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Big Canoe® POA

LAKE PETIT DAM

Pickens County, Georgia

State ID No. 112-009-00462

NID No. GA00685

Low-Level Outlet Repair

Revision 0

Prepared for:

Big Canoe® Property Owners Association, Inc.
10586 Big Canoe
Jasper, GA 30143

Prepared by:

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Project No: GST8061

Document No: GA240256

July 2024

NATHAN PETER HOLMER

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STATE OF GEORGIA PROFESSIONAL ENGINEER LICENSE NO PE049663 EXP. 12/31/24

July 25, 2024

APPROVED
STATE OF GEORGIA
DEPT OF NATURAL RESOURCES
AUG 13 2024
Environmental Protection Division
Safe Dams Program

Geosyntec
consultants

CALCULATION PACKAGE COVER SHEET

Client: Big Canoe Property Owners Association **Project:** LLO Outlet Repair

Project No.: GST8061 **Task #:** 04/03

TITLE OF COMPUTATION Low-Level Outlet Repair

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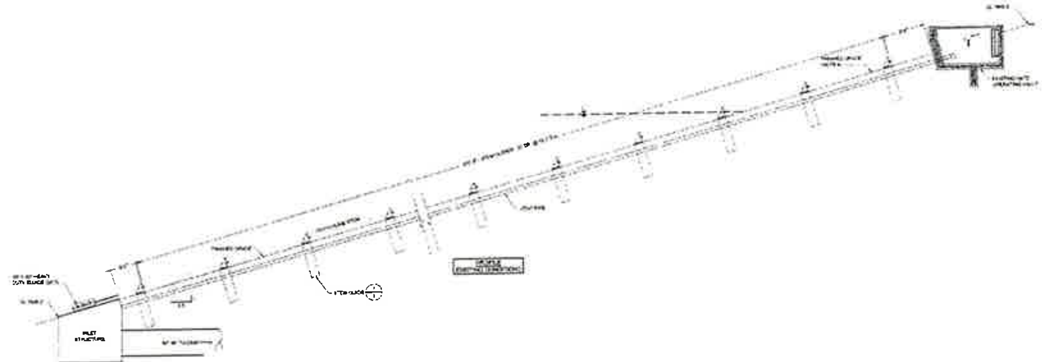
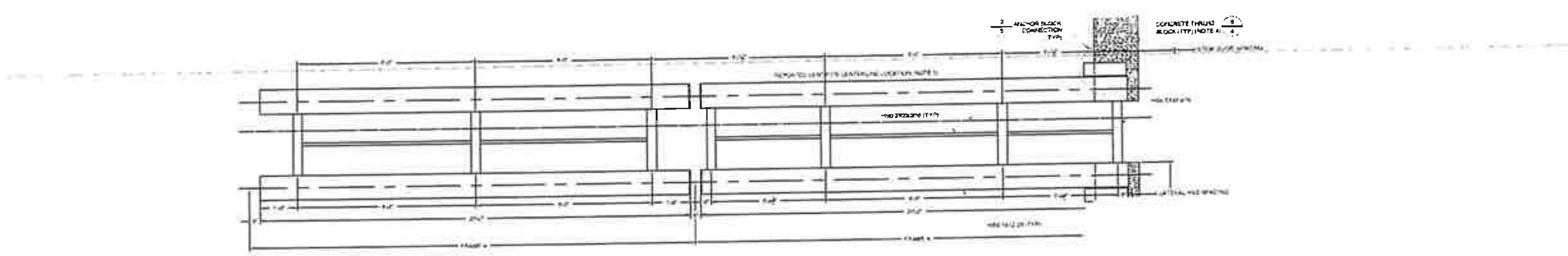
Gate Force Analysis and Guide Frame Member Sizing

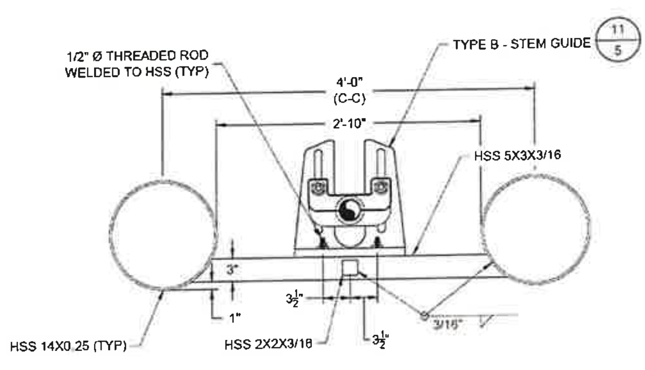
REFERENCES:
- *AISC Steel Construction Manual 15 Ed.*
- *HILTI North American Product Technical Guide Vol 2*

The Low Level Outlet (LLO) gate operating system will be replaced with a new stem, stem guides, and steel frame to support the stem guides. The steel frame will be composed of modular sections that are linked together and anchored near the top of the slope. This calculation package evaluates the force requried to operate the gate and the force effects on the proposed guide frame assembly.





FRAME PLAN VIEW



TYPICAL SECTION

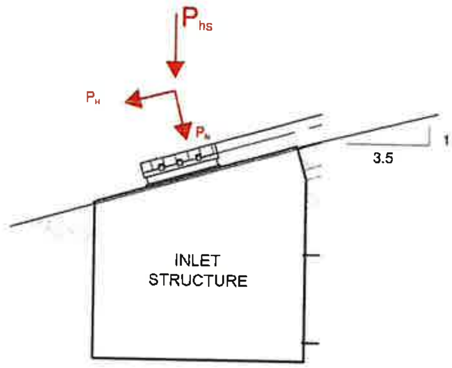
12/5 DETAIL
FRAME SECTION
SCALE N.T.S

Geosyntec consultants

Project Name: Lake Petit LLO Gate
Project Number: GST8061

Prepared By: NPH 5/20/24
Checked By: RLP 5/24/24

Hydrostatic Force



$h_s := 100\ ft$ — Depth of water over gate

$\gamma_w := 62.4\ pcf$ — Density of water

$Q_{hs} := h_s \cdot \gamma_w = 6.24\ ksf$ — Hydrostatic Pressure

$b_{gate} := 2.833\ ft$ — Width of Gate

$l_{gate} := 2.5\ ft$ — Length of Gate

$A_{gate} := b_{gate} \cdot l_{gate} = 7.083\ ft^2$ — Area of Gate

$P_{hs} := A_{gate} \cdot Q_{hs} = 44.195\ kip$ — Total Hydrostatic Load on Gate

$\theta_{gate} := \operatorname{atan}\left(\frac{1}{3.5}\right) = 15.945\ °$ — (Slope 3.5:1 H:V)

$P_N := \cos\left(\theta_{gate}\right) \cdot P_{hs} = 42.494\ kip$ — Force Normal to Plane of Gate Support

$P_H := \sin\left(\theta_{gate}\right) \cdot P_{hs} = 12.141\ kip$ — Force Parallel to plane of Gate Support

Reduction Factors

$\phi_c := 0.9$ $\phi_{ty} := 0.9$ $\phi_{tr} := 0.75$ — Reduction Factors for Steel under Compression, tension yielding, and tension rupture

Opening Force

$\mu_s := 0.4$ — Conservative (per Hydrogate representative, existing/historical gates and new gates have a coefficient of static friction of approximately 0.35)

$F_{n\_open} := P_H + \mu_s \cdot P_N = 29.139\ kip$

Closing Force

$$F_{n\_close} := \mu_s \cdot P_N - P_H = 4.856\ kip$$

Stem Guide Design

$F_y := 36\ ksi$ $F_u := 58\ ksi$ $E := 29000\ ksi$

Compression Design (Closing Operation)

$K := 1.0$ Assume Pinned at Stem Guides

$L_b := 8.25\ ft$ unbraced length of stem = spacing between stem guides

$D_{stem} := 2.5\ in$ Diameter of the stem

$t_{corr} := 0\ in$ Stem will be stainless steel, therefore corrosion is set to 0.

$$d_{stem} := D_{stem} - 2 \cdot t_{corr}$$

$$A_{stem} := \frac{\pi \cdot d_{stem}^{2}}{4} = 4.909\ in^2$$ Area of the stem

$L_{stem} := 378\ ft$ Length of Stem

$$V_{stem} := A_{stem} \cdot L_{stem} = 12.885\ ft^3$$

$$I_{stem} := \frac{\pi \cdot d_{stem}^{4}}{64} = 1.917\ in^4$$

$$W_{stem} := 1.05 \cdot V_{stem} \cdot 490\ pcf = 6.63\ kip$$

$$Z_{stem} := \frac{\pi \cdot d_{stem}^{3}}{32} = 1.534\ in^3$$

$$w_{bar} := \frac{W_{stem}}{L_{stem}} = 17.539\ plf$$

$$r_{stem} := \frac{d_{stem}}{4} = 0.625\ in$$

$$\frac{L_b}{r_{stem}} = 158.4$$ Slenderness Ratio (<200)

$$F_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_b}{r_{stem}}\right)^2} = 11.407\ ksi$$ (AISC E3-4)

$$F_{cr} := \text{if } \frac{K \cdot L_b}{r_{stem}} \le 4.71 \cdot \sqrt{\frac{E}{F_y}} \;\; \| \; 0.658^{\left(\frac{F_y}{F_e}\right)} \cdot F_y \;\; \text{else} \;\; \| \; 0.877 \cdot F_e \quad = 10.004 \; ksi$$

(AISC E3-2, E3-3)

$$\phi_c \cdot F_{cr} \cdot A_{stem} = 44.198 \; kip$$

(AISC E3-1)

$$FOS_{hs\_bar\_comp} := 3$$

Factor of Safety for Bar in Compression

$$Str\_Check\_Comp := \text{if } \frac{\phi_c \cdot F_{cr} \cdot A_{stem}}{F_{n\_close}} > FOS_{hs\_bar\_comp} \;\; \| \; \text{"OK"} \;\; \text{else} \;\; \| \; \text{"Increase Bar Diameter"} \quad = \text{"OK"}$$

$$\frac{\phi_c \cdot F_{cr} \cdot A_{stem}}{F_{n\_close}} = 9.101$$

Tension Design (Opening Operation)

$$T_c := min\left(\phi_{ty} \cdot F_y, \phi_{tr} \cdot F_u\right) \cdot A_{stem} = 159.043 \; kip$$

(AISC D2-1, D2-2)

$$FOS_{hs\_bar\_ten} := 5.0$$

$$Str\_Check\_Ten := \text{if } \frac{T_c}{F_{n\_open}} > FOS_{hs\_bar\_ten} \;\; \| \; \text{"OK"} \;\; \text{else} \;\; \| \; \text{"Increase Bar Size"} \quad = \text{"OK"}$$

$$\frac{T_c}{F_{n\_open}} = 5.458$$

Stem Guide Load

$$\mu_{guide} := 0.4$$

Friction between stem and guide bushing (Conservative value - Recommended value by Hydrogate was less than 0.2 for lubricated steel on bronze bushing)

$$F_{guide\_close} := \left(\frac{W_{stem}}{No_{guide}}\right) \cdot \mu_{guide} = 0.058 \; kip$$

$$No_{guide} := \text{ceil}\left(\frac{L_{stem}}{L_b}\right) = 46$$

$$F_{guide\_open} := \left(\frac{W_{stem}}{No_{guide}}\right) \cdot \mu_{guide} = 0.058\ \textbf{kip}$$

Guide assemblies are oversized to allow for free movement of the stem, therefore there is no transfer of the opening/closing force through friction to the guide assemblies.

Frame Load

$\mu_{frame\_soil} := 0.2$ Steel on Silty Soil

$L_{frame} := 20\ \textbf{ft}$ Length of Frame

$b_{frame} := 4\ \textbf{ft}$ Width of Frame (C-C Pontoon)

Approximate Frame Weight/ft

$w_{pontoon} := 36.75\ \textbf{plf}$ Weight of HSS 14x0.25 (round)

$w_{bot\_hss} := 4.32\ \textbf{plf}$ Weight of HSS 2x2x3/16 (tube)

$w_{bot\_hss\_lat} := 9.42\ \textbf{plf}$ Weight of HSS 5x3x3/16 (tube)

$w_{bar} = 17.539\ \textbf{plf}$ Weight of 2.5" Dia. stem

$$W_{frame} := 1.1 \cdot \left(2 \cdot w_{pontoon} + w_{bot\_hss} + w_{bar} + \left(w_{bot\_hss\_lat} \cdot \frac{b_{frame}}{L_b}\right)\right) = 109.918\ \textbf{plf}$$

Average weight of frame per foot

$Slide_{frame} := W_{frame} \cdot \sin(\theta_{gate}) = 30.197\ \textbf{plf}$ Frame Force acting downslope

$Normal_{frame} := W_{frame} \cdot \cos(\theta_{gate}) = 105.689\ \textbf{plf}$ Frame Normal Force

$Friction_{frame} := Normal_{frame} \cdot \mu_{frame\_soil} = 21.138\ \textbf{plf}$ Frame Friction Resistance Force

$$Static\_Stability_{Frame} := \begin{array}{l} \text{if } \dfrac{Normal_{frame} \cdot \mu_{frame\_soil}}{Slide_{frame}} > 1.5 \\ \quad \text{“Okay”} \\ \text{else} \\ \quad \text{“Support Frames at Anchor”} \end{array} = \text{“Support Frames at Anchor”}$$

Due to the slope and poor friction between the steel frame and silty soils, the frames are not self stable, therefore they must be anchored. Full load will transfered through modular frame connections.

Frame Stability Load at Frame Bolt Connection

$$F_{H\_bolt\_frame} := L_{frame} \cdot \left(Slide_{frame} - Friction_{frame}\right) = 181.181\ \boldsymbol{lbf}$$

Total Frame Stability Load Required at Anchors

$$F_{H\_anchor\_frame} := 1.5 \cdot \left(Slide_{frame} - Friction_{frame}\right) \cdot L_{stem} = 5.136\ \boldsymbol{kip}$$

Maximum Frame Loads (reactions opposite of stem, ie; frame is in tension when the stem is in compression)

$No_{frame} := 18$

$$F_{total\_ten\_frame} := F_{H\_bolt\_frame} \cdot No_{frame} + F_{guide\_close} \cdot No_{guide} = 5.913\ \boldsymbol{kip}$$

$$F_{total\_comp\_frame} := F_{guide\_open} \cdot No_{guide} - F_{H\_bolt\_frame} \cdot No_{frame} = -0.609\ \boldsymbol{kip}$$

(No Compression load - Frame remains in tension during Opening Operations)

$F_{total\_ten\_frame}$ represents the maximum force at the last modular frame connection

<u>Evaluate frame members and connections under Design Tension Load</u>

By inspection, frame is sufficient under tension loading while the gate is being closed;
$F_{total\_ten\_frame} = 5.913\ \boldsymbol{kip}$, $\dfrac{Pn}{\Omega} = 220\ \boldsymbol{kips}$ for HSS 14x0.25 (AISC Table 5-6)

Each frame is connected by four (4) 1/2" Dia. A325 Bolts.

$F_{nv} := 68\ \boldsymbol{ksi}$ — Nominal Shear Strength of A325 Bolt (AISC T J3.2)

$d_b := 0.5\ \boldsymbol{in}$ $\qquad d_{hole} := \dfrac{9}{16}\ \boldsymbol{in}$

$A_b := \pi \cdot \dfrac{{d_b}^2}{4}$

$R_{n\_bolt} := F_{nv} \cdot A_b = 13.352\ \boldsymbol{kip}$ $\qquad \Omega := 2$ — (AISC J3-1)

$l_c := 3\ \boldsymbol{in} - \dfrac{d_{hole}}{2}$ — Edge distance of bolt

$t_{plate} := 0.25\ \boldsymbol{in}$ — Connection plate thickness

$\boxed{F_u} := 58\ \boldsymbol{ksi}$ — Tensile Strength of A36

$R_{n\_plate} := min\left(1.2 \cdot l_c \cdot t_{plate} \cdot F_u, 2.4 \cdot d_b \cdot t_{plate} \cdot F_u\right) = 17.4\ \boldsymbol{kip}$ — (AISC J3-6a)

$$R_a := \frac{min\left(R_{n\_bolt}, R_{n\_plate}\right)}{\Omega} = 6.676\ kip$$

Capacity of one bolt is greater than the demand. By inspection the 4 bolt connection with 1/4 inch plates is sufficient.

Check welded connections

$D := 3$ Number of 16ths of an inch for weld size

$$R_{a\_weld\_inch} := 0.928 \cdot D \cdot 1\ in \cdot \left(\frac{kip}{in}\right) = 2.784\ kip$$ (AISC 8-2b)

3/16 inch welded connections are okay by inspection. Maximum Force per guide assembly is less than 100 pounds.

Thrust Block Connection

$No\_anchors := 8$ $R_u := 1.2 \cdot \frac{F_{total\_ten\_frame}}{No\_anchors} = 0.887\ kip$

Threaded Rod Strength Design (per HILTI) Assuming cracked concrete (CONSERVATIVE)

Table 41 — Steel design strength for Hilti HAS threaded rods for use with ACI 318 Chapter 17

Nominal anchor diameter in.	HAS-V-36 / HAS-V-36 HDG [illegible]			HAS-E-55 / HAS-E-55 HDG ASTM F1554 Gr. 55			HAS-B 105 and HAS B 105 HDG ASTM A193 B7 and ASTM F 1554 Gr.105			HAS R stainless steel ASTM F593 (3/8-in to 1-in) ASTM A193 (1-1/8 in to 2-in)		
	Tensile ΦN_{sa} lb (kN)	Shear ΦV_{sa} lb (kN)	Seismic Shear $\Phi V_{sa,eq}$ lb (kN)	Tensile ΦN_{sa} lb (kN)	Shear ΦV_{sa} lb (kN)	Seismic Shear $\Phi V_{sa,eq}$ lb (kN)	Tensile ΦN_{sa} lb (kN)	Shear ΦV_{sa} lb (kN)	Seismic Shear $\Phi V_{sa,eq}$ lb (kN)	Tensile ΦN_{sa} lb (kN)	Shear ΦV_{sa} lb (kN)	Seismic Shear $\Phi V_{sa,eq}$ lb (kN)
3/8	3,370 (15.0)	1,750 (7.8)	1,050 (4.7)	4,360 (19.4)	2,270 (10.1)	1,590 (7.1)	7,270 (32.3)	3,780 (16.8)	2,645 (11.8)	5,040 (22.4)	2,790 (12.4)	1,955 (8.7)
[illegible]	6,175 (27.5)	[illegible] (14.3)	1,925 (8.6)	7,985 (35.5)	4,150 (18.5)	2,905 (12.9)	13,305 (59.2)	6,920 (30.8)	4,845 (21.6)	9,225 (41.0)	5,110 (22.7)	3,575 (15.9)

Table 40 — Hilti HIT-HY 200 V3 adhesive design strength with concrete / bond failure for threaded rod in cracked concrete [1,2,3,4,5,6,7,8,9]

Nominal anchor diameter in.	Effective embedment in. (mm)	Tension — ΦN_n				Shear — ΦV_n			
		f'_c = 2,500 psi (17.2 MPa) lb (kN)	f'_c = 3,000 psi (20.7 MPa) lb (kN)	f'_c = 4,000 psi (27.6 MPa) lb (kN)	f'_c = 6,000 psi (41.4 MPa) lb (kN)	f'_c = 2,500 psi (17.2 MPa) lb (kN)	f'_c = 3,000 psi (20.7 MPa) lb (kN)	[illegible] (27.6 MPa) lb (kN)	f'_c = 6,000 psi (41.4 MPa) lb (kN)
3/8	2-3/8 (60)	1,900 (8.5)	1,935 (8.6)	1,990 (8.9)	2,075 (9.2)	2,045 (9.1)	2,085 (9.3)	2,145 (9.5)	2,235 (9.9)
	3-3/8 (86)	2,700 (12.0)	2,750 (12.2)	2,830 (12.6)	2,950 (13.1)	5,815 (25.9)	5,925 (26.4)	6,095 (27.1)	6,350 (28.2)
	4-1/2 (114)	3,600 (16.0)	3,665 (16.3)	3,775 (16.8)	3,930 (17.5)	7,755 (34.5)	7,900 (35.1)	8,130 (36.2)	8,465 (37.7)
	7-1/2 (191)	6,000 (26.7)	6,110 (27.2)	6,290 (28.0)	6,550 (29.1)	12,925 (57.5)	13,165 (58.6)	13,550 (60.3)	14,110 (62.8)
[illegible]	2-3/4 (70)	2,520 (11.2)	2,760 (12.3)	3,185 (14.2)	3,480 (15.5)	5,425 (24.1)	5,945 (26.4)	6,865 (30.5)	7,490 (33.3)
	4-1/2 (114)	5,215 (23.2)	5,310 (23.6)	5,465 (24.3)	5,690 (25.3)	11,230 (50.0)	11,440 (50.9)	11,770 (52.4)	12,260 (54.5)
	6 (152)	6,955 (30.9)	7,080 (31.5)	7,290 (32.4)	7,590 (33.8)	14,975 (66.6)	15,250 (67.8)	[illegible] (69.8)	16,345 (72.7)
	10 (254)	11,590 (51.6)	11,800 (52.5)	12,145 (54.0)	12,650 (56.3)	24,960 (111.0)	25,420 (113.1)	26,160 (116.4)	27,245 (121.2)

Table 45 — Load adjustment factors for 1/2-in. diameter threaded rods in cracked concrete[1,2,3]

1/2-in. threaded rods cracked concrete		Spacing factor in tension f_{AN}				Edge distance factor in tension f_{RN}				Spacing factor in shear[4] f_{AV}				Edge distance in shear ⊥ Toward edge f_{RV}				Edge distance in shear ∥ To and away from edge f_{RV}				Concrete thickness factor in shear[4] f_{HV}			
Embedment h_{ef}	in. (mm)	2-3/4 (70)	4-1/2 (114)	6 (152)	10 (254)	2-3/4 (70)	4-1/2 (114)	6 (152)	10 (254)	2-3/4 (70)	4-1/2 (114)	[illegible] (152)	10 (254)	2-3/4 (70)	4-1/2 (114)	[illegible] (152)	10 (254)	2-3/4 (70)	4-1/2 (114)	6 (152)	10 (254)	2-3/4 (70)	4-1/2 (114)	6 (152)	10 (254)
Concrete thickness (h), - in. (mm): 1-3/4	(44)	n/a	n/a	n/a	n/a	0.48	0.48	0.45	0.41	n/a	n/a	n/a	n/a	0.10	0.05	0.04	0.02	0.21	0.11	0.06	0.05	n/a	n/a	n/a	n/a
2-1/2	(64)	0.58	0.58	0.57	0.54	0.54	0.54	0.50	0.44	0.55	0.53	0.53	0.52	0.18	0.09	0.07	0.04	0.35	0.19	0.14	0.08	n/a	n/a	n/a	n/a
3	(76)	0.60	0.60	0.58	0.55	0.58	0.58	0.53	0.46	0.56	0.54	[illegible]	0.52	0.23	0.12	0.09	0.06	0.47	0.25	0.18	0.11	n/a	n/a	n/a	n/a
4	(102)	0.63	0.63	0.61	0.57	0.66	0.66	0.60	0.49	0.58	0.55	0.55	0.53	0.36	0.19	[illegible]	0.09	0.66	0.38	0.28	0.17	0.58	n/a	n/a	n/a
5	(127)	0.67	0.67	0.64	0.58	0.76	0.76	0.67	0.53	0.61	0.57	0.56	0.54	0.50	0.26	0.20	0.12	0.76	0.53	0.40	0.24	0.65	n/a	n/a	n/a
5-3/4	(146)	0.69	0.69	0.66	0.60	0.83	0.83	0.73	0.56	0.62	0.58	0.57	0.55	0.62	0.33	0.24	0.15	0.83	0.65	0.49	0.20	0.70	0.56	n/a	n/a
6	(152)	0.70	0.70	0.67	0.60	0.85	0.85	0.75	0.57	0.63	0.58	0.57	0.55	0.66	0.35	0.26	0.16	0.85	0.70	0.52	0.31	0.71	0.57	n/a	n/a
7	(178)	0.74	0.74	0.69	0.62	0.96	0.96	0.83	0.62	0.65	0.60	0.58	0.56	0.83	0.44	0.33	0.20	0.96	0.88	0.66	0.30	0.77	0.62	n/a	n/a
7-1/4	(184)	0.74	0.74	0.70	0.62	0.98	0.98	0.85	0.63	0.65	0.60	0.58	0.56	0.88	0.46	0.35	0.21	0.98	0.92	0.69	0.42	0.78	0.63	0.57	n/a
8	(203)	0.77	0.77	0.72	0.63	1.00	1.00	0.91	0.66	0.67	0.61	0.59	0.56	1.00	0.54	0.40	0.24	1.00	1.00	0.80	0.46	0.82	0.66	0.60	n/a
9	(229)	0.80	0.80	0.75	0.65			1.00	0.70	0.69	0.62	0.60	0.57		0.64	0.48	0.29			0.96	0.58	0.87	0.70	0.64	n/a
10	(254)	0.84	0.84	0.78	0.67				0.75	0.71	0.64	0.61	0.58		0.75	0.56	0.34			1.00	0.67	0.92	0.74	0.67	n/a

$\phi V_{sa} := 3.2\ kip$

$\phi V_n := 15.695\ kip$

$f_{AV} := 0.53$

$f_{RV} := 0.14$

$R_{a\_anchor} := min\left(\phi V_{sa}, \phi V_n \cdot f_{AV} \cdot f_{RV}\right) = 1.165\ kip$

$$Design\_Check := \text{if } R_{a\_anchor} > R_u \ \| \ \text{"OK"} \ \text{else} \ \| \ \text{"Revise Design"} = \text{"OK"}$$