LAKE SHORE
A DIVISION OF FRONTIER-KEMPER CONSTRUCTORS, INC.

1695 Allen Road
Evansville, Indiana 47710
Phone: 812.426.2741
FAX: 812.425.318

TRANSMITTAL

TO:	Fermi Research Alliance LLC.	**DATE:**	9-3-19
		Transmittal No.	8018-195-T-005
		RE:	100% Complete Cage Drawings
ATTN:	**David L. Crabb**		

WE ARE SENDING YOU: ☒ Attached the following items: ☐ Under separate cover via: _____

☒ Design Drawings ☐ Prints ☐ Plans ☐ Samples

☒ Specifications ☐ Copy of Letter ☐ Change Order ☐ Electronic Drawing

COPIES	DATE	DRAWING NO.	SHEET NO.	REV.	DESCRIPTION
	9-3-19	8018195-320-01	1-4	P-6	Preliminary Approval cage design drawings
	9-3-19	8018195-320-02	1-3	P0, P4, P5	Preliminary Approval work deck design drawings
	9-3-19		1-8		Lifting Lug Design Calculations
	9-3-19		1-3		Cage Floor Main Beam Calculations
	9-3-19		1-9		Underslung lug design #1 Calculations
	9-3-19		1-9		Underslung lug design #2 Calculations
	9-3-19		1-9	REV A	Structural Design Calculations

THESE ARE TRANSMITTED as checked below:

☒ For Approval ☐ Approved as submitted ☐ Resubmit_____copies for approval

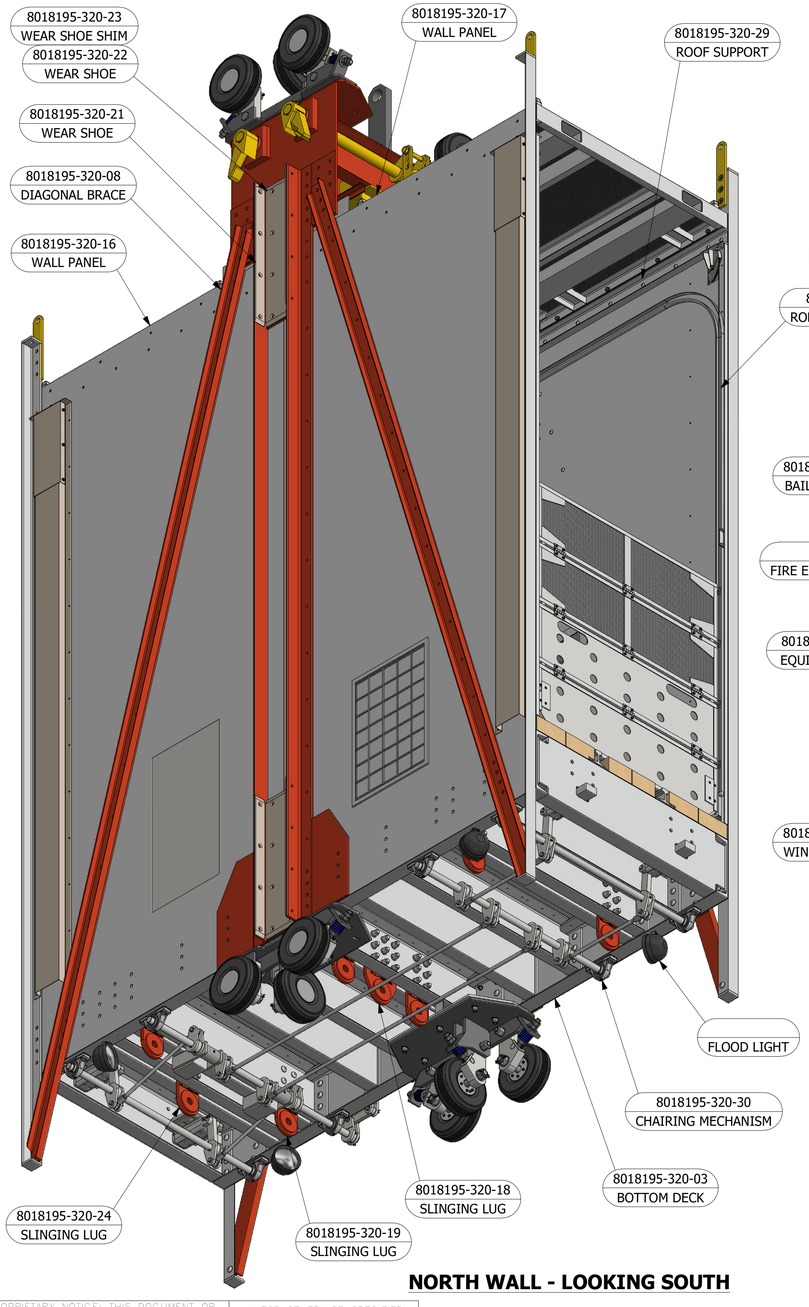
☐ For your Use ☐ Approved as noted ☐ Submit_____copies for distribution

☐ As requested ☐ Returned for corrections ☐ Return _____corrected prints

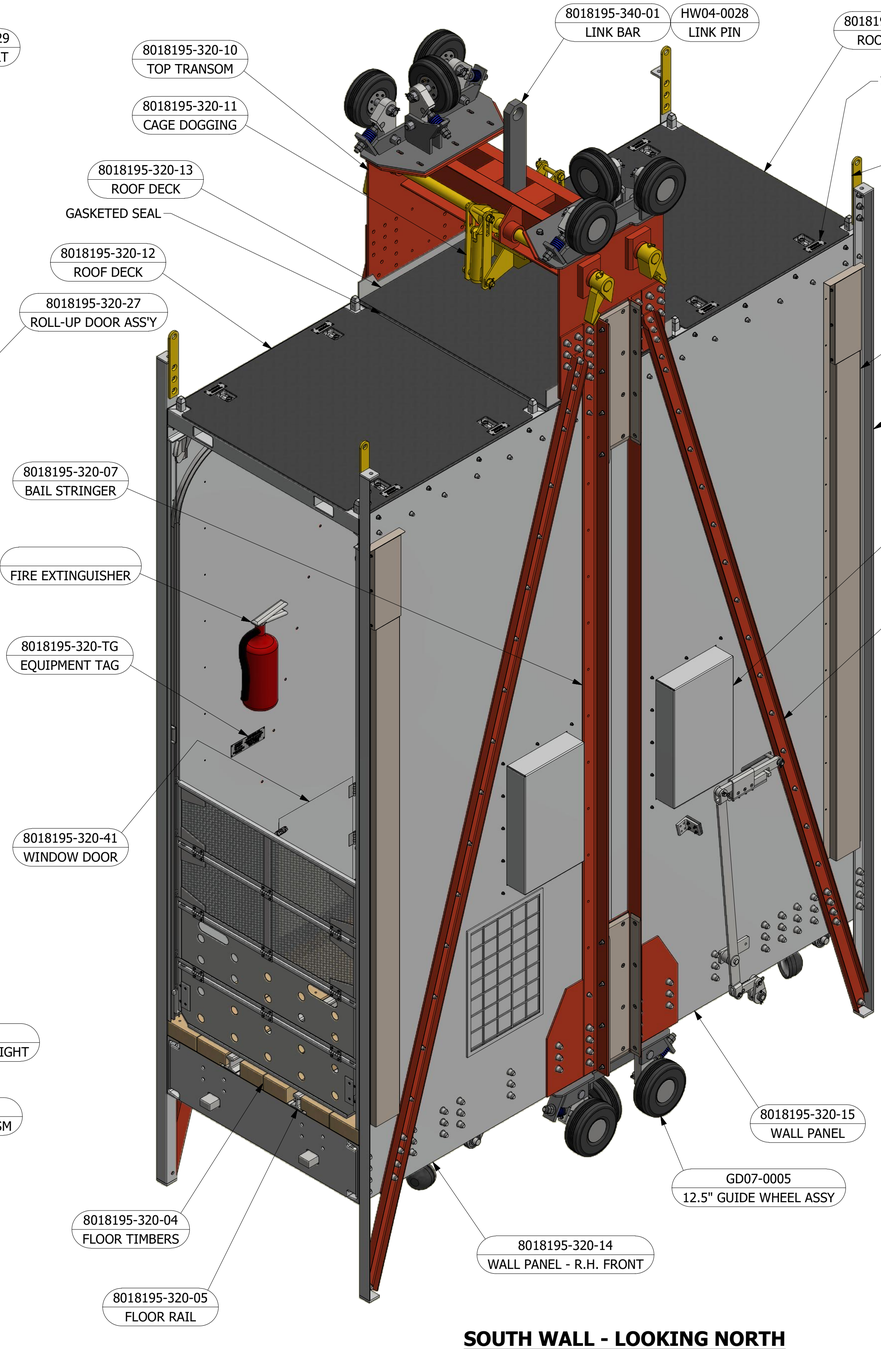
☐ For review and comment ☐ Other:

☐ FOR BIDS DUE _____, 20___ ☐ PRINTS RETURNED AFTER LOAN TO FKCI

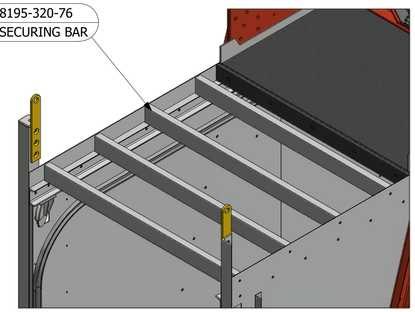
REMARKS:	
COPY TO:	**Syd Devries**
SIGNED:	**Kevin Dartt** **DATE:** **9-3-19**



NORTH WALL - LOOKING SOUTH



SOUTH WALL - LOOKING NORTH



CAGE LOAD SECURING

FOR APPROVAL

DATE:_____

APP. BY:_____

NOTE:

1. TOTAL WEIGHT DOES NOT INCLUDE INSPECTION CANOPY/HANDRAIL, MAINTENANCE PLATFORM/CANOPY/HANDRAIL.
2. ALL FASTENERS TO BE STAINLESS STEEL

TOTAL WEIGHT (LB)
8457

ITEM	QTY	PART NO.	NOMENCLATURE	DESCRIPTION	MATERIAL	COMMENTS	WT. (LB)
41	4		FLOOD LIGHT	FLOOD LIGHT			4
40	1		FIRE EXTINGUISHER	20 LB. CLASS ABC			31
39	2	1142A330	SEAL	3/8" X 5/8" RUBBER SEAL			0
38	8	94748A426	PIN	QUICK RELEASE PIN			2
37	1	HW04-0028	LINK PIN	SEE ASSEMBLY DRAWING			6
36	4	GD07-0005	12.5" GUIDE WHEEL ASSY	SEE ASSEMBLY DRAWING			1148
35	1	CS6721	SOCKET	M26 SOCKET W/ PIN			36
34	1	8018195-340-01	LINK BAR	SEE DETAIL DRAWING			92
33	1	8018195-320-TG	EQUIPMENT TAG	SEE DETAIL DRAWING			0
32	4	8018195-320-76	LOAD SECURING BAR	SEE ASSEMBLY DRAWING			38
31	2	8018195-320-41	WINDOW DOOR	SEE ASSEMBLY DRAWING			21
30	1	8018195-320-40	ESCAPE DOOR	SEE ASSEMBLY DRAWING			39
29	2	8018195-320-36	INSPECTION CANOPY	SEE ASSEMBLY DRAWING			728
28	2	8018195-320-35	ELECT. ENCL. BOX	SEE ASSEMBLY DRAWING			32
27	4	8018195-320-32	COUNTER WT. GUARD	SEE ASSEMBLY DRAWING			143
26	1	8018195-320-30	CHAIRING MECHANISM	SEE ASSEMBLY DRAWING			574
25	2	8018195-320-29	ROOF SUPPORT	SEE ASSEMBLY DRAWING			48
24	1	8018195-320-27	ROLL-UP DOOR ASS'Y	SEE ASSEMBLY DRAWING			503
23	1	8018195-320-26	FLOOR - KICK PL.	SEE ASSEMBLY DRAWING			9
22	1	8018195-320-24	SLINGING LUG	SEE ASSEMBLY DRAWING			24
21	4	8018195-320-23	WEAR SHOE SHIM	SEE ASSEMBLY DRAWING			89
20	4	8018195-320-22	WEAR SHOE	SEE ASSEMBLY DRAWING			130
19	8	8018195-320-21	WEAR SHOE	SEE ASSEMBLY DRAWING			81
18	4	8018195-320-20	LIFTING LUG	SEE ASSEMBLY DRAWING			21
17	6	8018195-320-19	SLINGING LUG	SEE ASSEMBLY DRAWING			143
16	1	8018195-320-18	SLINGING LUG	SEE ASSEMBLY DRAWING			32
15	1	8018195-320-17	WALL PANEL	SEE ASSEMBLY DRAWING			158
14	1	8018195-320-16	WALL PANEL	SEE ASSEMBLY DRAWING			153
13	1	8018195-320-15	WALL PANEL	SEE ASSEMBLY DRAWING			155
12	1	8018195-320-14	WALL PANEL - R.H. FRONT	SEE ASSEMBLY DRAWING			151
11	1	8018195-320-13	ROOF DECK	SEE ASSEMBLY DRAWING			120
10	2	8018195-320-12	ROOF DECK	SEE ASSEMBLY DRAWING			353
9	1	8018195-320-11	CAGE DOGGING	SEE ASSEMBLY DRAWING			506
8	1	8018195-320-10	TOP TRANSOM	SEE ASSEMBLY DRAWING			737
7	2	8018195-320-09	DIAGONAL BRACE	SEE ASSEMBLY DRAWING			144
6	2	8018195-320-08	DIAGONAL BRACE	SEE ASSEMBLY DRAWING			144
5	2	8018195-320-07	BAIL STRINGER	SEE ASSEMBLY DRAWING			318
4	4	8018195-320-06	CORNER STRINGER	SEE ASSEMBLY DRAWING			150
3	2	8018195-320-05	FLOOR RAIL	SEE ASSEMBLY DRAWING			453
2	1	8018195-320-04	FLOOR TIMBERS	SEE ASSEMBLY DRAWING			475
1	1	8018195-320-03	BOTTOM DECK	SEE ASSEMBLY DRAWING			1131

PARTS LIST - REQUIRED FOR ONE ASSEMBLY

PART #8018195-320-02
MAN / MATERIAL CAGE
ISO VIEWS
SCALE 3/4" = 1'-0"

PRELIMINARY
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X.XX = ±0.01
X.XXX = ±0.005
X.XXXX = ±0.0005
INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED IN ASME Y14.100M

REV.	DATE	BY	DESCRIPTION	APP.	REV.	DATE	BY	DESCRIPTION	APP.
P1	10/15/18	JAD	GENERAL UPDATE FOR PROGRESS	CLL	P4	11/13/18	JAD	ISSUED FOR 75% DESIGN REVIEW	CLL
P2	10/25/18	JAD	UPDATES FOR DESIGN CHANGE REQUEST	CLL	P5	6/5/19	JAD	ISSUED FOR 90% DESIGN REVIEW	CLL
P3	11/5/18	JAD	UPDATES FOR DESIGN CHANGE REQUEST	CLL	P6	8/30/2019	MAK	ISSUED FOR 100% APPROVAL	CLL

DWG DATE: 9/4/2018
DESIGN BY: FKC - LS
DRAWN BY: JAD
CHECKED BY: CLL

FK LAKE SHORE
A DIVISION OF FRONTIER-KEMPER CONSTRUCTORS, INC.

CLIENT: FKC - LAKESHORE, EVANSVILLE, IN, MAN / MATERIAL CAGE
DRAWING STATUS: PRELIMINARY
ORIGINAL SIZE: 22 x 34

TITLE: ROSS, MAN / MATERIAL CAGE, ISO VIEWS & PART LIST

FILE: 8018195-320-01.idw
DRAWING NO.: 8018195-320-01
REV.: P6
DO NOT SCALE DRAWING
SHEET: 1 OF 4

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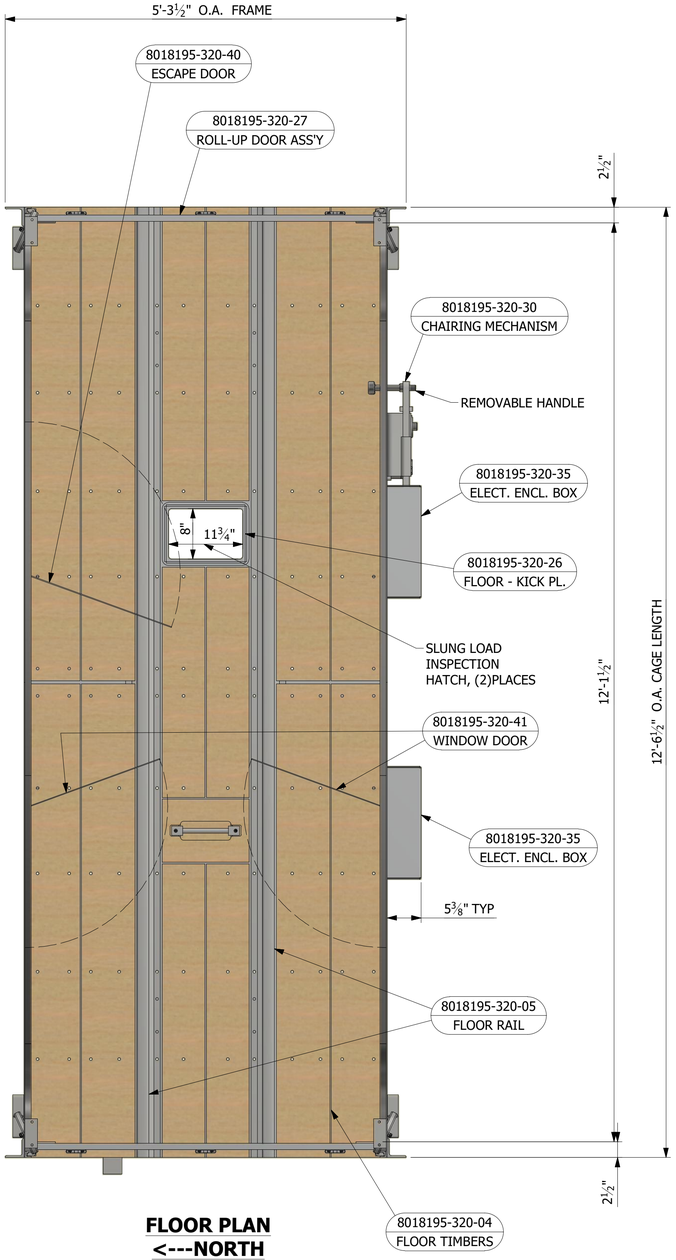
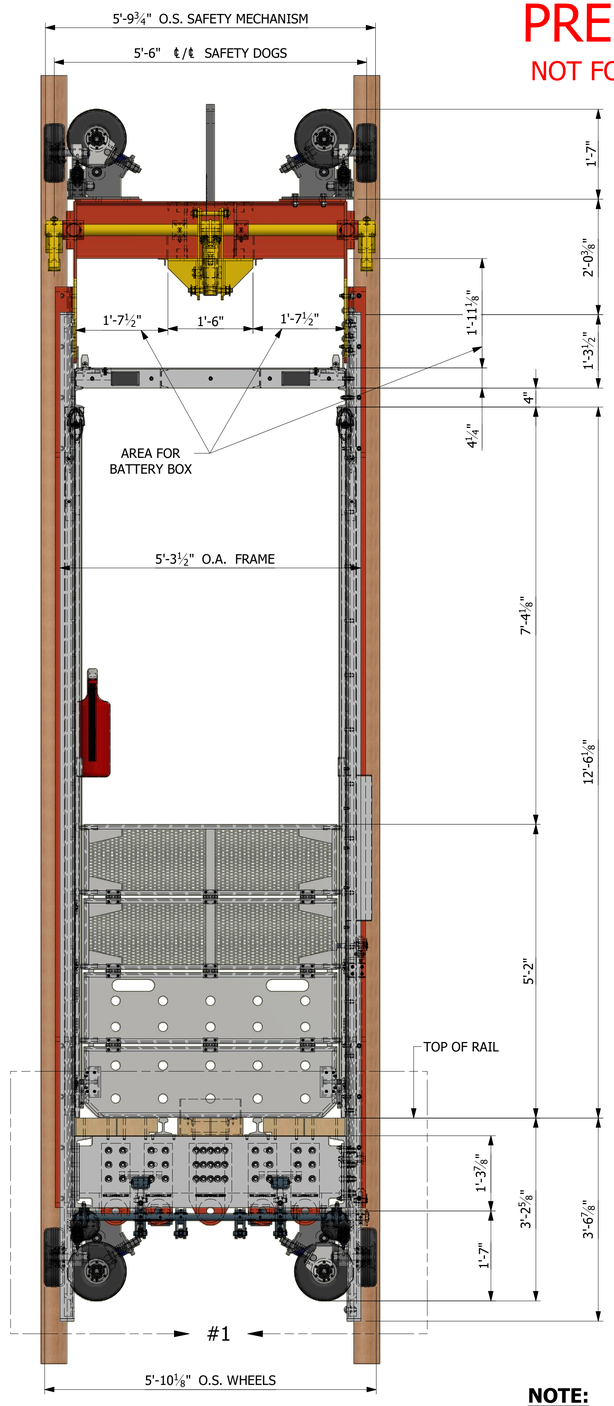
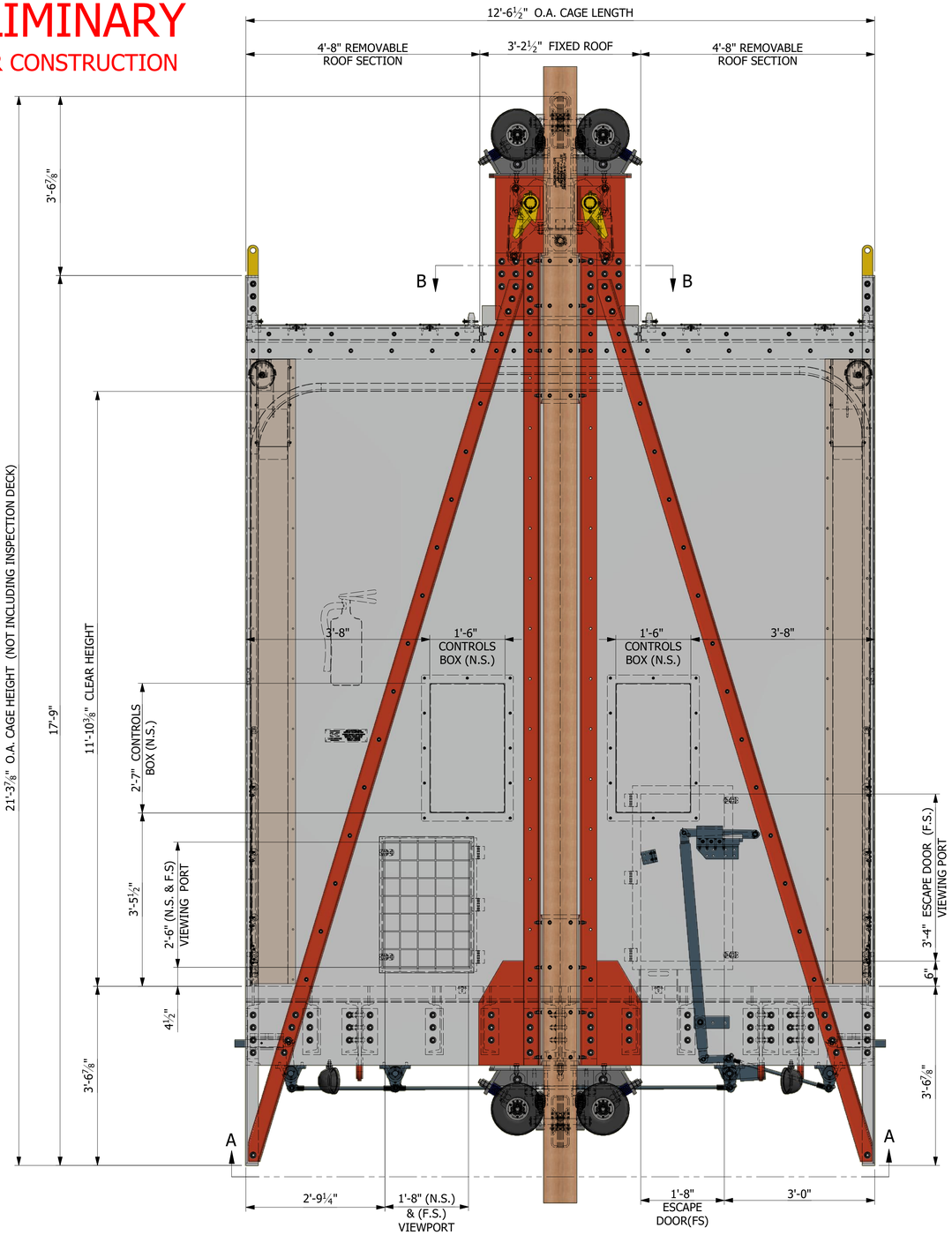


FLOOR PLAN
<---NORTH
SCALE 1" = 1'-0"



WEST END VIEW - LOOKING EAST
SCALE 3/4" = 1'-0"



SOUTH WALL ELEVATION VIEW - LOOKING NORTH
SCALE 3/4" = 1'-0"

NOTE:
1.) SEE ADDITIONAL SECTIONS & DETAILS ON SHEET #3.
2.) SEE INSPECTION DECK ARRANGEMENT ON SHEET #4.

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X.XX = ±0.01
X.XXX = ±0.005
X.XXXX = ±0.0005
INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED IN ASME Y14.100M

FOR APPROVAL

DATE:_____

APP. BY:_____

REV.	DATE	BY	DESCRIPTION	APP.
P1	10/15/18	JAD	GENERAL UPDATE FOR PROGRESS	CLL
P2	10/25/18	JAD	UPDATES FOR DESIGN CHANGE REQUEST	CLL
P3	11/5/18	JAD	UPDATES FOR DESIGN CHANGE REQUEST	CLL
P4	11/13/18	JAD	ISSUED FOR 75% DESIGN REVIEW	CLL
P5	6/5/19	JAD	ISSUED FOR 90% DESIGN REVIEW	CLL
P6	8/30/2019	MAK	ISSUED FOR 100% APPROVAL	CLL

DWG DATE: 9/4/2018
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DRAWN BY: JAD
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CLIENT: FKC - LAKESHORE
EVANSVILLE, IN
MAN / MATERIAL CAGE

DRAWING STATUS: PRELIMINARY
ORIGINAL SIZE: 22 x 34

TITLE: ROSS
MAN / MATERIAL CAGE
GENERAL ARRANGEMENT

FILE: 8018195-320-01.idw
DRAWING NO. 8018195-320-01
REV. P6
DO NOT SCALE DRAWING
SHEET: 2 OF 4

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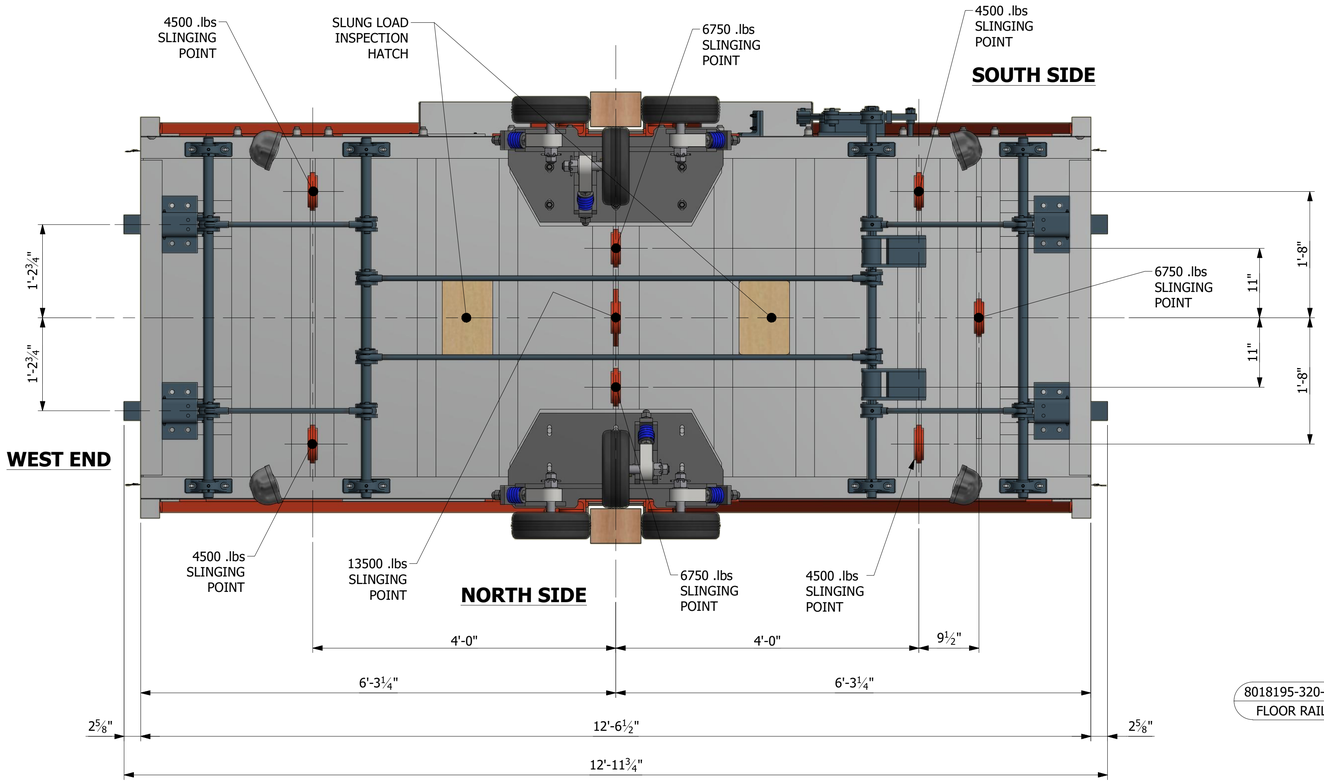
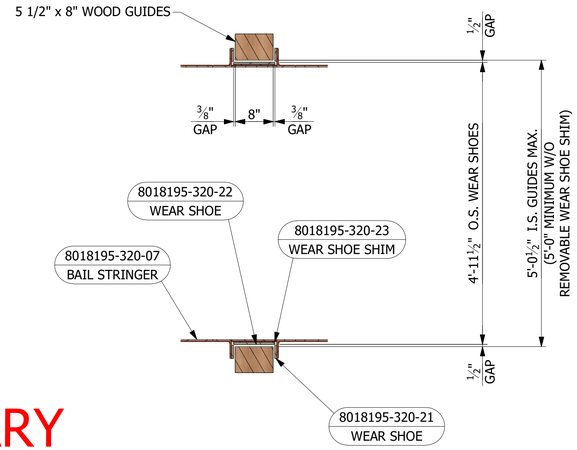


NOTE: ALL SLINGING POINT LUGS STAMPED WITH LOAD RATING

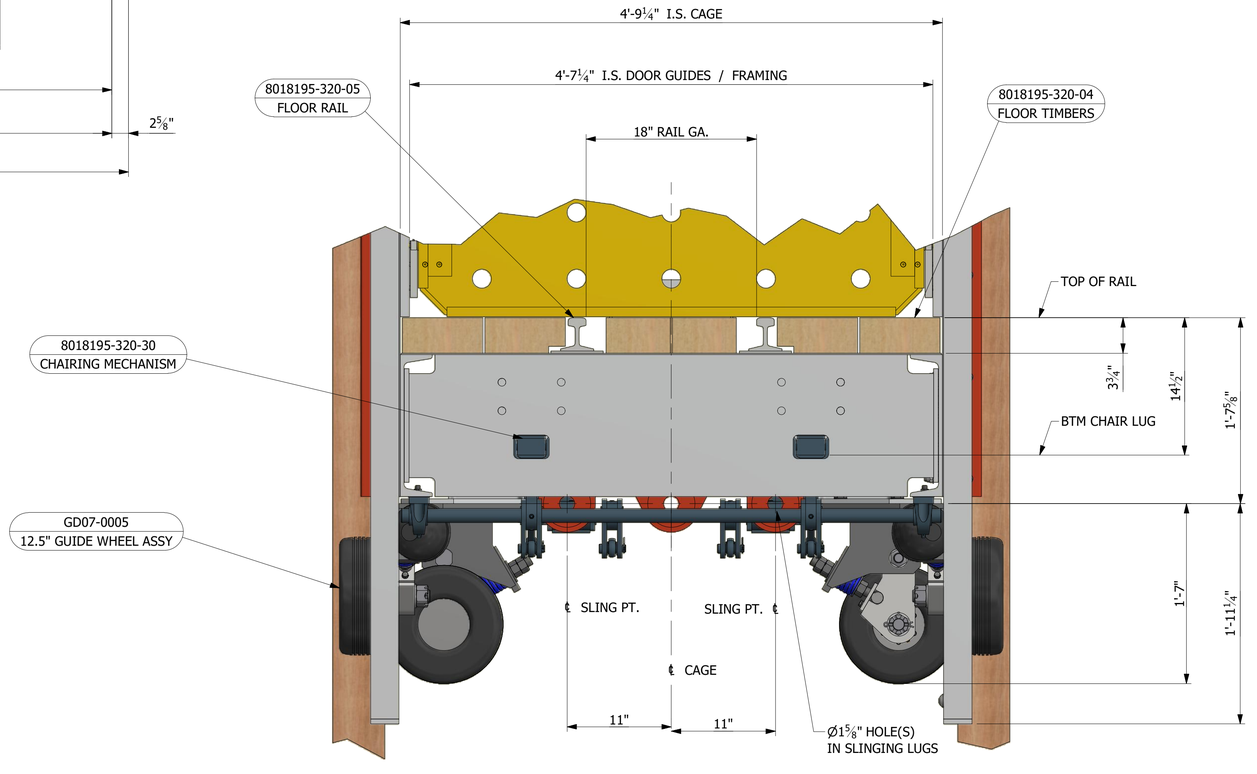
VIEW A-A
SLINGING POINTS
SCALE 1" = 1'-0"



SECTION B-B
SCALE 3/4" = 1'-0"

PRELIMINARY

NOT FOR CONSTRUCTION



DETAIL #1
SCALE 1 1/2" = 1'-0"

FOR APPROVAL

DATE:_____

APP. BY:_____

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CLIENT: FKC - LAKESHORE
EVANSVILLE, IN
MAN / MATERIAL CAGE

DRAWING STATUS: PRELIMINARY
ORIGINAL SIZE: 22 x 34

TITLE: ROSS
MAN / MATERIAL CAGE
SECTIONS AND DETAILS

FILE: 8018195-320-01.idw
DRAWING NO. 8018195-320-01
REV. P6
DO NOT SCALE DRAWING
SHEET: 3 OF 4

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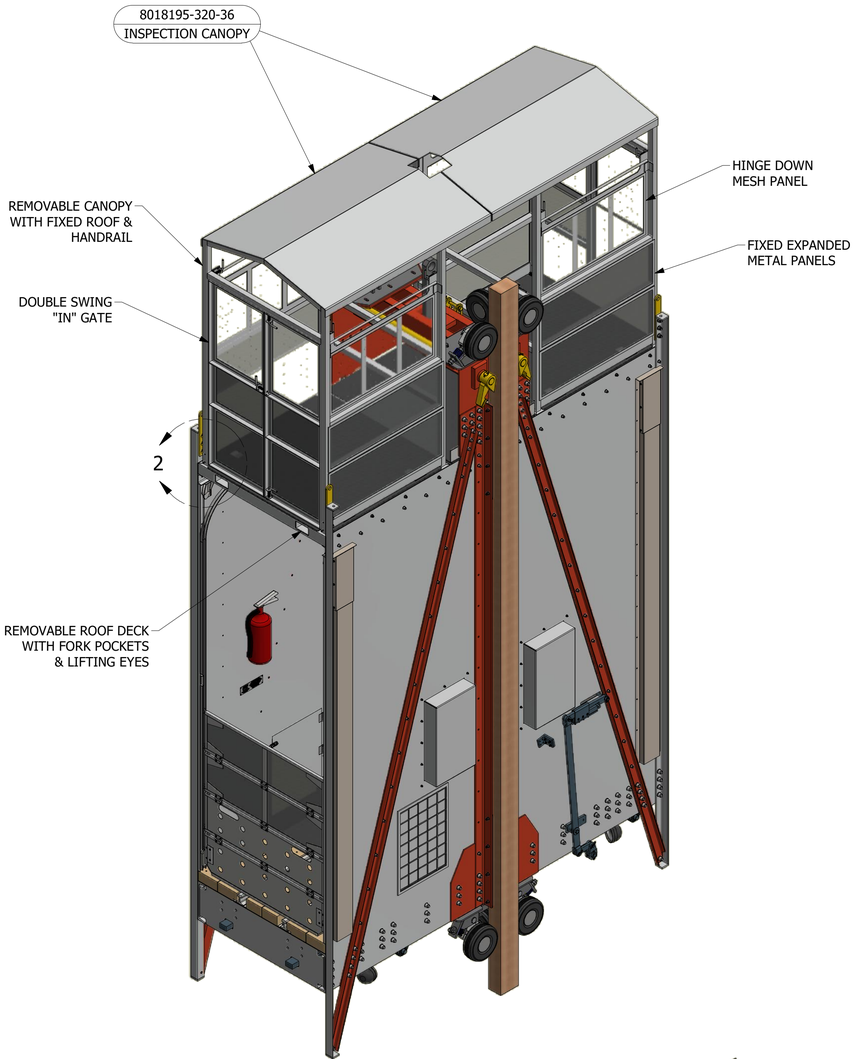
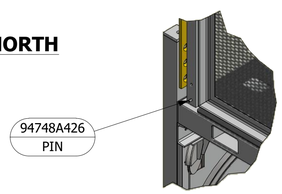
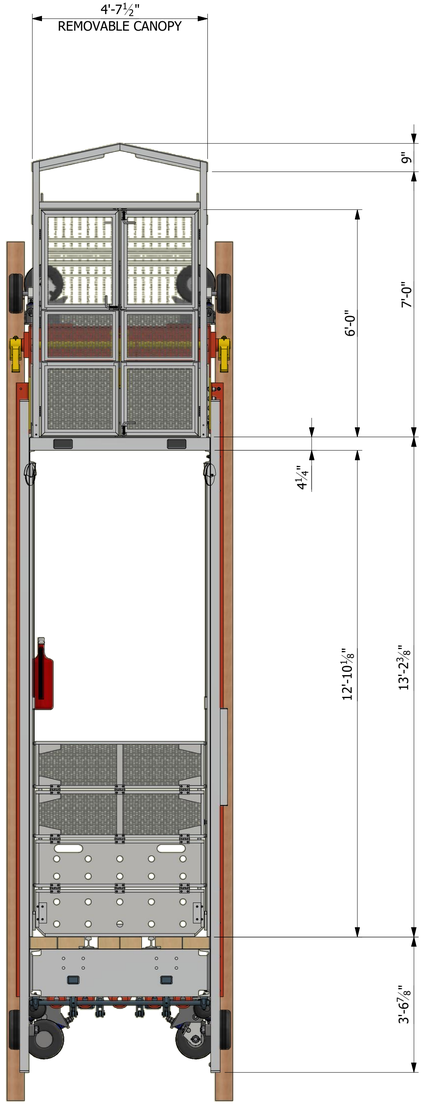


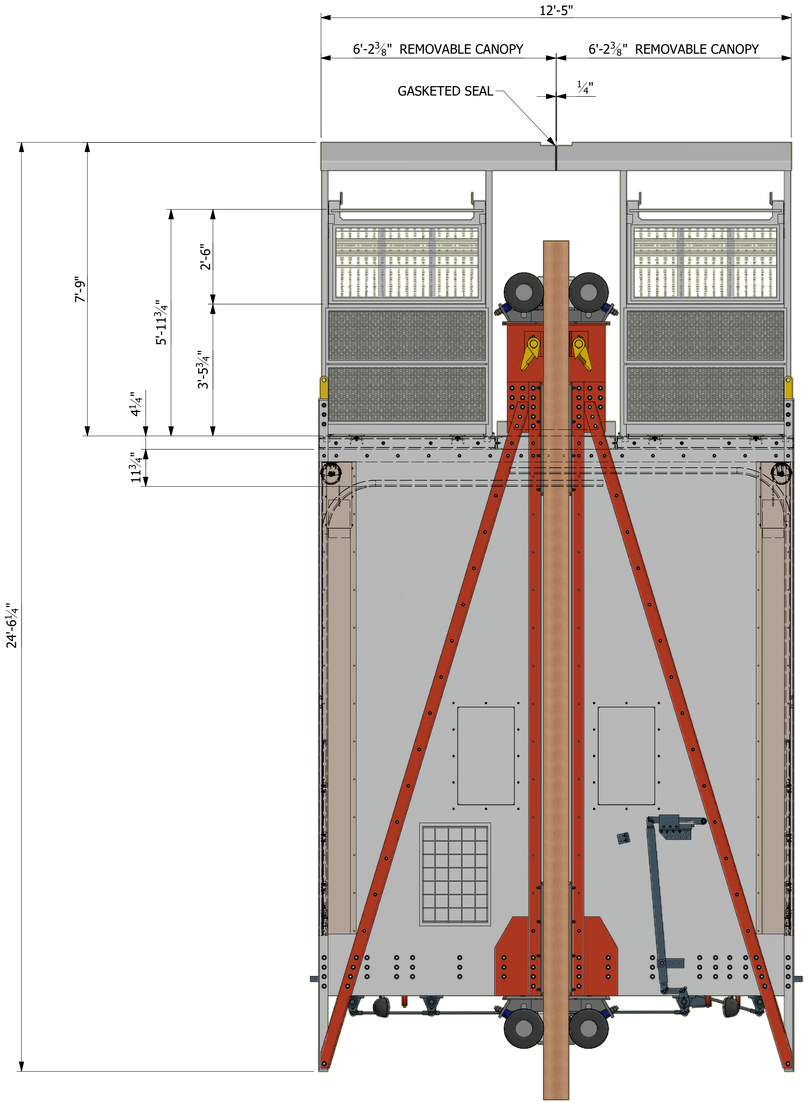
SOUTH WALL - LOOKING NORTH
SCALE 1/2" = 1'-0"



DETAIL 2
SCALE 1" = 1'-0"



WEST END VIEW - LOOKING EAST
SCALE 1/2" = 1'-0"



SOUTH WALL ELEVATION VIEW - LOOKING NORTH
SCALE 1/2" = 1'-0"

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ANGULAR BEND = ±1°
X.XX = ±0.01
X.XXX = ±0.005
X.XXXX = ±0.0005

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DATE:_____
APP. BY:_____

REV.	DATE	BY	DESCRIPTION	APP.	REV.	DATE	BY	DESCRIPTION	APP.
P1	10/15/18	JAD	GENERAL UPDATE FOR PROGRESS	CLL	P4	11/13/18	JAD	ISSUED FOR 75% DESIGN REVIEW	CLL
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DWG DATE: 9/4/2018
DESIGN BY: FKC - LS
DRAWN BY: JAD
CHECKED BY: CLL

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CLIENT: FKC - LAKESHORE
EVANSVILLE, IN
MAN / MATERIAL CAGE

DRAWING STATUS: PRELIMINARY
ORIGINAL SIZE: 22 x 34

TITLE: ROSS
MAN / MATERIAL CAGE
INSPECTION DECK ARRANGEMENT

FILE: 8018195-320-01.idw
DRAWING NO. 8018195-320-01
REV. P6
DO NOT SCALE DRAWING
SHEET: 4 OF 4

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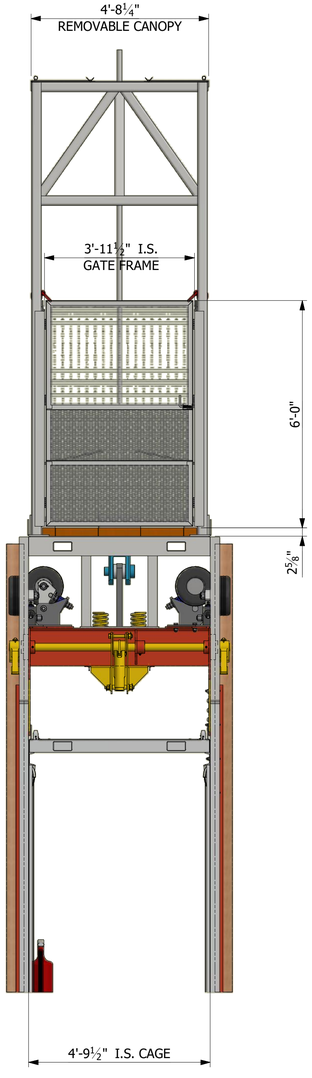
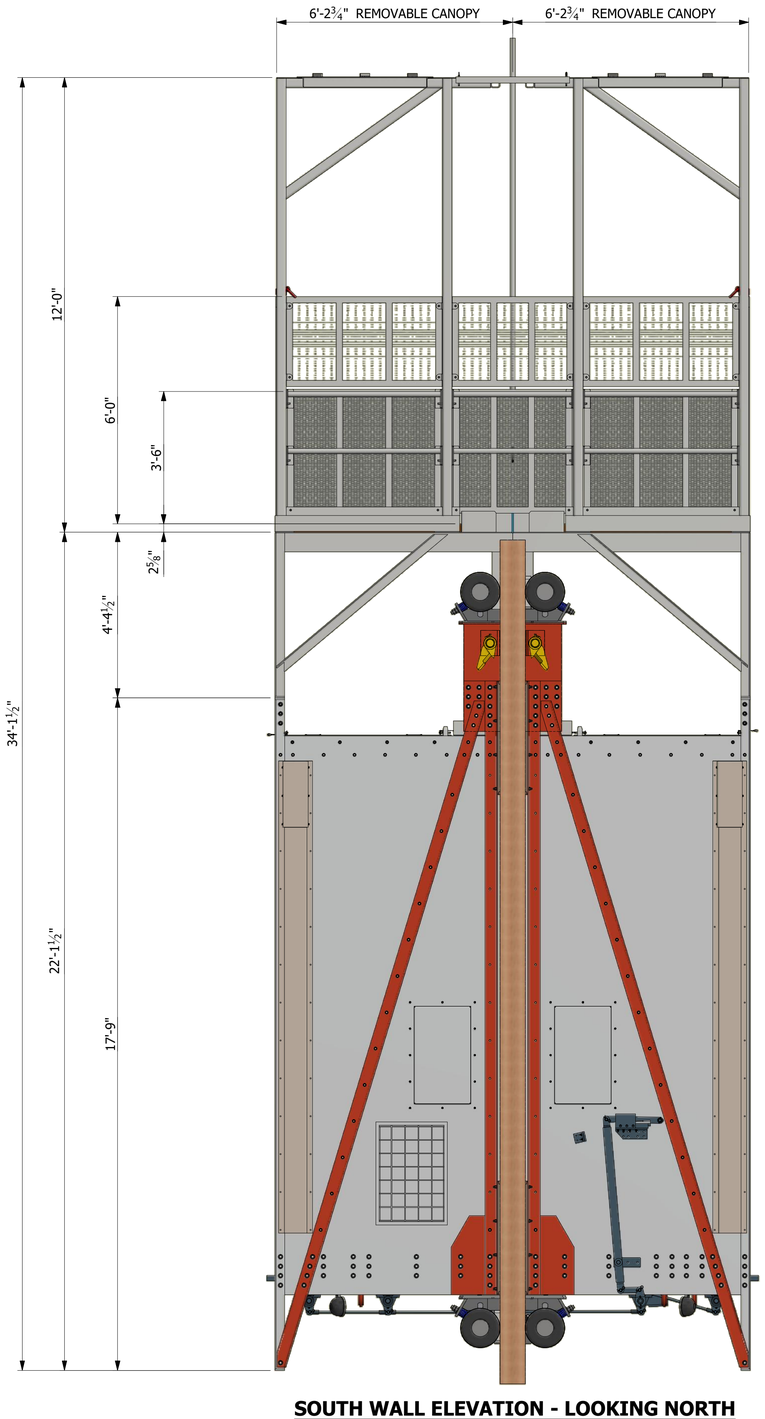


WEST END VIEW - LOOKING EAST

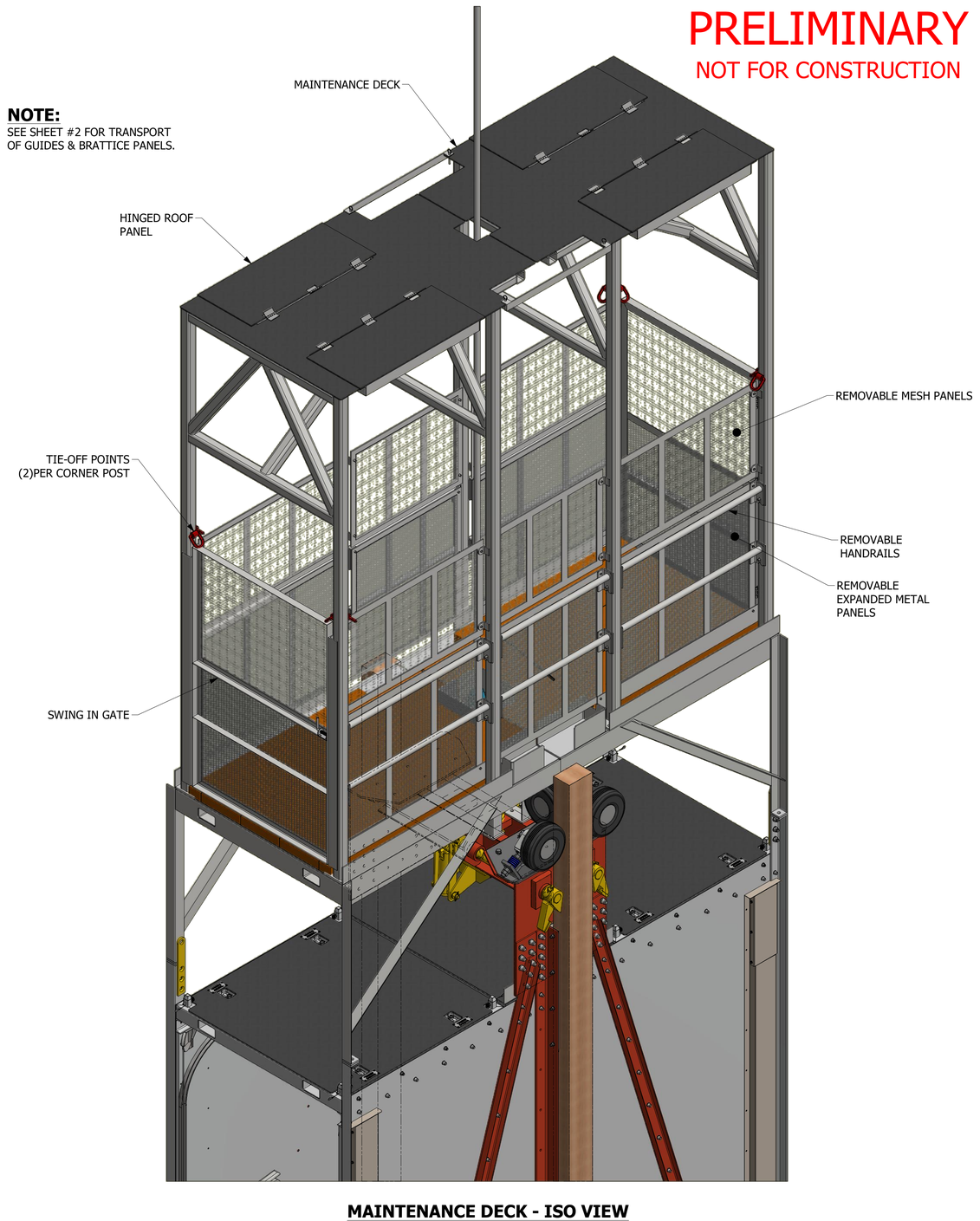
SCALE 1/2" = 1'-0"



SOUTH WALL ELEVATION - LOOKING NORTH

SCALE 1/2" = 1'-0"

NOTE:
SEE SHEET #2 FOR TRANSPORT OF GUIDES & BRATTICE PANELS.



MAINTENANCE DECK - ISO VIEW

SCALE 3/4" = 1'-0"

PRELIMINARY

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DATE:_____

APP. BY:_____

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X.XXXX = ±0.0005

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P2	11/5/18	JAD	UPDATES FOR DESIGN CHANGE REQUEST	CLL
P3	11/13/18	JAD	ISSUED FOR 75% DESIGN REVIEW	CLL
P4	6/5/19	JAD	ISSUED FOR 90% DESIGN REVIEW	CLL
P5	8/30/2019	MAK	ISSUED FOR 100% APPROVAL	CLL

DWG DATE: 10/15/2018
DESIGN BY: FKC - LS
DRAWN BY: JAD
CHECKED BY: CLL

FK LAKE SHORE
A DIVISION OF FRONTIER-KEMPER CONSTRUCTORS, INC.

CLIENT: FKC - LAKESHORE
EVANSVILLE, IN
MAN / MATERIAL CAGE

DRAWING STATUS: PRELIMINARY
ORIGINAL SIZE: 22 x 34

TITLE: ROSS
MAN / MATERIAL CAGE
MAINTENANCE DECK ARRANGEMENT

FILE: 8018195-320-02.idw
DRAWING NO. 8018195-320-02
REV. P5
DO NOT SCALE DRAWING
SHEET: 1 OF 3

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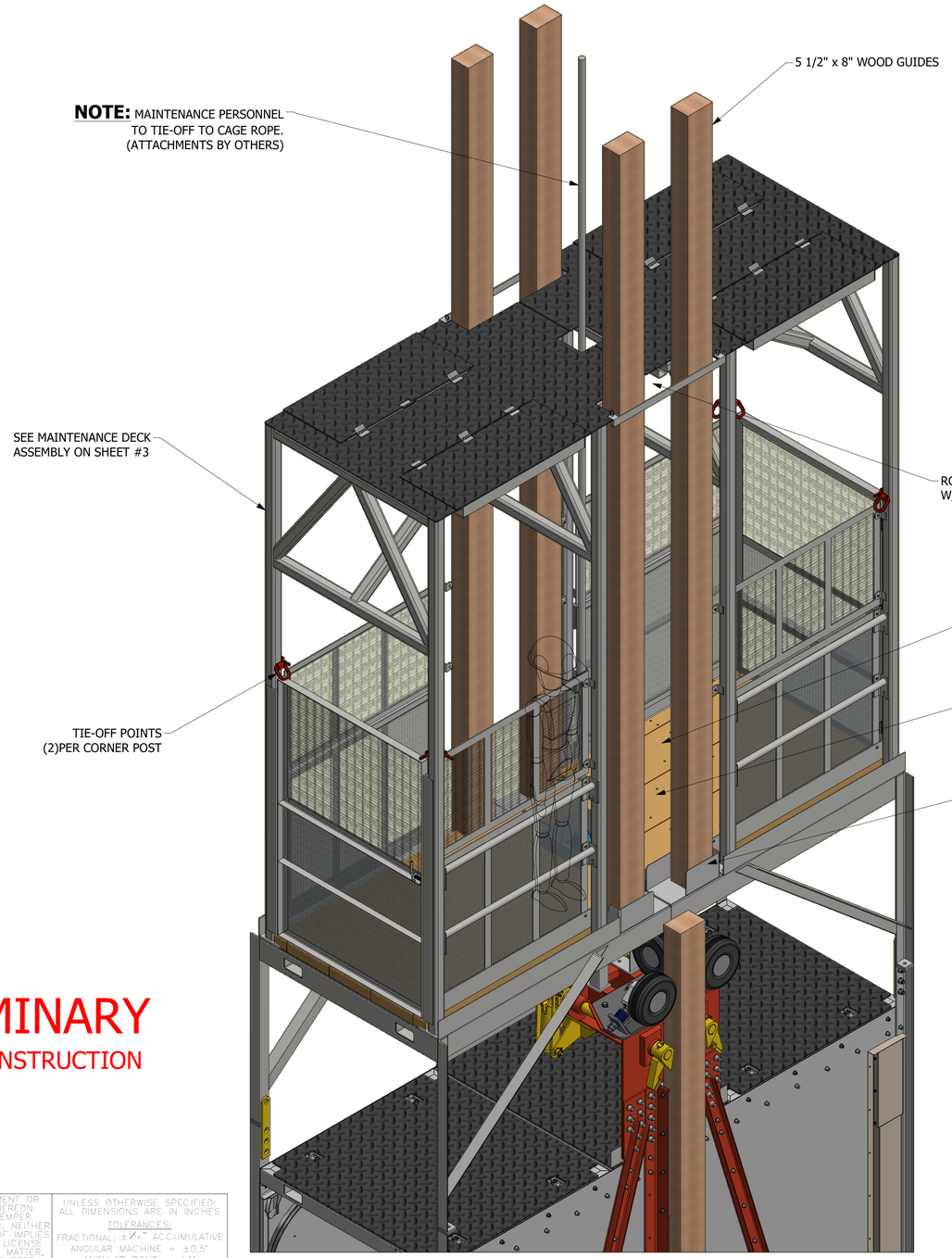
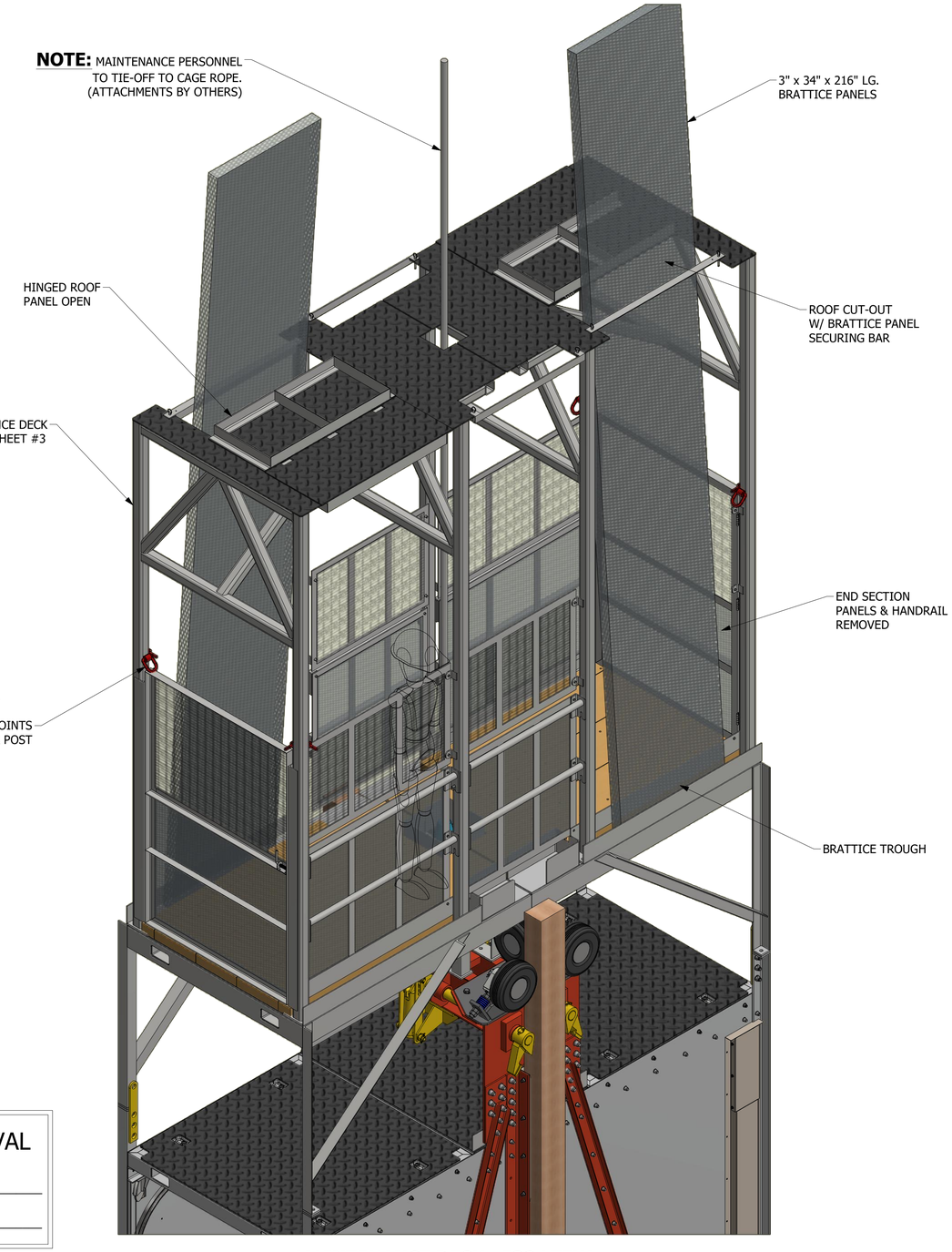


MAINTENANCE DECK - ISO VIEW
GUIDE TRANSPORT
SCALE 3/4" = 1'-0"



MAINTENANCE DECK - ISO VIEW
BRATTICE PANEL TRANSPORT
SCALE 3/4" = 1'-0"

PRELIMINARY
NOT FOR CONSTRUCTION

FOR APPROVAL

DATE:_____

APP. BY:_____

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ANGULAR BEND = ±1°
X.XX = ±0.01
X.XXX = ±0.005
X.XXXX = ±0.0005
INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED IN ASME Y14.100M

REV.	DATE	BY	DESCRIPTION	APP.
P0	10/25/18	JAD	ADD SHEET FOR BRATTICE PANEL HATCH	CLL
P1	11/5/18	JAD	ADD SHEET FOR BRATTICE PANEL HATCH	CLL
P2	11/13/18	JAD	ISSED FOR 75% DESIGN REVIEW	CLL
P3	6/6/19	JAD	ISSUED FOR 90% DESIGN REVIEW	CLL
P4	8/30/2019	MAK	ISSUED FOR 100% APPROVAL	CLL

DWG DATE: 10/15/2018
DESIGN BY: FKC - LS
DRAWN BY: JAD
CHECKED BY: CLL

FK LAKE SHORE
A DIVISION OF FRONTIER-KEMPER CONSTRUCTORS, INC.

CLIENT: FKC - LAKESHORE
EVANSVILLE, IN
MAN / MATERIAL CAGE

DRAWING STATUS: PRELIMINARY
ORIGINAL SIZE: 22 x 34

TITLE: ROSS
MAN / MATERIAL CAGE
GUIDE & BRATTICE TRANSPORT

FILE: 8018195-320-02.idw
DRAWING NO. 8018195-320-02
REV. P4
DO NOT SCALE DRAWING
SHEET: 2 OF 3

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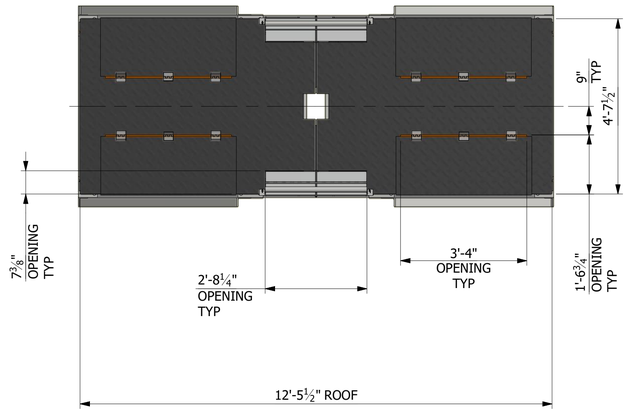
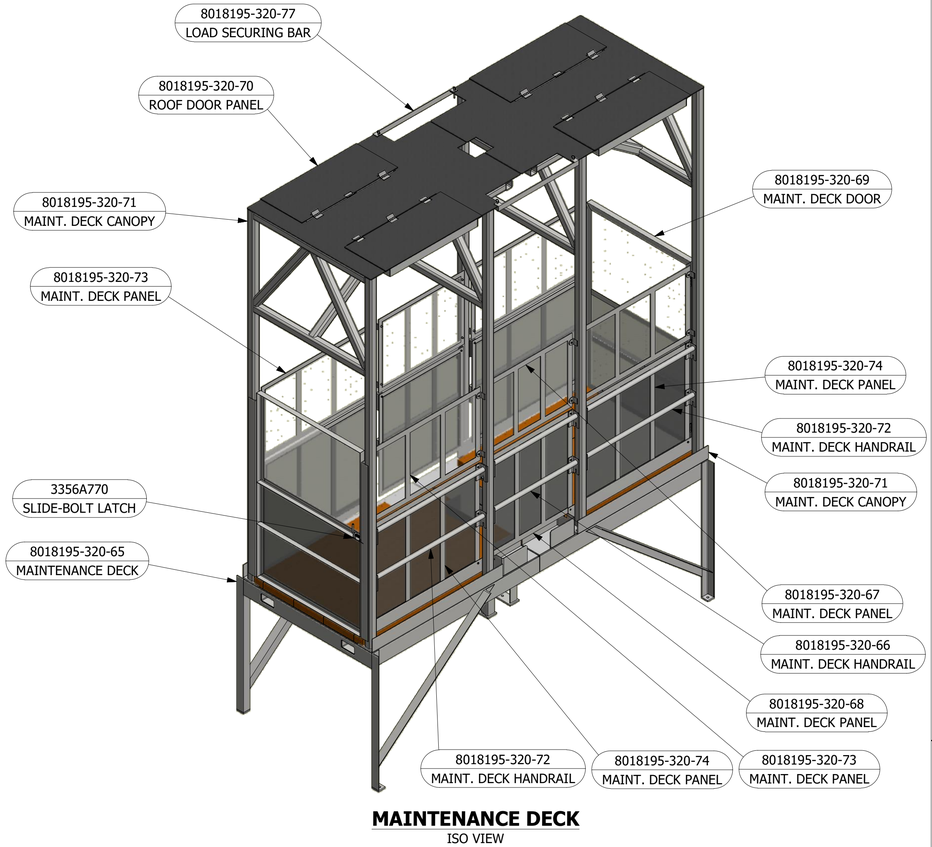
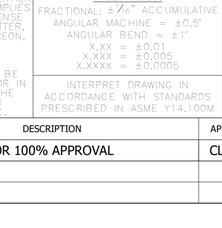
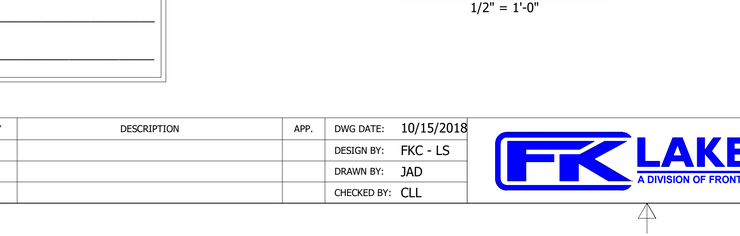




MAINTENANCE DECK
ISO VIEW





PRELIMINARY
NOT FOR CONSTRUCTION

FOR APPROVAL

DATE:_____

APP. BY:_____

PART# 8018195-320-02
MAINTENANCE DECK
1/2" = 1'-0"

TOTAL WEIGHT (LB): 5939

ITEM	QTY	PART NO.	NOMENCLATURE	DESCRIPTION	MATERIAL	COMMENTS	WT. (LB)
14	1	3356A770	SLIDE-BOLT LATCH	3" WD x 1 3/4" HI, 1/2" DIA. BOLT		McMASTER CARR	0
13	6	1609A220	HINGE	3" x 1 1/2" LEAF, .012 THK		McMASTER CARR	3
12	4	8018195-320-74	MAINT. DECK PANEL	SEE ASSEMBLY DRAWING			175
11	4	8018195-320-73	MAINT. DECK PANEL	SEE ASSEMBLY DRAWING			232
10	8	8018195-320-72	MAINT. DECK HANDRAIL	SEE ASSEMBLY DRAWING			105
9	2	8018195-320-78	LOAD SECURING BAR	SEE ASSEMBLY DRAWING			22
8	2	8018195-320-77	LOAD SECURING BAR	SEE ASSEMBLY DRAWING			11
7	2	8018195-320-71	MAINT. DECK CANOPY	SEE ASSEMBLY DRAWING			2687
6	4	8018195-320-70	ROOF DOOR PANEL	SEE ASSEMBLY DRAWING			387
5	2	8018195-320-69	MAINT. DECK DOOR	SEE ASSEMBLY DRAWING			132
4	2	8018195-320-68	MAINT. DECK PANEL	SEE ASSEMBLY DRAWING			76
3	2	8018195-320-67	MAINT. DECK PANEL	SEE ASSEMBLY DRAWING			95
2	4	8018195-320-66	MAINT. DECK HANDRAIL	SEE ASSEMBLY DRAWING			44
1	2	8018195-320-65	MAINTENANCE DECK	SEE ASSEMBLY DRAWING			1970

PARTS LIST - REQUIRED FOR ONE ASSEMBLY

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INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED IN ASME Y14.100M

REV.	DATE	BY	DESCRIPTION	APP.	REV.	DATE	BY	DESCRIPTION	APP.
P0	8/30/2019	MAK	ISSUED FOR 100% APPROVAL	CLL					

DWG DATE: 10/15/2018
DESIGN BY: FKC - LS
DRAWN BY: JAD
CHECKED BY: CLL

FK LAKE SHORE
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CLIENT: FKC - LAKESHORE, EVANSVILLE, IN, MAN / MATERIAL CAGE
DRAWING STATUS: PRELIMINARY | ORIGINAL SIZE: 22 x 34

TITLE: ROSS
MAN / MATERIAL CAGE
MAINTENANCE DECK ARRANGEMENT

FILE: 8018195-320-02.idw
DRAWING NO. 8018195-320-02 | REV. P0
DO NOT SCALE DRAWING | SHEET: 3 OF 3

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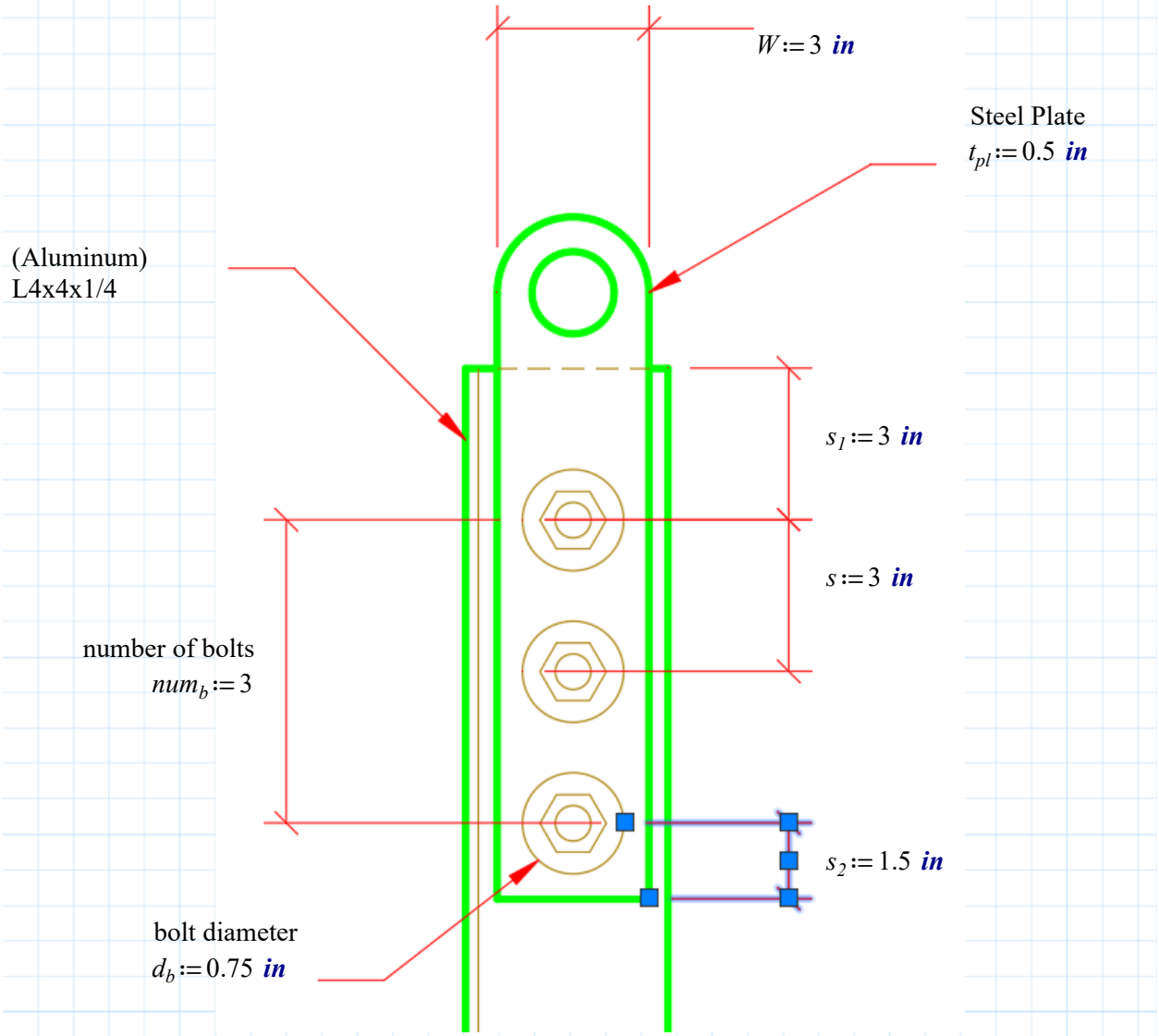

Steel Bolts

ASTM A193 Grade B8

Tensile Stress

$F_{u_b} := 70$ ***ksi***

Yield Stress

$F_{y_b} := 30$ ***ksi***

Structural Steel

$F_{y_s} := 36$ ***ksi***

$F_{u_s} := 50$ ***ksi***

Aluminum

$F_{y_a} := 35$ ***ksi***

$F_{u_a} := 38$ ***ksi***

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Failure Modes in Steel Plate

1. Bearing Strength at Bolt Holes
J3.10

clear distance between the edge of the hole and the edge of the adjacent hole or edge of material

Bolt Row #1 $l_{c_1} := s_1 - \left(\frac{d_b + \frac{1}{8}\ in}{2} \right) = 2.563\ in$

Bolt Row #2+ $l_{c_2} := s - \left(d_b + \frac{1}{8}\ in \right) = 2.125\ in$

Nominal Strength

Bolt Row #1

$R_{n_1} := min\left(1.2 \cdot l_{c_1} \cdot t_{pl} \cdot F_{u_s}, 2.4 \cdot d_b \cdot t_{pl} \cdot F_{u_s}\right)$

$R_{n_1} = 45\ kip$

Bolt Row #2+

$R_{n_2} := min\left(1.2 \cdot l_{c_2} \cdot t_{pl} \cdot F_{u_s}, 2.4 \cdot d_b \cdot t_{pl} \cdot F_{u_s}\right)$

$R_{n_2} = 45\ kip$

Design Strength $R_{n1} := 1 \cdot R_{n_1} + \left(num_b - 1\right) \cdot R_{n_2} = 135\ kip$

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2. Rupture Strength of Plate
J4.1

Gross Area

$$A_g := W \cdot t_{pl} = 1.5 \ in^2$$

Effective Net Area

$$A_e := A_g - \left(d_b + \frac{1}{8} \cdot in\right) \cdot t_{pl}$$

$$A_e = 1.063 \ in^2$$

Nominal Strength
Tensile Yielding

$$R_{n_y} := A_g \cdot F_{y_s} = 54 \ kip$$

Nominal Strength
Tensile Rupture

$$R_{n_r} := F_{u_s} \cdot A_e = 53 \ kip$$

Design Strength

$$R_{n2} := min\left(R_{n_y}, R_{n_r}\right) = 53.1 \ kip$$

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3. Block Shear of the Plate

J4.1 N/A

4. Failure Modes in Steel Bolts

nominal unthreaded body area of bolt	$A_b := \frac{\pi \cdot d_b^{\,2}}{4} = 0.442\ \textit{in}^2$
nominal shear stress	$F_{nv} := 0.6 \cdot F_{u_b} = 42\ \textit{ksi}$
nominal strength of single bolt	$R_n := F_{nv} \cdot A_b = 18.555\ \textit{kip}$
Allowable Strength of entire bolt group	$R_{n4} := num_b \cdot R_n = 55.7\ \textit{kip}$

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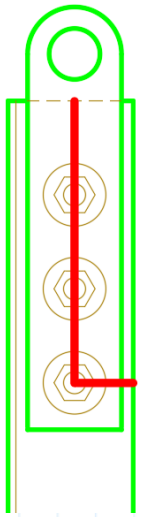
Failure Modes in Aluminum

5. Block Shear in Aluminum Member



thickness of Angle

$t_l := \frac{1}{4}\ in$

gross area in shear

$A_{gv} := \left(s_1 + \left(num_b - 1\right) \cdot s\right) \cdot t_l = 2.3\ in^2$

net area in shear

$A_{nv} := A_{gv} - \left(2.5 \cdot \left(d_b + \frac{1}{8}\ in\right)\right) \cdot t_l = 1.7\ in^2$

gross area in tension

$A_{gt} := \left(\frac{W}{2}\right) \cdot t_l = 0.375\ in^2$

net area in tension

$A_{nt} := A_{gt} - \left(\frac{1}{2} \cdot \left(d_b + \frac{1}{8}\ in\right) \cdot t_l\right) = 0.266\ in^2$

allowable force

$$P_{sr} := \begin{cases} \left(\left(\frac{F_{y_a}}{\sqrt{3}}\right) \cdot A_{gv} + F_{u_a} \cdot A_{nt}\right) & \text{if } F_{u_a} \cdot A_{nt} \geq \left(0.6 \cdot F_{u_a}\right) \cdot A_{nv} \\ \left(\left(0.6 \cdot F_{u_a}\right) \cdot A_{nv} + F_{y_a} \cdot A_{gt}\right) & \text{else} \end{cases}$$

$R_{n5} := P_{sr} = 52\ kip$

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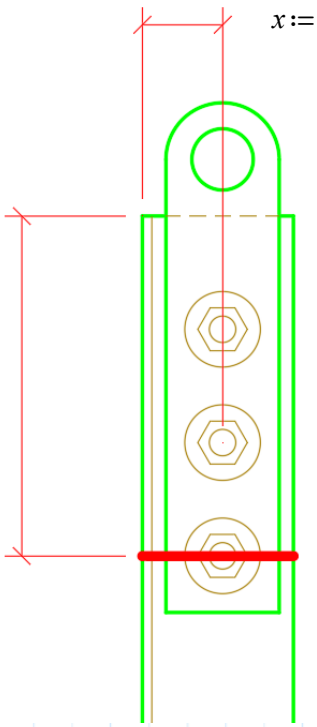
6. Rupture of Aluminum Angle

$x := \frac{W}{2} + 0.625\ in = 2.125\ in$



$L := s_1 + (num_b - 1) \cdot s = 9\ in$

Gross Area of angle	$A_g := 1.94\ in^2$
Net Area of angle	$A_n := A_g - \left(d_b + \frac{1}{8}\ in\right) \cdot t_l = 1.721\ in^2$
Shear lag Factor	$U := 1 - \frac{x}{L} = 0.764$
Effective net area	$A_e := A_n \cdot U = 1.315\ in^2$
Nominal Strength	$R_{n6} := F_{u_a} \cdot A_e = 50.0\ kip$

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7. Bolt bearing in Aluminum Member

edge distance

bolt row #1 $d_{e1} := min\left(s_1, 1.5 \cdot d_b\right) = 1.125\ in$

bolt row #2+ $d_{e2} := min\left(s - 1 \cdot \left(d_b + \frac{1}{8}\ in\right), 1.5 \cdot d_b\right)$

$d_{e2} = 1.125\ in$

Nominal Strength

Bolt Row #1

$$R_{n_1} := \left(2 \cdot F_{u_a} \cdot t_1 \cdot d_b\right) \cdot \left(\frac{d_{e1}}{2 \cdot d_b}\right) = 10.7\ kip$$

Bolt Row #2

$$R_{n_2} := \left(2 \cdot F_{u_a} \cdot t_1 \cdot d_b\right) \cdot \left(\frac{d_{e2}}{2 \cdot d_b}\right) = 10.7\ kip$$

Nominal Strength

$$R_{n7} := R_{n_1} + \left(num_b - 1\right) \cdot R_{n_2} = 32.1\ kip$$

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Summary of Failure Modes

1. Bearing Strength @ bolt holes (steel plate)	$R_{n1} = 135$ *kip*
2. Rupture (steel plate)	$R_{n2} = 53.1$ *kip*
3. Block shear (steel plate)	N/A
4. Shear in bolts	$R_{n4} = 55.7$ *kip*
5. Block Shear (Aluminum Member)	$R_{n5} = 52$ *kip*
6. Rupture (Aluminum Member)	$R_{n6} = 50$ *kip*
7. Bolt bearing (Aluminum Member)	$R_{n7} = 32.1$ *kip*

Governing Failure Mode

Safety Factor $\Omega := 5$

$gov =$ "7. Bolt Bearing (aluminum member)"

$R_n := min\left(R_{n1}, R_{n2}, R_{n4}, R_{n5}, R_{n6}, R_{n7}\right) = 32.1$ *kip*

$R_n := \frac{R_n}{\Omega} = 6.413$ *kip*

Design Load on Lug

$P := 4000$ *lbf*

Comparison of Demand to Capacity

$\frac{P}{R_n} = 0.624$

if $P \le R_n$ = "GOOD! :)"
  "GOOD! :)"
else
  "NO GOOD :("

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Beam in Cage Floor (Supporting Main underlung load)_

Aluminum Alloy	6061-T6, T6510
ultimate tensile strength	$F_{tu} := 38\ ksi$
Yield tensile strength	$F_{ty} := 35\ ksi$
Compression yield strength	$F_{cy} := 35\ ksi$
Shear yield strength	$F_{su} := 24\ ksi$
compressive Mod of Elasticity	$E := 10100\ ksi$
deflection Mod of Elasticity	$E_d := E - 100\ ksi = 10000\ ksi$

Safety Factor on Yield Stress	$n_y := 10$
Allowable Stress in Tension Flanges	$F_{at} := \frac{F_{ty}}{n_y} = 3.5\ ksi$
Allowable Stress in Compression Flanges	$F_{ac} := \frac{F_{cy}}{n_y} = 3.5\ ksi$

Beam Length $l := 57.25\ in$

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Beam Information

Beam Size **2 C12x12.1**

Dimensions/Geometry

depth	$d := 12\ in$
width	$b := 3.292\ in$
Flange Tip Thickness	$t_f := 0.24\ in$
Ave Flange Thickness	$t := 0.502\ in$
Web Thickness	$t_w := 0.673\ in$
Area	$A := 2 \cdot 10.3\ in^2$
depth	$d := 12\ in$

Properties (of back to back channels)

Strong Axis

Mod of Elasticity	$I_x := 2 \cdot 180\ in^4$
Section Modulus	$S_x := 2 \cdot 29.9\ in^3$

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Force on the Lug $P := 13500\ lbf$

Weight of floor $w_d := 20\ psf \cdot 18\ in = 30\ plf$

Maximum Moment $M_{max} := \frac{(w_d) \cdot l^2}{8} = 16.2\ kip \cdot ft$
$+ \frac{(P) \cdot l}{4}$

Maximum Deflection $\Delta_{max} := \frac{5 \cdot (w_d) \cdot l^4}{384 \cdot E_d \cdot I_x} = 0.015\ in$
$+ \frac{(P) \cdot l^3}{48 \cdot E_d \cdot I_x}$

Maximum Stress $f_s := \frac{M_{max}}{S_x} = 3.248\ ksi$

Maximum Stress / Allowable Stress $\frac{f_s}{F_{at}} = 0.928$

if $\frac{f_s}{F_{at}} \le 1.0$ = "GOOD"
"GOOD"
else
"NO GOOD"

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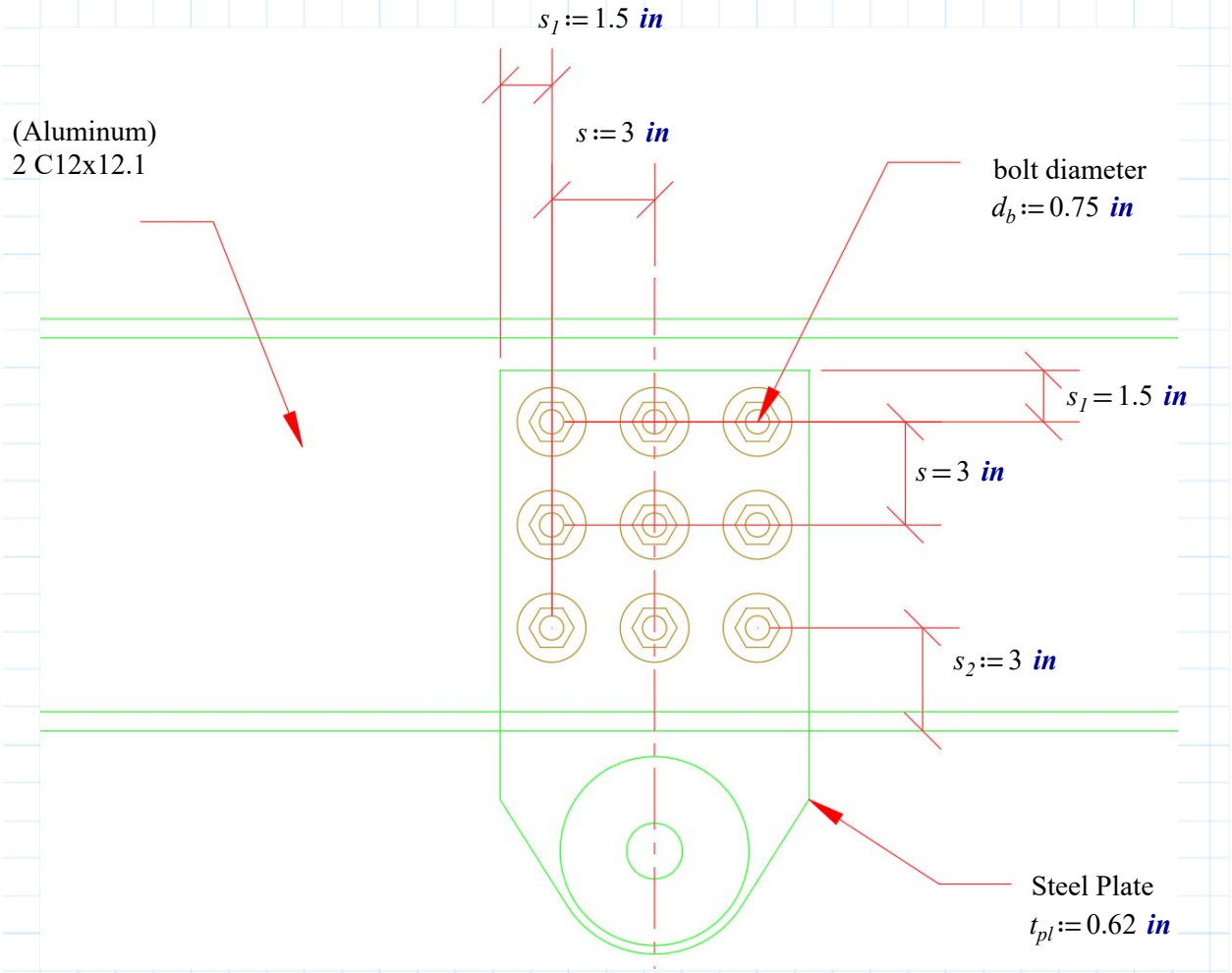

Steel Bolts

ASTM A193 Grade B8

Tensile Stress

$F_{u_b} := 70$ *ksi*

Yield Stress

$F_{y_b} := 30$ *ksi*

Structural Steel

$F_{y_s} := 36$ *ksi*

$F_{u_s} := 50$ *ksi*

Aluminum

$F_{y_a} := 35$ *ksi*

$F_{u_a} := 38$ *ksi*

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Failure Modes in Steel Plate

1. Bearing Strength at Bolt Holes
   J3.10

clear distance between the edge of the hole and the edge of the adjacent hole or edge of material

Bolt Row #1 $l_{c_1} := s_2 - \left(\frac{d_b + \frac{1}{8}\ in}{2} \right) = 2.563\ in$

Bolt Row #2 $l_{c_2} := s - \left(d_b + \frac{1}{8}\ in \right) = 2.125\ in$

Bolt Row #3 $l_{c_3} := s - \left(d_b + \frac{1}{8}\ in \right) = 2.125\ in$

Nominal Strength

Bolt Row #1

$$R_{n_1} := min\left(1.2 \cdot l_{c_1} \cdot t_{pl} \cdot F_{u_s}, 2.4 \cdot d_b \cdot t_{pl} \cdot F_{u_s}\right)$$

$$R_{n_1} = 55.8\ kip$$

Bolt Row #2

$$R_{n_2} := min\left(1.2 \cdot l_{c_2} \cdot t_{pl} \cdot F_{u_s}, 2.4 \cdot d_b \cdot t_{pl} \cdot F_{u_s}\right)$$

$$R_{n_2} = 55.8\ kip$$

Bolt Row #3

$$R_{n_3} := min\left(1.2 \cdot l_{c_3} \cdot t_{pl} \cdot F_{u_s}, 2.4 \cdot d_b \cdot t_{pl} \cdot F_{u_s}\right)$$

$$R_{n_3} = 55.8\ kip$$

Design Strength $R_{n1} := 3 \cdot R_{n_1} + 3 \cdot R_{n_2} + 3 \cdot R_{n_3} = 502.2\ kip$

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2. Rupture Strength of Plate
J4.1

Gross Area

$$A_g := \left(2 \cdot s_1 + 2 \cdot s\right) \cdot t_{pl} = 5.58\ \textit{in}^2$$

Effective Net Area

$$A_e := \left(\left(2 \cdot s_1 + 2 \cdot s\right) - 3 \cdot \left(d_b + \frac{1}{8}\ \textit{in}\right)\right) \cdot t_{pl}$$

$$A_e = 3.953\ \textit{in}^2$$

Nominal Strength
Tensile Yielding

$$R_{n_y} := A_g \cdot F_{y_s} = 200.88\ \textit{kip}$$

Nominal Strength
Tensile Rupture

$$R_{n_r} := F_{u_s} \cdot A_e = 198\ \textit{kip}$$

Design Strength

$$R_{n2} := min\left(R_{n_y}, R_{n_r}\right) = 197.6\ \textit{kip}$$

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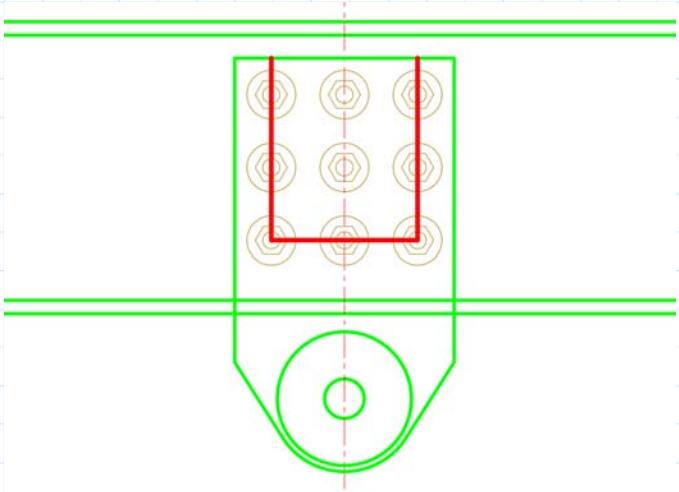
3. Block Shear of the Plate
J4.1

Situation 1



gross area subject to shear $A_{gv} := 2 \cdot (s_1 + 2 \cdot s) \cdot t_{pl}$

$A_{gv} = 9.3\ in^2$

net area subject to shear $A_{nv} := 2 \cdot \left((s_1 + 2 \cdot s) - 2.5 \cdot \left(d_b + \frac{1}{8}\ in \right) \right) \cdot t_{pl}$

$A_{nv} = 6.588\ in^2$

net area subject to tension $A_{nt} := \left(2 \cdot s - 2 \cdot \left(d_b + \frac{1}{8}\ in \right) \right) \cdot t_{pl}$

$A_{nt} = 2.635\ in^2$

uniform stress factor $U_{bs} := 1.0$

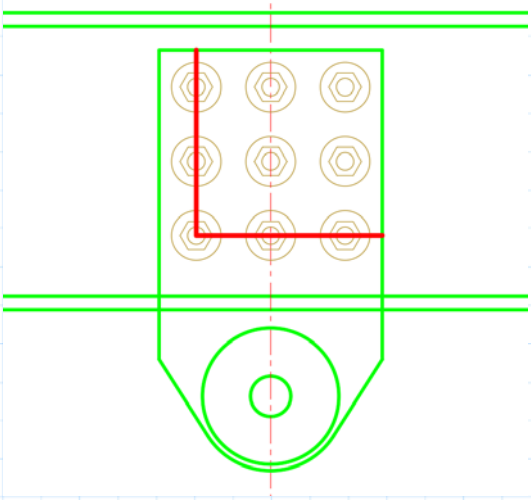
Nominal Strength

$$R_{n_1} := min\left(0.60 \cdot F_{u_s} \cdot A_{nv} + U_{bs} \cdot F_{u_s} \cdot A_{nt},\ 0.60 \cdot F_{y_s} \cdot A_{gv} + U_{bs} \cdot F_{u_s} \cdot A_{nt}\right)$$

$R_{n_1} = 329\ kip$

Created with PTC Mathcad Express. See www.mathcad.com for more information.

Situation 2



gross area subject to shear $A_{gv} := (s_1 + 2 \cdot s) \cdot t_{pl}$

$A_{gv} = 4.65\ in^2$

net area subject to shear $A_{nv} := \left((s_1 + 2 \cdot s) - 2.5 \cdot \left(d_b + \frac{1}{8}\ in\right)\right) \cdot t_{pl}$

$A_{nv} = 3.294\ in^2$

net area subject to tension $A_{nt} := \left((2 \cdot s + s_1) - 2.5 \cdot \left(d_b + \frac{1}{8}\ in\right)\right) \cdot t_{pl}$

$A_{nt} = 3.294\ in^2$

uniform stress factor $U_{bs} := 1.0$

Nominal Strength

$R_{n_2} := min\left(0.60 \cdot F_{u_s} \cdot A_{nv} + U_{bs} \cdot F_{u_s} \cdot A_{nt}, 0.60 \cdot F_{y_s} \cdot A_{gv} + U_{bs} \cdot F_{u_s} \cdot A_{nt}\right)$

$R_{n_2} = 264\ kip$

Bolock Shear Design Strength $R_{n3} := min\left(R_{n_1}, R_{n_2}\right) = 263.5\ kip$

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4. Failure Modes in Steel Bolts

number of bolts	$n_b := 9$
nominal unthreaded body area of bolt	$A_b := \frac{\pi \cdot d_b^{\,2}}{4} = 0.442\ \textit{in}^2$
nominal shear stress	$F_{nv} := 0.6 \cdot F_{u_b} = 42\ \textit{ksi}$
nominal strength of single bolt	$R_n := F_{nv} \cdot A_b = 18.555\ \textit{kip}$
Allowable Strength of entire bolt group	$R_{n4} := n_b \cdot R_n = 167.0\ \textit{kip}$

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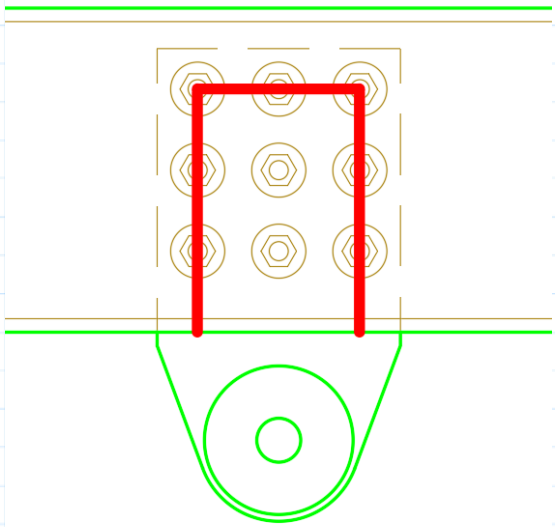
Failure Modes in Aluminum

5. Block Shear in Aluminum Member

C12x12.1 dimensions



flange width

$b_f := 3.292\ in$

flange thickness

$t_f := 0.502\ in$

web thickness

$t_w := 0.632\ in$

gross area in shear

$$A_{gv} := \left(\left(2 \cdot s + s_2\right) \cdot t_w + b_f \cdot t_f\right) \cdot 4 = 29.4\ in^2$$

net area in shear

$$A_{nv} := A_{gv} - 4 \cdot \left(2.5 \cdot \left(d_b + \frac{1}{8}\ in\right)\right) \cdot t_w = 23.8\ in^2$$

gross area in tension

$$A_{gt} := 2 \cdot \left(2 \cdot s \cdot t_w\right) = 7.584\ in^2$$

net area in tension

$$A_{nt} := A_{gt} - 2 \cdot \left(2 \cdot \left(d_b + \frac{1}{8}\ in\right) \cdot t_w\right) = 5.372\ in^2$$

allowable force

$$P_{sr} := \begin{cases} \left(\left(\frac{F_{y_a}}{\sqrt{3}}\right) \cdot A_{gv} + F_{u_a} \cdot A_{nt}\right) & \text{if } F_{u_a} \cdot A_{nt} \geq \left(0.6 \cdot F_{u_a}\right) \cdot A_{nv} \\ \left(\left(0.6 \cdot F_{u_a}\right) \cdot A_{nv} + F_{y_a} \cdot A_{gt}\right) & \text{else} \end{cases}$$

$R_{n5} := P_{sr} = 808.8\ kip$

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6. Bolt bearing in Aluminum Member

edge distance

bolt row #1 $d_{e1} := min\left(s_2, 1.5 \cdot d_b\right) = 1.125\ in$

bolt row #2 $d_{e2} := min\left(s - \frac{1}{2} \cdot \left(d_b + \frac{1}{8}\ in\right), 1.5 \cdot d_b\right)$

$d_{e2} = 1.125\ in$

bolt row #3 $d_{e3} := min\left(s - \frac{1}{2} \cdot \left(d_b + \frac{1}{8}\ in\right), 1.5 \cdot d_b\right)$

$d_{e3} = 1.125\ in$

Nominal Strength

Bolt Row #1

$$R_{n_1} := 2 \cdot \left(2 \cdot F_{u_a} \cdot t_w \cdot d_b\right) \cdot \left(\frac{d_{e1}}{2 \cdot d_b}\right) = 54\ kip$$

Bolt Row #2

$$R_{n_2} := 2 \cdot \left(2 \cdot F_{u_a} \cdot t_w \cdot d_b\right) \cdot \left(\frac{d_{e2}}{2 \cdot d_b}\right) = 54\ kip$$

Bolt Row #3

$$R_{n_3} := 2 \cdot \left(2 \cdot F_{u_a} \cdot t_w \cdot d_b\right) \cdot \left(\frac{d_{e3}}{2 \cdot d_b}\right) = 54\ kip$$

Design Strength

$$R_{n6} := 3 \cdot R_{n_1} + 3 \cdot R_{n_2} + 3 \cdot R_{n_3} = 486.3\ kip$$

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Summary of Failure Modes

1. Bearing Strength @ bolt holes (steel plate)	$R_{n1} = 502.2$ *kip*
2. Rupture (steel plate)	$R_{n2} = 197.6$ *kip*
3. Block shear (steel plate)	$R_{n3} = 263.5$ *kip*
4. Shear in bolts	$R_{n4} = 167.0$ *kip*
5. Block Shear (Aluminum Member)	$R_{n5} = 808.8$ *kip*
6. Bolt bearing (Aluminum Member)	$R_{n6} = 486.3$ *kip*

Governing Failure Mode

Safety Factor $\Omega := 10$

$gov =$ "4. Bolt Shear Strength"

$R_n := min\left(R_{n1}, R_{n2}, R_{n3}, R_{n4}, R_{n5}, R_{n6}\right) = 167.0$ *kip*

Design Load on Lug

$P := 13500$ *lbf*

Determination of Safety Factor

$\Omega_{actual} := \frac{R_n}{P} = 12.37$

if $\frac{R_n}{P} \geq 10.0$ "GOOD! :)"
else "NO GOOD :(" = "GOOD! :)"

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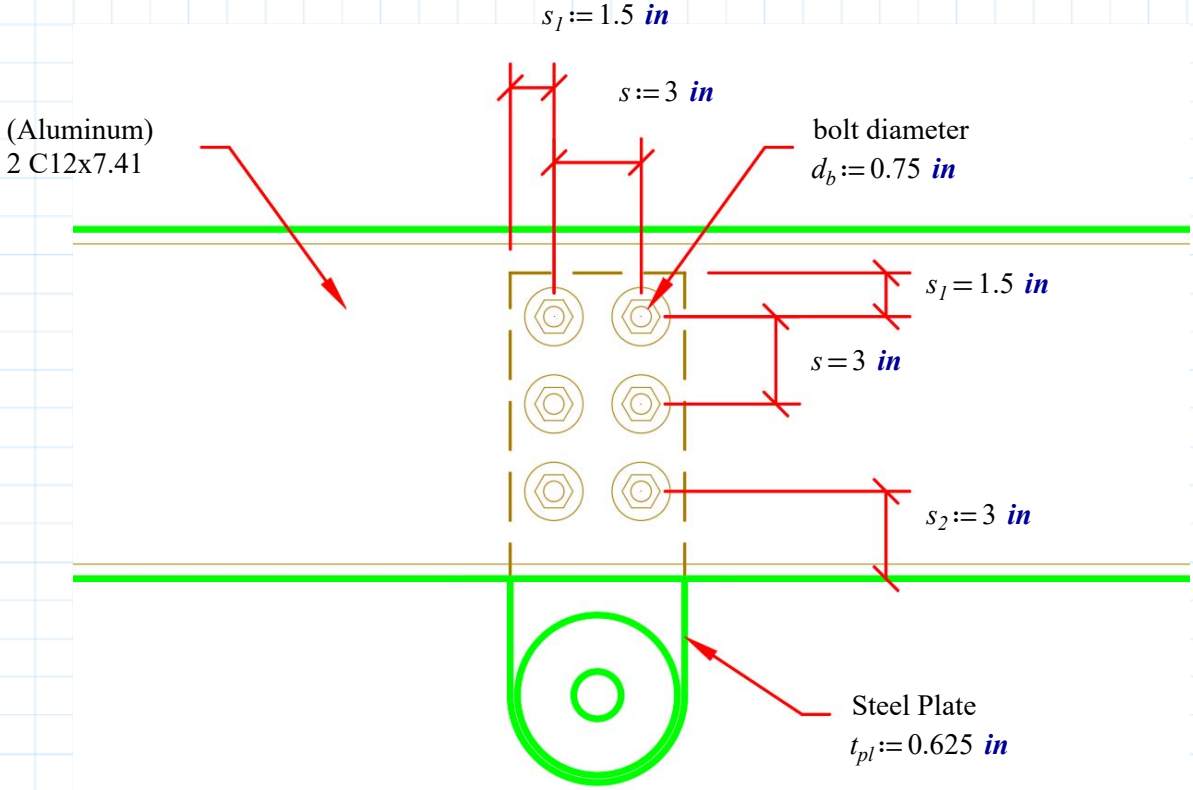
$s_1 := 1.5\ in$



Steel Bolts

ASTM A193 Grade B8

Tensile Stress

$F_{u_b} := 70\ ksi$

Yield Stress

$F_{y_b} := 30\ ksi$

Structural Steel

$F_{y_s} := 36\ ksi$

$F_{u_s} := 50\ ksi$

Aluminum

$F_{y_a} := 35\ ksi$

$F_{u_a} := 38\ ksi$

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Failure Modes in Steel Plate

1. Bearing Strength at Bolt Holes
J3.10

clear distance between the edge of the hole and the edge of the adjacent hole or edge of material

Bolt Row #1 $l_{c_1} := s_2 - \left(\frac{d_b + \frac{1}{8}\ in}{2} \right) = 2.563\ in$

Bolt Row #2 $l_{c_2} := s - \left(d_b + \frac{1}{8}\ in \right) = 2.125\ in$

Bolt Row #3 $l_{c_3} := s - \left(d_b + \frac{1}{8}\ in \right) = 2.125\ in$

Nominal Strength

Bolt Row #1

$R_{n_1} := min\left(1.2 \cdot l_{c_1} \cdot t_{pl} \cdot F_{u_s}, 2.4 \cdot d_b \cdot t_{pl} \cdot F_{u_s}\right)$

$R_{n_1} = 56.25\ kip$

Bolt Row #2

$R_{n_2} := min\left(1.2 \cdot l_{c_2} \cdot t_{pl} \cdot F_{u_s}, 2.4 \cdot d_b \cdot t_{pl} \cdot F_{u_s}\right)$

$R_{n_2} = 56.25\ kip$

Bolt Row #3

$R_{n_3} := min\left(1.2 \cdot l_{c_3} \cdot t_{pl} \cdot F_{u_s}, 2.4 \cdot d_b \cdot t_{pl} \cdot F_{u_s}\right)$

$R_{n_3} = 56.25\ kip$

Design Strength $R_{n1} := 2 \cdot R_{n_1} + 2 \cdot R_{n_2} + 2 \cdot R_{n_3} = 337.5\ kip$

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2. Rupture Strength of Plate
J4.1

Gross Area

$$A_g := \left(2 \cdot s_1 + 1 \cdot s\right) \cdot t_{pl} = 3.75\ \textit{in}^2$$

Effective Net Area

$$A_e := \left(\left(2 \cdot s_1 + 1 \cdot s\right) - 2 \cdot \left(d_b + \frac{1}{8}\ \textit{in}\right)\right) \cdot t_{pl}$$

$$A_e = 2.656\ \textit{in}^2$$

Nominal Strength
Tensile Yielding

$$R_{n_y} := A_g \cdot F_{y_s} = 135\ \textit{kip}$$

Nominal Strength
Tensile Rupture

$$R_{n_r} := F_{u_s} \cdot A_e = 133\ \textit{kip}$$

Design Strength

$$R_{n2} := min\left(R_{n_y}, R_{n_r}\right) = 132.8\ \textit{kip}$$

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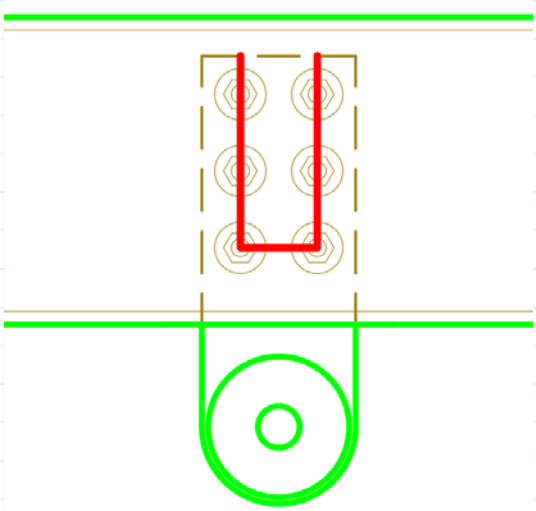
3. Block Shear of the Plate
J4.1

Situation 1



gross area subject to shear $A_{gv} := 2 \cdot (s_1 + 2 \cdot s) \cdot t_{pl}$

$A_{gv} = 9.375\ in^2$

net area subject to shear $A_{nv} := 2 \cdot \left((s_1 + 2 \cdot s) - 2.5 \cdot \left(d_b + \frac{1}{8}\ in \right) \right) \cdot t_{pl}$

$A_{nv} = 6.641\ in^2$

net area subject to tension $A_{nt} := \left(1 \cdot s - 1 \cdot \left(d_b + \frac{1}{8}\ in \right) \right) \cdot t_{pl}$

$A_{nt} = 1.328\ in^2$

uniform stress factor $U_{bs} := 1.0$

Nominal Strength

$R_{n_1} := min\left(0.60 \cdot F_{u_s} \cdot A_{nv} + U_{bs} \cdot F_{u_s} \cdot A_{nt}, 0.60 \cdot F_{y_s} \cdot A_{gv} + U_{bs} \cdot F_{u_s} \cdot A_{nt}\right)$

$R_{n_1} = 266\ kip$

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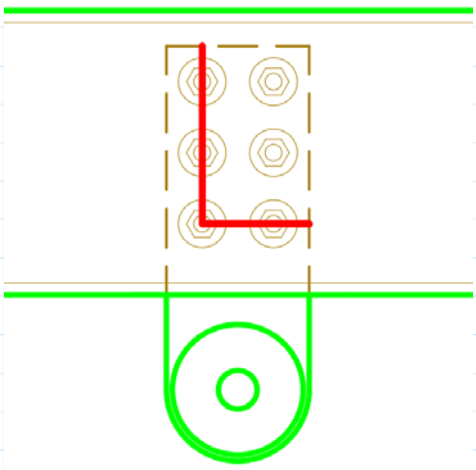
Situation 2



gross area subject to shear $A_{gv} := (s_1 + 2 \cdot s) \cdot t_{pl}$

$A_{gv} = 4.688\ in^2$

net area subject to shear $A_{nv} := \left((s_1 + 2 \cdot s) - 2.5 \cdot \left(d_b + \frac{1}{8}\ in\right)\right) \cdot t_{pl}$

$A_{nv} = 3.32\ in^2$

net area subject to tension $A_{nt} := \left((1 \cdot s + s_1) - 1.5 \cdot \left(d_b + \frac{1}{8}\ in\right)\right) \cdot t_{pl}$

$A_{nt} = 1.992\ in^2$

uniform stress factor $U_{bs} := 1.0$

Nominal Strength

$$R_{n_2} := min\left(0.60 \cdot F_{u_s} \cdot A_{nv} + U_{bs} \cdot F_{u_s} \cdot A_{nt},\ 0.60 \cdot F_{y_s} \cdot A_{gv} + U_{bs} \cdot F_{u_s} \cdot A_{nt}\right)$$

$R_{n_2} = 199\ kip$

Bolock Shear Design Strength $R_{n3} := min\left(R_{n_1}, R_{n_2}\right) = 199.2\ kip$

Created with PTC Mathcad Express. See www.mathcad.com for more information.

4. Failure Modes in Steel Bolts

number of bolts	$n_b := 6$
nominal unthreaded body area of bolt	$A_b := \frac{\pi \cdot d_b^{\,2}}{4} = 0.442\ \textit{in}^2$
nominal shear stress	$F_{nv} := 0.6 \cdot F_{u_b} = 42\ \textit{ksi}$
nominal strength of single bolt	$R_n := F_{nv} \cdot A_b = 18.555\ \textit{kip}$
Allowable Strength of entire bolt group	$R_{n4} := n_b \cdot R_n = 111.3\ \textit{kip}$

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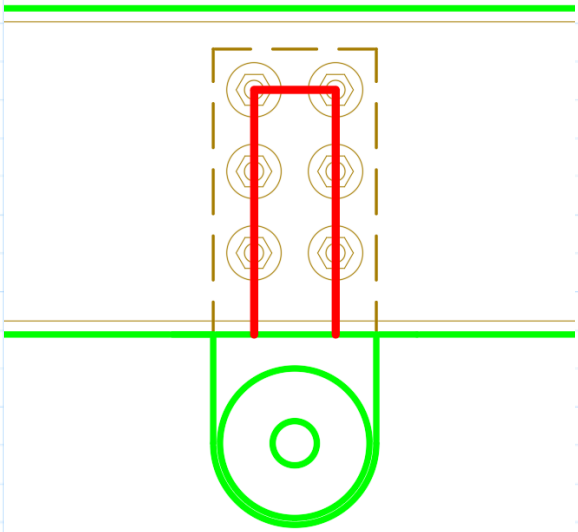
Failure Modes in Aluminum

5. Block Shear in Aluminum Member

C12x7.41 dimensions



flange width

$b_f := 2.960\ in$

flange thickness

$t_f := 0.502\ in$

web thickness

$t_w := 0.300\ in$

gross area in shear

$$A_{gv} := \left(\left(2 \cdot s + s_2\right) \cdot t_w + b_f \cdot t_f\right) \cdot 4 = 16.7\ in^2$$

net area in shear

$$A_{nv} := A_{gv} - 4 \cdot \left(2.5 \cdot \left(d_b + \frac{1}{8}\ in\right)\right) \cdot t_w = 14.1\ in^2$$

gross area in tension

$$A_{gt} := 2 \cdot \left(2 \cdot s \cdot t_w\right) = 3.6\ in^2$$

net area in tension

$$A_{nt} := A_{gt} - 2 \cdot \left(1 \cdot \left(d_b + \frac{1}{8}\ in\right) \cdot t_w\right) = 3.075\ in^2$$

allowable force

$$P_{sr} := \begin{cases} \left(\left(\frac{F_{y_a}}{\sqrt{3}}\right) \cdot A_{gv} + F_{u_a} \cdot A_{nt}\right) & \text{if } F_{u_a} \cdot A_{nt} \geq \left(0.6 \cdot F_{u_a}\right) \cdot A_{nv} \\ \left(\left(0.6 \cdot F_{u_a}\right) \cdot A_{nv} + F_{y_a} \cdot A_{gt}\right) & \text{else} \end{cases}$$

$R_{n5} := P_{sr} = 447.9\ kip$

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6. Bolt bearing in Aluminum Member

edge distance

bolt row #1 $d_{e1} := min\left(s_2, 1.5 \cdot d_b\right) = 1.125\ in$

bolt row #2 $d_{e2} := min\left(s - \frac{1}{2} \cdot \left(d_b + \frac{1}{8}\ in\right), 1.5 \cdot d_b\right)$

$d_{e2} = 1.125\ in$

bolt row #3 $d_{e3} := min\left(s - \frac{1}{2} \cdot \left(d_b + \frac{1}{8}\ in\right), 1.5 \cdot d_b\right)$

$d_{e3} = 1.125\ in$

Nominal Strength

Bolt Row #1

$$R_{n_1} := 2 \cdot \left(2 \cdot F_{u_a} \cdot t_w \cdot d_b\right) \cdot \left(\frac{d_{e1}}{2 \cdot d_b}\right) = 25.7\ kip$$

Bolt Row #2

$$R_{n_2} := 2 \cdot \left(2 \cdot F_{u_a} \cdot t_w \cdot d_b\right) \cdot \left(\frac{d_{e2}}{2 \cdot d_b}\right) = 25.7\ kip$$

Bolt Row #3

$$R_{n_3} := 2 \cdot \left(2 \cdot F_{u_a} \cdot t_w \cdot d_b\right) \cdot \left(\frac{d_{e3}}{2 \cdot d_b}\right) = 25.7\ kip$$

Design Strength

$$R_{n6} := 2 \cdot R_{n_1} + 2 \cdot R_{n_2} + 2 \cdot R_{n_3} = 153.9\ kip$$

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Summary of Failure Modes

1. Bearing Strength @ bolt holes (steel plate)	$R_{n1} = 337.5$ *kip*
2. Rupture (steel plate)	$R_{n2} = 132.8$ *kip*
3. Block shear (steel plate)	$R_{n3} = 199.2$ *kip*
4. Shear in bolts	$R_{n4} = 111.3$ *kip*
5. Block Shear (Aluminum Member)	$R_{n5} = 447.9$ *kip*
6. Bolt bearing (Aluminum Member)	$R_{n6} = 153.9$ *kip*

Governing Failure Mode

Safety Factor $\Omega := 10$

$gov =$ "4. Bolt Shear Strength"

$R_n := min\left(R_{n1}, R_{n2}, R_{n3}, R_{n4}, R_{n5}, R_{n6}\right) = 111.3$ *kip*

$R_n := \frac{R_n}{\Omega} = 11.133$ *kip*

Design Load on Lug

$P := \frac{13500}{2}$ *lbf* $= 6750$ *lbf*

Comparison of Demand to Capacity

$\frac{P}{R_n} = 0.606$

if $P \le R_n$ = "GOOD! :)"
  "GOOD! :)"
else
  "NO GOOD :("

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FRONTIER-KEMPER CONSTRUCTORS, INC.
A TutorPerini Company

FERMI NATIONAL ACCELERATOR LABORATORY

Long Baseline Neutrino Facility

Project #: 1800
Work Order #: 8018-195

PRELIMINARY

Ross Cage Structural Design Calculations - ADDENDUM

Date: August 28, 2019
Revision: A

Prepared By:
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Checked By:
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FKCI Civil/Structural Engineering Manager

1 DESIGN SUMMARY/PURPOSE/OVERVIEW

1.1 PURPOSE OF DOCUMENT

This document summarizes the calculations made for the Maintenance Deck Platforms. This is a supplemental structure that is attached to the Main Ross Cage only during maintenance activities. It is *not* considered part of the permanent structure

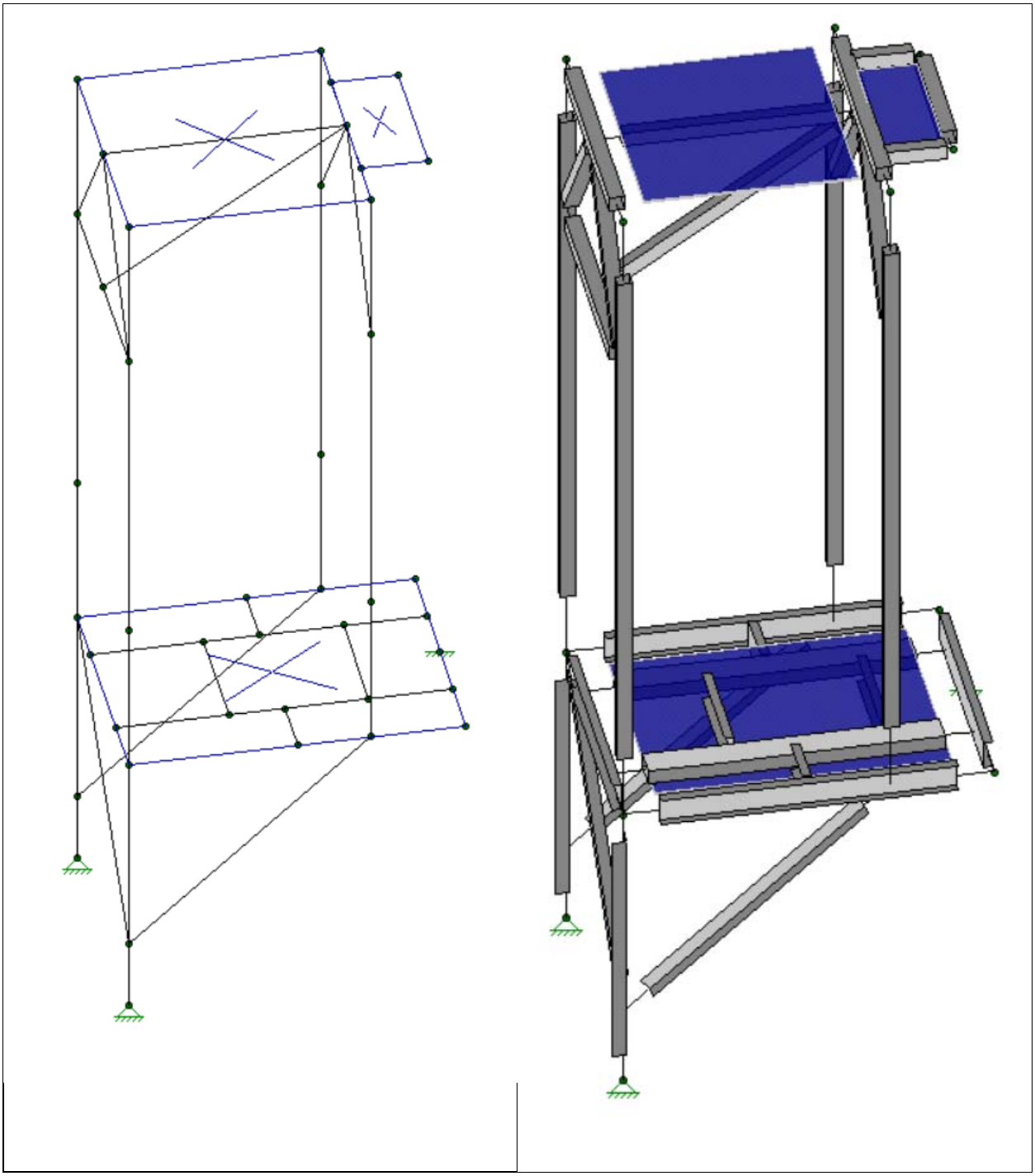
2 DESIGN CRITERIA/REFERENCE INFORMATION

2.1 DESIGN CODES

International Building Code	IBC-2015
Minimum Design Loads for Buildings and Other Structures,	ASCE 7-10
Design Loads on Structures during Construction,	ASCE 37-14
Building Code Requirements for Structural Concrete,	ACI 318-11
Specifications for Structural Steel Buildings,	AISC 360-10
Specifications for Aluminum Structures	AA SAS30-10
Mine Safety and Health Administration Standards & Regulations	MSHA CFR Title 30

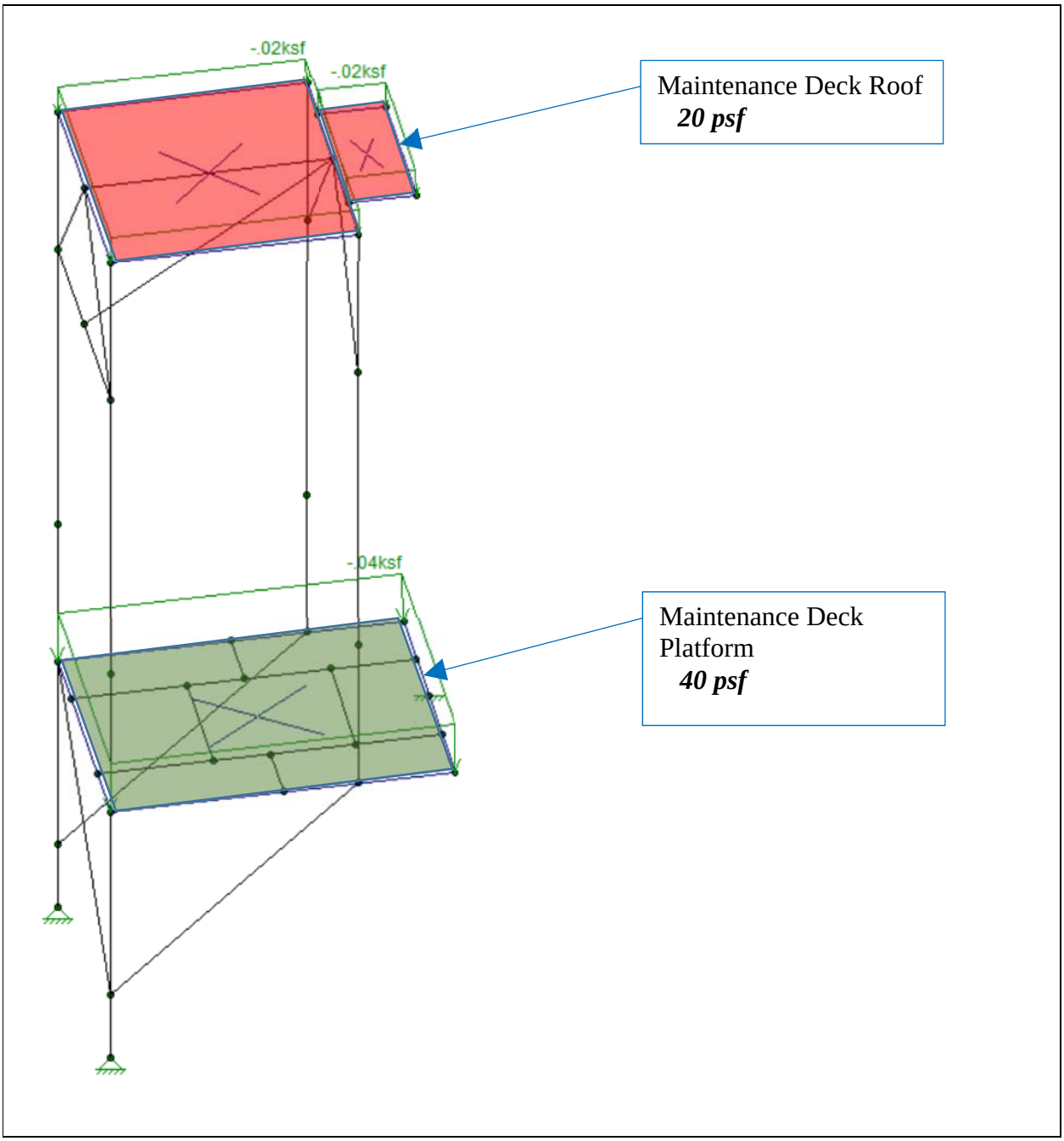
2.2 DESIGN LOADS

Dead Loads

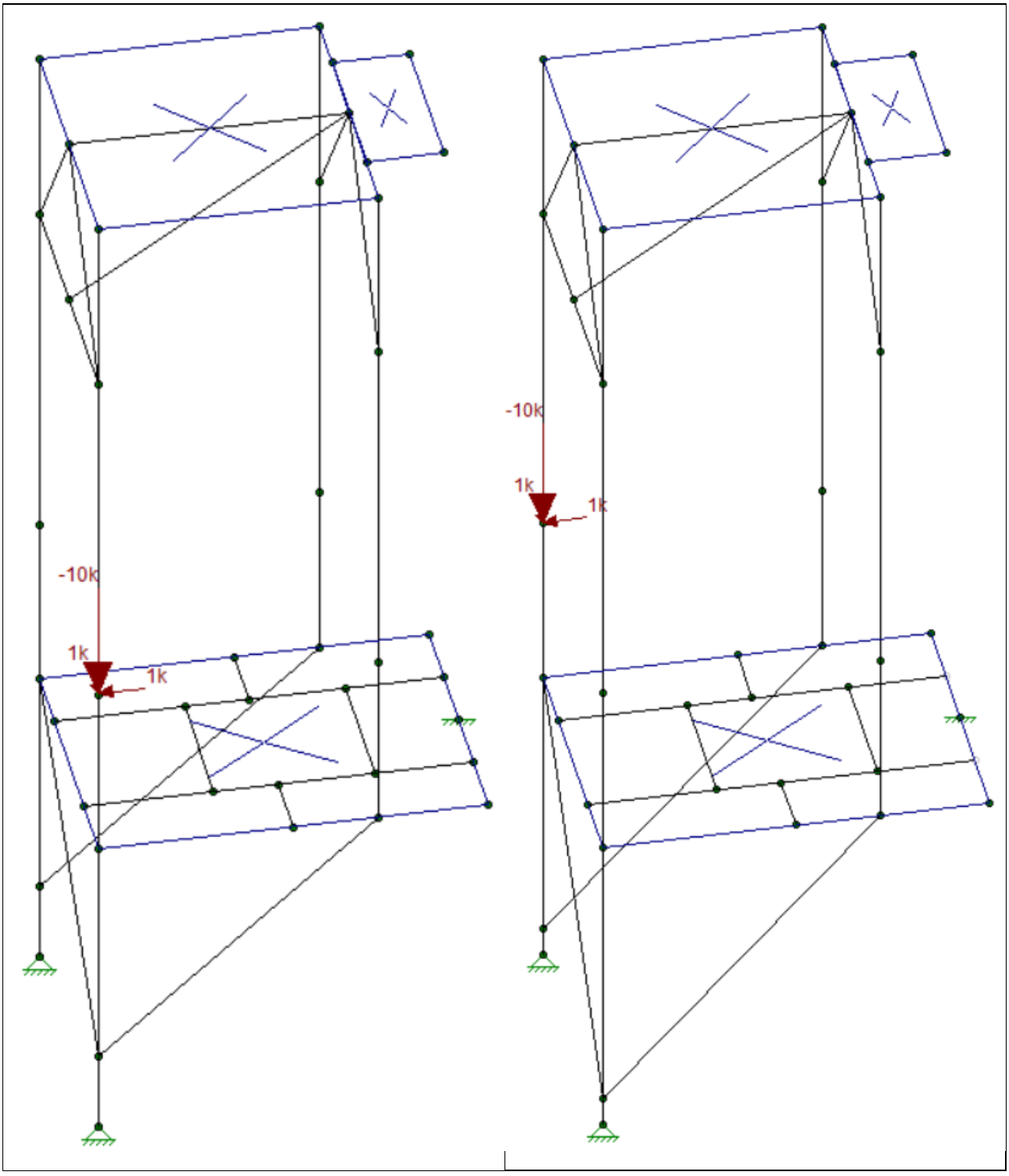


Dead Loads for the structure consist solely of the self-weight of the steel materials (HSS, Angles, Channels, Plates, Etc.) that make up the structure. Note that since the structure is symmetric, only 1 side of the structure is modelled.

Live Loads – Platform



Live Loads – Personnel Tie-off Points



There are (2) tie-off points on each corner post, 8 total. We consider the case where (2) tie-off points on a single post are used simultaneously. Each tie-off point supports 5000 lbs (vertical load) and 500 lbs (horizontal in both axis).

Soil Loads

N/A

Snow Loads

N/A

Rain Loads

N/A

Ice Loads

N/A

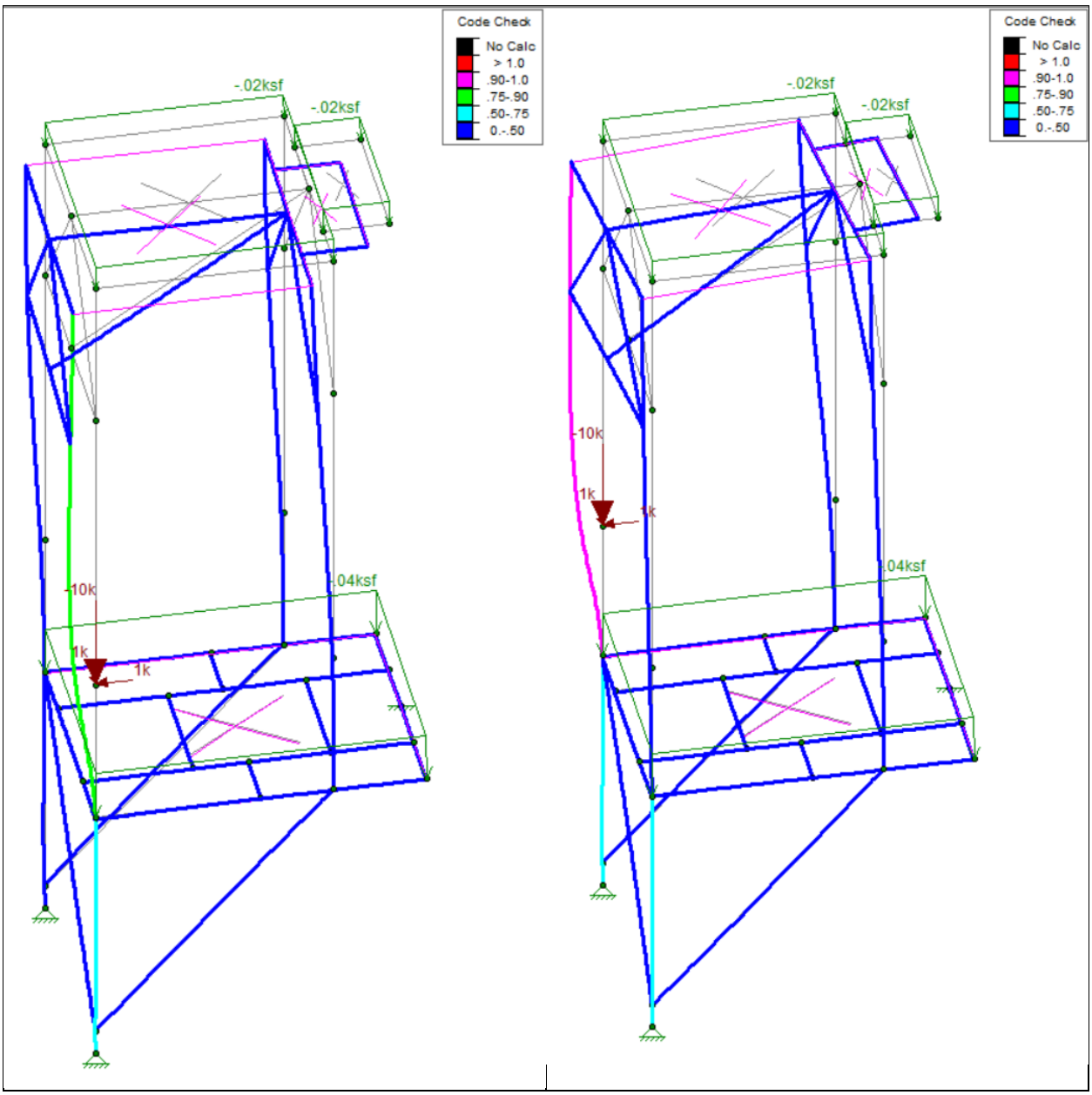
Seismic Loads

N/A

Wind Loads

N/A

3 CALCULATIONS/STRUCTURAL MODEL



Results of the Calculations are shown here for the two tie-off point situations. “Code Check” refers to the ratio of a member’s demand to capacity. A ratio less than 1.0 is good.

4 CONCLUSIONS

A structural model was created to analyze the Maintenance Deck structure. This is a supplemental structure attached to the main Ross Cage during maintenance activities.

Unlike the main cage (which is composed of mainly aluminum), the maintenance deck is composed of structural steel rolled shapes. It is bolted into the main deck at the 4 corners, as well as the middle over the main cage transom beam.

The structural model accounts for the dead load of the major structural materials used. It also accounts for a blanket live load over both the work deck below and the roof deck above. Additionally, it accounts for personnel tie-off points on each of the corner posts.

The structural analysis showed the members are adequate for the expected loads.