H}{2}\right)^4 - \left(\frac{ID_H}{2}\right)^4\right]}{2} = 0.886\cdot in^4$

Moment of inertia: $I_H := \frac{\pi\cdot\left(D_H^{\,4} - ID_H^{\,4}\right)}{64} = 0.443\cdot in^4$

Rb over t: $R\_t_H := \frac{\frac{D_H - t_H}{2}}{t_H} = 4.833$

Elastic section modulus: $S_H := \frac{\pi\cdot\left(D_H^{\,4} - ID_H^{\,4}\right)}{32\cdot D_H} = 0.443\cdot in^3$

Selfweight: $wt_H := A_H\cdot\gamma_a = 1.253\cdot plf$

Radius of gyration: $r_H := \frac{\sqrt{D_H^{\,2} + ID_H^{\,2}}}{4} = 0.644\cdot in$

Plastic section modulus: $Z_H := \frac{\left(D_H^{\,3} - ID_H^{\,3}\right)}{6} = 0.618\cdot in^3$

Global Truss Properties

Truss center of chord to center of chord depth: $d_{tr} := 24 \cdot in - D_c = 22 \cdot in$

Truss center of chord to center of chord width: $b_{tr} := 24in - D_c = 22 \cdot in$

Area of truss: $A_{tr} := 4 \cdot A_c$ $\quad A_{tr} = 4.271 \cdot in^2$

Moment of inertia of truss: $I_{tr} := 4 \cdot \left[I_c + A_c \cdot \left(\frac{d_{tr}}{2} \right)^2 \right]$ $\quad I_{tr} = 518.515 \cdot in^4$ *strong axis*

Radius of gyration of truss: $r_{tr} := \sqrt{\frac{I_{tr}}{A_{tr}}}$ $\quad r_{tr} = 11.019 \cdot in$

Modulus of Elasticity of truss: $E_{tr} := 10100 \cdot ksi$

Diagonals

Axial Capacity

The vertical diagonals are 6005-T6/T61 aluminum. Since no weld occurs outside of 5% of the member length the diag will be treated as non weld affected for compression buckling checks

Length of diagonals: $L_d := 23.5in$ *distance between brace points.*

Axial tension - D.2a/b

Allowable stress on gross area (weld affected): $F_{t\_D2a\_w} := 9.1 \cdot ksi$

Allowable stress on net area(weld affected): $F_{t\_D2b\_net\_w} := 12.3 \cdot ksi$

Compression in diagonal - E.2

Slenderness: $S_{E2} := \frac{1.0 \cdot L_d}{r_d}$ $\quad S_{E2} = 75.2$

Allowable stress:

$$F_{c\_E2\_d} := \begin{cases} (21.2 \cdot ksi) & \text{if } S_{E2} \le 17.8 \\ \left(0.00047 \cdot S_{E2}^2 - 0.232 \cdot S_{E2} + 25.2\right) \cdot ksi & \text{if } 17.8 < S_{E2} < 66 \\ \left(\frac{51352}{S_{E2}^2}\right) \cdot ksi & \text{if } S_{E2} \ge 66 \end{cases}$$

$F_{c\_E2\_d} = 9.081 \cdot ksi$

Compression in diagonal - B5.4.5 - WELD AFFECTED

Slenderness: $S_{B545} := R\_t_d^{0.5}$ $\quad S_{B545} = 1.871$

Allowable stress:

$$F_{c\_B545\_d\_w} := \begin{cases} (9.1 \cdot ksi) & \text{if } S_{B545} \le 6.8 \\ \left(11.8 - 0.396 \cdot \sqrt{S_{B545}}\right) \cdot ksi & \text{if } 6.8 < S_{B545} < 20 \\ \left[\dfrac{3776}{S_{B545} \cdot \left(1 + \dfrac{\sqrt{S_{B545}}}{35}\right)^2}\right] \cdot ksi & \text{if } 20 \le S_{B545} \end{cases}$$

$F_{c\_B545\_d\_w} = 9.1 \cdot ksi$

Diag tension stress (gross area): $F_t := F_{t\_D2a\_w} = 9.1 \cdot ksi$ $\quad F_t = 9.1 \cdot ksi$

Diag compression stress: $F_c := \min\left(F_{c\_E2\_d}, F_{c\_B545\_d\_w}\right)$ $\quad F_c = 9.081 \cdot ksi$

Diag tension capacity: $T_d := A_d \cdot F_t$ $\quad T_d = 3.127 \cdot kip$

Diag compression capacity: $C_d := A_d \cdot F_c$ $\quad C_d = 3.12 \cdot kip$

Weld of Diagonal to Chord

Nominal stress of base metal corresponding to its welded ultimate strength, A3.3: $F_{nBM} := 15ksi$ Table A3.3

Nominal stress of weld metal corresponding to it ultimate strength, A3.6: $F_{nw} := 24ksi$ Table A3.6

Safety factor $n_u := 1.95$

Angle of diagonal to horizontal: $\theta_d := 58.8 \cdot deg$

Length of weld $L_{weld} := \pi \sqrt{2 \cdot \left[\left(\dfrac{D_d}{\sin(\theta_d)} \cdot 0.5\right)^2 + \left(D_d \cdot 0.5\right)^2\right]}$ *ellipse* $\quad L_{weld} = 3.418 \cdot in$

Size of weld $S_w := \dfrac{3}{16} in$

Weld section modulus: $S_{weld} := \left(0.5 \cdot D_d\right)^2 \cdot \pi$ $\quad S_{weld} = 0.785 \cdot \dfrac{in^3}{in}$ *assuming weld is round*

Effective throat of fillet weld $S_{we} := S_w \dfrac{\sqrt{2}}{2}$ $\quad S_{we} = 0.1326 \cdot in$

Nominal weld stress: $F_{sw} := \min\left(0.6 \cdot F_{nBM} \cdot S_w \cdot L_{weld}, 0.6 \cdot 0.85 \cdot F_{nw} \cdot S_{we} \cdot L_{weld}\right) = 5.546 \cdot kip$

Allowable weld strength: $F_{weld} := \dfrac{F_{sw}}{n_u}$ $\quad F_{weld} = 2.844 \cdot kip$

Capacity of diagonal: $P_{diag} := \min\left(T_d, C_d, F_{weld}\right) = 2.844 \cdot kip$

Horizontal

Axial Capacity

The Horizontal are 6005A T6/T61 aluminum. Chords are welded between brace points, treat Horizontal as weld affected for compression buckling.

Length of Horizontal $L_H := 20in = 1.667\,ft$ *distance between Chords*

Axial tension - D.2a/b

Allowable stress on gross area (weld affected): $F_{t\_D2a\_wc} := 9.1 \cdot ksi$

Allowable stress on net area(weld affected): $F_{t\_D2b\_net\_wc} := 12.3 \cdot ksi$

Compression in Horizontal - E.2 - WELD AFFECTED

Slenderness: $S_{E2c} := \frac{0.9 \cdot L_H}{r_H}$ $S_{E2c} = 27.94$

Allowable stress:

$$F_{c\_E2\_c\_wc} := \begin{cases} (9.1 \cdot ksi) & \text{if } S_{E2c} \le 21.8 \\ \left(0.00007 \cdot S_{E2c}^{2} - 0.066 \cdot S_{E2c} + 10.5\right) \cdot ksi & \text{if } 21.8 < S_{E2c} < 133 \\ \left(\frac{51352}{S_{E2c}^{2}}\right) \cdot ksi & \text{if } S_{E2c} \ge 133 \end{cases}$$

$F_{c\_E2\_c\_wc} = 8.711 \cdot ksi$

Compression in Horizontal - B5.4.5 - WELD AFFECTED

Slenderness: $S_{B545c} := R\_t_H^{0.5}$ $S_{B545c} = 2.198$

Allowable stress:

$$F_{c\_B545\_c\_wc} := \begin{cases} (9.1 \cdot ksi) & \text{if } S_{B545c} \le 6.8 \\ \left(11.8 - 0.396 \cdot \sqrt{S_{B545c}}\right) \cdot ksi & \text{if } 6.8 < S_{B545c} < 20 \\ \left[\frac{3776}{S_{B545c} \cdot \left(1 + \frac{\sqrt{S_{B545c}}}{35}\right)^{2}}\right] \cdot ksi & \text{if } 20 \le S_{B545c} \end{cases}$$

$F_{c\_B545\_c\_wc} = 9.1 \cdot ksi$

Horizontal tension stress: $F_{tc} := F_{t\_D2a\_wc} = 9.1 \cdot ksi$ $F_{tc} = 9.1 \cdot ksi$

Horizontal compression stress: $F_{cc} := \min\left(F_{c\_E2\_c\_wc}, F_{c\_B545\_c\_wc}\right)$ $F_{cc} = 8.711 \cdot ksi$

Horizontal tension capacity in Horizontal $T_H := A_c \cdot F_{tc}$ $T_H = 9.716 \cdot kip$

Horizontal Compression Capacity $C_H := A_c \cdot F_{cc}$ $C_H = 9.3 \cdot kip$

Weld of Horizontal to Chord

Nominal stress of base metal corresponding to its welded ultimate strength, A3.3: $F_{nBM} := 15ksi$ Table A3.3

Nominal stress of weld metal corresponding to it ultimate strength, A3.6: $F_{nw} := 24ksi$ Table A3.6

Safety factor $n_u := 1.95$

Angle of Horizontal to Chord: $\theta_H := 90 \cdot deg$

Length of weld $L_{weld} := \pi \sqrt{2 \cdot \left[\left(\frac{D_H}{\sin(\theta_H)} \cdot 0.5\right)^2 + (D_H \cdot 0.5)^2\right]}$ *ellipse* $L_{weld} = 6.283 \cdot in$

Size of weld $S_w := \frac{3}{16} in$

Weld section modulus: $S_{weld} := (0.5 \cdot D_H)^2 \cdot \pi$ $S_{weld} = 3.142 \cdot \frac{in^3}{in}$ *assuming weld is round*

Effective throat of fillet weld $S_{we} := S_w \frac{\sqrt{2}}{2}$ $S_{we} = 0.1326 \cdot in$

Nominal weld stress: $F_{sw} := \min(0.6 \cdot F_{nBM} \cdot S_w \cdot L_{weld}, 0.6 \cdot 0.85 \cdot F_{nw} \cdot S_{we} \cdot L_{weld}) = 10.196 \cdot kip$

Allowable weld strength: $F_{weld.H} := \frac{F_{sw}}{n_u}$ $F_{weld.H} = 5.229 \cdot kip$

Capacity of Horizontal $P_{Hor} := \min(T_H, C_H, F_{weld.H}) = 5.229 \cdot kip$

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Chords

Axial Capacity

The chords are 6005A T6/T61 aluminum. Diagonals are welded between brace points, treat chord as weld affected for compression buckling.

Length of chord $L_{c.Bot} := 24.04 \cdot in$ *distance between horizontals; top chord is weld affected at midspan due to diagonals*

Length of chord $L_{c.Top} := 14 \cdot in$

Axial tension - D.2a/b

Allowable stress on gross area (weld affected): $F_{t\_D2a\_wc} := 9.1 \cdot ksi$

Allowable stress on net area(weld affected): $F_{t\_D2b\_net\_wc} := 12.3 \cdot ksi$

Compression in Chord - E.2 - WELD AFFECTED

Slenderness: $S_{E2c} := \frac{0.9 \cdot L_{c.Top}}{r_c}$ $S_{E2c} = 19.558$

Allowable stress:

$$F_{c\_E2\_c\_wc} := \begin{cases} (9.1 \cdot ksi) & \text{if } S_{E2c} \le 21.8 \\ \left(0.00007 \cdot S_{E2c}^2 - 0.066 \cdot S_{E2c} + 10.5\right) \cdot ksi & \text{if } 21.8 < S_{E2c} < 133 \\ \left(\frac{51352}{S_{E2c}^2}\right) \cdot ksi & \text{if } S_{E2c} \ge 133 \end{cases}$$

$F_{c\_E2\_c\_wc} = 9.1 \cdot ksi$

Compression in Chord - B5.4.5 - WELD AFFECTED

Slenderness: $S_{B545c} := R\_t_c^{0.5}$ $S_{B545c} = 2.198$

Allowable stress:

$$F_{c\_B545\_c\_wc} := \begin{cases} (9.1 \cdot ksi) & \text{if } S_{B545c} \le 6.8 \\ \left(11.8 - 0.396 \cdot \sqrt{S_{B545c}}\right) \cdot ksi & \text{if } 6.8 < S_{B545c} < 20 \\ \left[\frac{3776}{S_{B545c} \cdot \left(1 + \frac{\sqrt{S_{B545c}}}{35}\right)^2}\right] \cdot ksi & \text{if } 20 \le S_{B545c} \end{cases}$$

$F_{c\_B545\_c\_wc} = 9.1 \cdot ksi$

Chord tension stress: $F_{tc} := F_{t\_D2a\_wc} = 9.1 \cdot ksi$ $F_{tc} = 9.1 \cdot ksi$

Chord compression stress: $F_{cc} := \min\left(F_{c\_E2\_c\_wc}, F_{c\_B545\_c\_wc}\right)$ $F_{cc} = 9.1 \cdot ksi$

Chord tension capacity in bottom chord: $T_c := A_c \cdot F_{tc}$ $T_c = 9.716 \cdot kip$

Chord compression capacity in top chord: $C_c := A_c \cdot F_{cc}$ $C_c = 9.716 \cdot kip$

Aluminum Forked End

6061-T6 Extrusion Mechanical Properties

	Unwelded	Welded
Tension Yield Stress:	$F_{ty} := 35ksi$	$F_{tyw} := 15ksi$
Ultimate Tensile Stress:	$F_{tu} := 38ksi$	$F_{tuw} := 24ksi$
Compression Yield Stress:	$F_{cy} := 35ksi$	$F_{cyw} := 15ksi$
Shear yield stress:	$F_{sy} := 0.6 \cdot F_{ty} = 21 \cdot ksi$	$F_{syw} := 0.6 \cdot F_{tyw} = 9 \cdot ksi$
Ultimate shear stress:	$F_{su} := 24ksi$	$F_{suw} := 15ksi$
Tension coefficient:	$k_t := 1.0$	
Thickness of fork:	$t_m := .69 \cdot in$	
Center of hole to edge:	$L_m := 1in$	
Center of hole to end:	$L_{m\_end} := 1.732 \cdot in$	
Height of plate:	$h_m := 2 \cdot in$	
Diameter of hole:	$d_{m\_hole} := .625 \cdot in$	

Axial tension - D.2a/b

Allowable stress gross section: $F_{t\_D.2\_a} := 21.2 \cdot ksi$

Allowable gross tension: $P_{m\_gross} := F_{t\_D.2\_a} \cdot t_m \cdot h_m$ $\quad P_{m\_gross} = 29.256 \cdot kip$

Allowable stress net section: $F_{t\_D.2\_b} := 19.5 \cdot ksi$

Allowable net tension: $P_{m\_net} := F_{t\_D.2\_b} \cdot t_m \cdot \left(h_m - d_{m\_hole} + \frac{1}{32} \cdot in\right)$ $\quad P_{m\_net} = 18.921 \cdot kip$

Bearing - J.6.5

Allowable stress bearing: $F_{t\_J.3.7} := 25.9 \cdot ksi$

Allowable bearing: $P_{m\_brg} := \frac{L_m \cdot t_m \cdot F_{tu}}{1.5} = 17480\, lbf$ $P_{m\_brg} = 17.48 \cdot kip$

Allowable Bearing Check $Limit := 1.33 \cdot d_{m\_hole} \cdot t_m \cdot F_{tu} = 21795.375\, lbf$

Check to see if J.6.5 Conditions are met

$$Check := \begin{cases} \text{"VALID"} & \text{if } P_{m\_brg} < Limit \\ \text{"NOT VALID"} & \text{otherwise} \end{cases} = \text{"VALID"}$$

Compression - E.3:

Unbraced length: $L_c := L_{m\_end}$

Plate moment of inertia: $Iy_m := \frac{1}{12} \cdot h_m \cdot t_m^{\,3}$ $Iy_m = 0.055 \cdot in^4$

Area of plate: $A_m := t_m \cdot h_m$ $A_m = 1.38 \cdot in^2$

Radius of gyration: $ry_m := \sqrt{\frac{Iy_m}{A_m}}$ $ry_m = 0.199 \cdot in$

Slenderness: $S_{E.3} := \frac{2.1 \cdot L_{m\_end}}{ry_m}$ $S_{E.3} = 18.26$

Allowable stress:

$$F_{vert\_E.3} := \begin{cases} (21.2 \cdot ksi) & \text{if } S_{E.3} \le 17.8 \\ \left(0.00047 \cdot S_{E.3}^{\,2} - 0.232 \cdot S_{E.3} + 25.2\right) \cdot ksi & \text{if } (0 < S_{E.3}) \wedge (66 > S_{E.3}) \\ \left(\frac{51352}{S_{E.3}^{\,2}}\right) \cdot ksi & \text{if } 66 < S_{E.3} \end{cases}$$

$F_{vert\_E.3} = 21.1 \cdot ksi$

Allowable compression: $P_{m\_comp} := F_{vert\_E.3} \cdot t_m \cdot h_m$ $P_{m\_comp} = 29.146 \cdot kip$

Allowable axial force in fork: $P_{allow\_fork} := \min(P_{m\_gross}, P_{m\_net}, P_{m\_brg}, P_{m\_comp})$ $P_{allow\_fork} = 17.48 \cdot kip$

Diameter of pin: $d_{pin} := .625 \cdot in$

Pin yield strength: $Fy_{pin} := 50 \cdot ksi$

Pin tensile strength: $Fu_{pin} := 65 \cdot ksi$

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Pin shear capacity:

The pin will be in double shear. Use Table J3.2 for nominal stress of fasteners.

Nominal shear stress: $F_{nv\_pin} := 0.5 \cdot Fu_{pin}$ $F_{nv\_pin} = 32.5 \cdot ksi$

Area of pin: $A_{pin} := \dfrac{\pi \cdot d_{pin}^{2}}{4}$ $A_{pin} = 0.307 \cdot in^{2}$

Available double shear capacity of pin: $V_{a\_pin} := \dfrac{F_{nv\_pin} \cdot A_{pin}}{2} \cdot 2$ $V_{a\_pin} = 9.971 \cdot kip$

Split Pins

The forks are connected to the aluminum with Split Pins. The Spirol pins are coiled 3/8" diameter pins Use a factor of safety of 2 on the coil pins.

Capacity of coiled spirol pin in double shear: $P_{allow\_split\_pin} := 16 \cdot kip$

There is a single pin therefore allowable load is: $P_{allow\_split} := \dfrac{2P_{allow\_split\_pin}}{2}$ $P_{allow\_split} = 16 \cdot kip$

Aluminum Bearing

The aluminum chord to split pin bearing shall be checked. There are (4) bearing surfaces.

Thickness of truss chord: $t_{chord} := t_c$

Diameter of coil pin: $d_{split\_pin} := 0.375 \cdot in$

Allowable pin bearing strength in aluminum: $P_{brg\_al} := 4 \cdot t_{chord} \cdot d_{split\_pin} \cdot 39 \cdot ksi$ $P_{brg\_al} = 10.969 \cdot kip$

assumes non-weld affected areas

Truss Allowable Capacity

The allowable moment and shear capacity of the truss will be determined from the capacities determined above.

Minimum axial force in chord: $P_{chord\_min} := \min\left[T_c, C_c, P_{allow\_fork}, \left(P_{brg\_al}\right)\right]$ $P_{chord\_min} = 9.716 \cdot kip$

Allowable truss moment capacity: $M_{truss} := \min\left(2 \cdot d_{tr} \cdot P_{chord\_min}\right)$ $M_{truss} = 35.624 \cdot ft \cdot kip$

Minimum axial force in diagonal: $P_{diag\_min} := P_{diag}$ $P_{diag\_min} = 2.844 \cdot kip$

Allowable truss shear capacity: $V_{truss} := 2 \cdot \sin\left(\theta_d\right) \cdot P_{diag\_min}$ $V_{truss} = 4.866 \cdot kip$

Total Weight $wt_{truss} := \dfrac{125lbf}{8ft} = 15.625 \cdot plf$ On Christie Lites' site.

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Allowable Loads Due to Moment

Uniform Load: $w_{mUDL}(L) := -\dfrac{L^2 \cdot wt_{truss} - 8 \cdot M_{truss}}{L^2}$

Center Point Load: $P_{mCPL}(L) := \dfrac{4 \cdot \left(M_{truss} - \dfrac{L^2 \cdot wt_{truss}}{8}\right)}{L}$

Third Point Loads: $P_{m3p}(L) := \dfrac{3 \cdot \left(M_{truss} - \dfrac{L^2 \cdot wt_{truss}}{8}\right)}{L}$

Quarter Point Loads: $P_{mQp}(L) := \dfrac{2 \cdot \left(M_{truss} - \dfrac{L^2 \cdot wt_{truss}}{8}\right)}{L}$

Fifth Point Loads: $P_{m5p}(L) := \dfrac{5 \cdot \left(M_{truss} - \dfrac{L^2 \cdot wt_{truss}}{8}\right)}{3 \cdot L}$

Allowable Loads Due to Shear

Uniform Load: $w_{vUDL}(L) := \dfrac{2 \cdot V_{truss} - L \cdot wt_{truss}}{L}$

Center Point Load: $P_{vCPL}(L) := 2 \cdot V_{truss} - L \cdot wt_{truss}$

Third Point Loads: $P_{v3p}(L) := V_{truss} - \dfrac{1}{2} \cdot wt_{truss} \cdot L$

Quarter Point Loads: $P_{vQp}(L) := \dfrac{2 \cdot V_{truss}}{3} - \dfrac{L \cdot wt_{truss}}{3}$

Fifth Point Loads: $P_{v5p}(L) := \dfrac{V_{truss}}{2} - \dfrac{L \cdot wt_{truss}}{4}$

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Allowable Loads Due to Deflection

The deflection will be limited to L/180.

Uniform Load: $$w_{\Delta UDL}(L) := -\frac{1.0e\text{-}41 \cdot \left(1.0e41 \cdot L^4 \cdot wt_{truss} - 7.769308e46 \cdot I_{tr} \cdot ksi \cdot \Delta(L)\right)}{L^4}$$

Center Point Load: $$P_{\Delta CPL}(L) := \frac{4.29730473043047e\text{-}22 \cdot \left(6.217e24 \cdot I_{tr} \cdot ksi - 1.4428e21 \cdot L^3 \cdot wt_{truss}\right)}{L^2}$$

Third Point Loads: $$P_{\Delta 3p}(L) := \frac{1.71e\text{-}21 \cdot \left(9.067e23 \cdot I_{tr} \cdot ksi - 2.10416e20 \cdot L^3 \cdot wt_{truss}\right)}{L^2}$$

Quarter Point Loads: $$P_{\Delta Qp}(L) := \frac{0.0034722 \cdot \left(323200.0 \cdot I_{tr} \cdot ksi - 75.0 \cdot L^3 \cdot wt_{truss}\right)}{L^2}$$

Fifth Point Loads: $$P_{\Delta 5p}(L) := \frac{8.595e\text{-}21 \cdot \left(1.0362e23 \cdot I_{tr} \cdot ksi - 2.40476e19 \cdot L^3 \cdot wt_{truss}\right)}{L^2}$$

Allowable Loads Based on Minimum Allowable Values

The following loads have been reduced by 0.85 per ANSI

$L := 8ft, 16ft .. 64ft$

Uniform load: $w_{UDL}(L) := \min\left(.85 \cdot w_{mUDL}(L), .85 \cdot w_{vUDL}(L), w_{\Delta UDL}(L)\right)$

Center point load: $P_{CPL}(L) := \min\left(.85 \cdot P_{mCPL}(L), .85 \cdot P_{vCPL}(L), P_{\Delta CPL}(L)\right)$

3rd point load: $P_{3rd}(L) := \min\left(.85 \cdot P_{m3p}(L), .85 \cdot P_{v3p}(L), P_{\Delta 3p}(L)\right)$

Quarter point load: $P_{4th}(L) := \min\left(.85 \cdot P_{mQp}(L), .85 \cdot P_{vQp}(L), P_{\Delta Qp}(L)\right)$

5th point load: $P_{5th}(L) := \min\left(.85 \cdot P_{m5p}(L), .85 \cdot P_{v5p}(L), P_{\Delta 5p}(L)\right)$

Corresponding deflections:

Uniform load:
$$\Delta_{UDL}(L) := \frac{5 \cdot wt_{truss} \cdot L^4}{384 \cdot E_a \cdot I_{tr}} + \frac{5 \cdot w_{UDL}(L) \cdot L^4}{384 \cdot E_a \cdot I_{tr}}$$

Center point load:
$$\Delta_{CPL}(L) := \frac{5 \cdot wt_{truss} \cdot L^4}{384 \cdot E_a \cdot I_{tr}} + \frac{0.021 \cdot P_{CPL}(L) \cdot L^3}{E_a \cdot I_{tr}}$$

3rd point load:
$$\Delta_{3rd}(L) := \frac{5 \cdot wt_{truss} \cdot L^4}{384 \cdot E_a \cdot I_{tr}} + \frac{0.036 \cdot P_{3rd}(L) \cdot L^3}{E_a \cdot I_{tr}}$$

Quarter point load:
$$\Delta_{4th}(L) := \frac{5 \cdot wt_{truss} \cdot L^4}{384 \cdot E_a \cdot I_{tr}} + \frac{0.05 \cdot P_{4th}(L) \cdot L^3}{E_a \cdot I_{tr}}$$

5th point load:
$$\Delta_{5th}(L) := \frac{5 \cdot wt_{truss} \cdot L^4}{384 \cdot E_a \cdot I_{tr}} + \frac{0.063 \cdot P_{5th}(L) \cdot L^3}{E_a \cdot I_{tr}}$$

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Allowable Loads

$\Delta_{UDL}(L)$ (in)	$\Delta_{CPL}(L)$ (in)	$\Delta_{3rd}(L)$ (in)	$\Delta_{4th}(L)$ (in)	$\Delta_{5th}(L)$ (in)	L (ft)
0.018	0.029	0.025	0.023	0.022	8
0.146	0.216	0.2	0.186	0.176	16
0.495	0.49	0.624	0.58	0.594	24
1.076	0.882	1.113	1.036	1.084	32
1.691	1.397	1.747	1.63	1.703	40
2.451	2.046	2.528	2.368	2.468	48
3.363	2.84	3.462	3.255	3.384	56
4.274	3.792	4.25	4.267	4.266	64

$w_{UDL}(L)$ (plf)	$P_{CPL}(L)$ (kip)	$P_{3rd}(L)$ (kip)	$P_{4th}(L)$ (kip)	$P_{5th}(L)$ (kip)	L (ft)
1021	8.165	4.083	2.722	2.041	8
504	7.464	4.029	2.686	2.015	16
331	4.887	3.666	2.444	1.988	24
223	3.573	2.679	1.786	1.489	32
138	2.762	2.072	1.381	1.151	40
92	2.205	1.653	1.102	0.919	48
64	1.791	1.343	0.896	0.746	56
44	1.468	1.003	0.726	0.576	64

Allowable Loads Based on Minimum Allowable Values

The following loads have been reduced by 1.0 per ANSI

Uniform load: $w_{UDL}(L) := 1\ \min\left(w_{mUDL}(L), w_{vUDL}(L), w_{\Delta UDL}(L)\right)$

Center point load: $P_{CPL}(L) := 1\ \min\left(P_{mCPL}(L), P_{vCPL}(L), P_{\Delta CPL}(L)\right)$

3rd point load: $P_{3rd}(L) := 1\ \min\left(P_{m3p}(L), P_{v3p}(L), P_{\Delta 3p}(L)\right)$

Quarter point load: $P_{4th}(L) := 1\ \min\left(P_{mQp}(L), P_{vQp}(L), P_{\Delta Qp}(L)\right)$

5th point load: $P_{5th}(L) := 1\ \min\left(P_{m5p}(L), P_{v5p}(L), P_{\Delta 5p}(L)\right)$

Corresponding deflections:

Uniform load: $$\Delta_{UDL}(L) := \frac{5 \cdot wt_{truss} \cdot L^4}{384 \cdot E_a \cdot I_{tr}} + \frac{5 \cdot w_{UDL}(L) \cdot L^4}{384 \cdot E_a \cdot I_{tr}}$$

Center point load: $$\Delta_{CPL}(L) := \frac{5 \cdot wt_{truss} \cdot L^4}{384 \cdot E_a \cdot I_{tr}} + \frac{0.021 \cdot P_{CPL}(L) \cdot L^3}{E_a \cdot I_{tr}}$$

3rd point load: $$\Delta_{3rd}(L) := \frac{5 \cdot wt_{truss} \cdot L^4}{384 \cdot E_a \cdot I_{tr}} + \frac{0.036 \cdot P_{3rd}(L) \cdot L^3}{E_a \cdot I_{tr}}$$

Quarter point load: $$\Delta_{4th}(L) := \frac{5 \cdot wt_{truss} \cdot L^4}{384 \cdot E_a \cdot I_{tr}} + \frac{0.05 \cdot P_{4th}(L) \cdot L^3}{E_a \cdot I_{tr}}$$

5th point load: $$\Delta_{5th}(L) := \frac{5 \cdot wt_{truss} \cdot L^4}{384 \cdot E_a \cdot I_{tr}} + \frac{0.063 \cdot P_{5th}(L) \cdot L^3}{E_a \cdot I_{tr}}$$

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Allowable Loads

L (ft)	$\Delta_{UDL}(L)$ (in)	$\Delta_{CPL}(L)$ (in)	$\Delta_{3rd}(L)$ (in)	$\Delta_{4th}(L)$ (in)	$\Delta_{5th}(L)$ (in)
8	0.021	0.034	0.029	0.027	0.026
16	0.171	0.254	0.235	0.218	0.206
24	0.578	0.573	0.73	0.678	0.694
32	1.254	1.025	1.297	1.206	1.263
40	1.959	1.613	2.025	1.888	1.973
48	2.821	2.344	2.912	2.722	2.841
56	3.739	3.224	3.717	3.713	3.733
64	4.274	4.262	4.25	4.267	4.266

L (ft)	$w_{UDL}(L)$ (plf)	$P_{CPL}(L)$ (kip)	$P_{3rd}(L)$ (kip)	$P_{4th}(L)$ (kip)	$P_{5th}(L)$ (kip)
8	1201	9.606	4.803	3.202	2.402
16	593	8.781	4.741	3.16	2.37
24	390	5.75	4.312	2.875	2.339
32	263	4.203	3.152	2.101	1.751
40	162	3.25	2.437	1.625	1.354
48	108	2.594	1.945	1.297	1.081
56	73	2.107	1.465	1.054	0.842
64	44	1.726	1.003	0.726	0.576