02 June 2009

C.R. Laurence Co., Inc.
2503 East Vernon
Los Angeles, CA 90058

SUBJ: CR LAURENCE SUN SHADES SERIES 7700

The CRL 7700 Series Aluminum Sun Shades were evaluated in accordance with the 2006 International Building Code and the 2005 Aluminum Design Manual to determine the allowable wind and snow loads.

The sun shades will safely support the following loading:

 Distributed live load = 25 psf over projected horizontal surface
 Concentrated live load = 300#
 Wind load = 55 psf
 Snow load = 55 psf
 Snow load + Wind load = 73 psf

Loading is based on using Hilti HSL-3 concrete anchors size 8mm with 2-3/8" embedment in to concrete with a minimum strength of $f'_c = 2,500$ psi. The sunshades may be attached to structural steel using 3/8" stainless steel bolts ASTM A276-85a Condition A or stronger with the same allowable loads.

The supporting structure shall be adequate to support the reactions as shown herein.

Edward Robison, P.E.

Attachments –
Calculations: 11 pages
Shop Drawings: 6 Sheets

Signed 06/03/2009

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WIND LOADING ON SUNSCREENS

Calculated in accordance with SEI/ASCE 7-05 Section 6.4 SIMPLIFIED PROCEDURE.

K_{zt} From Figure 6-4 for the site topography = 1.0.
V = Wind speed (mph) 3 second gust
p_{net30} = from Figure 6-3 Roof overhangs.
λ = from Figure 6-3
$w_v = p_{net30}*\lambda$ (uplift)
The wind load will cause a vertical uplift force

SNOW LOADING
Calculated in accordance with SEI/ASCE 7-05 Section 7.
$p_f = 0.7C_eC_tIp_g = 0.7*1.1*1.2*1.0*p_g = 0.924p_g$ psf
$p_s = C_sp_f = 0.38* p_f =$ psf
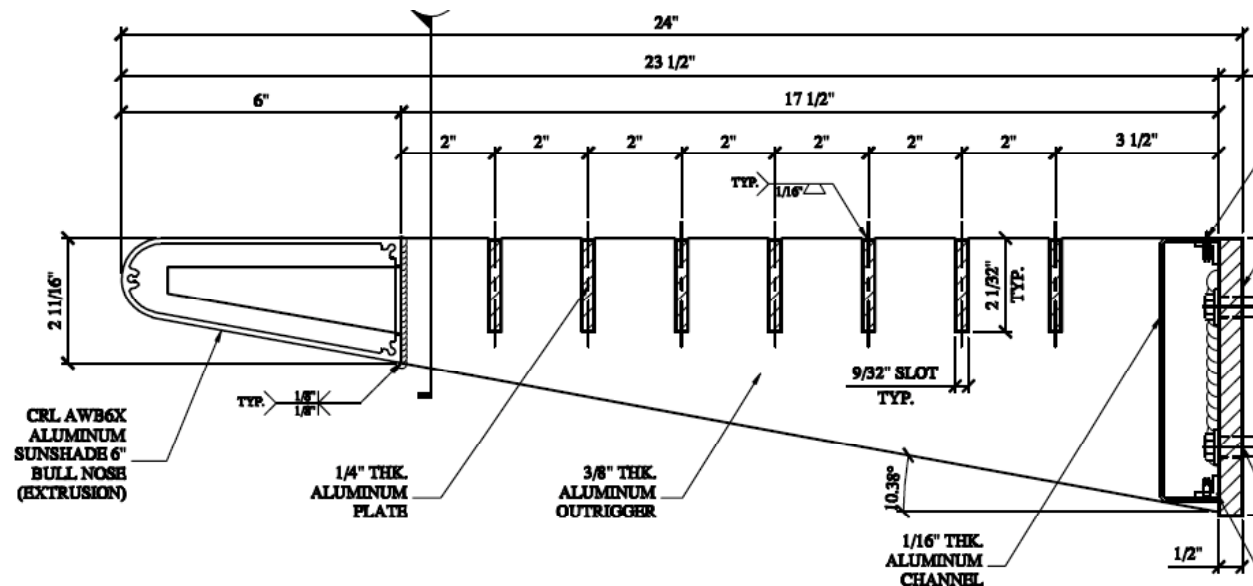$p_{ir} = 5$psf for icing and rain
$S = p_s + 5.0 =$ psf

ICE LOADING SEI/ASCE 7-05 Section 10
1" Equivalent = 5.2 psf

SUNSCREEN LOADS:
Wind load on blades:
w_v = wpsf*(0.25"*7+6")/12 = 0.505w plf
Snow load on blades:
S = Spsf*(0.25"*7+6")/12 = 0.505S plf
Live load
L = 2'*10psf = 20plf
Dead load
D = 0.6plf*7+2.4plf = 6.6 plf = 3.3 psf
Ice load
I = 5.2psf*((1+0.25")*7+6")/12 = 6.4plf
Wind on Ice
W_I = -w*((1+0.25")*7+6")/12 = -1.23w plf

24" PROJECTION SUNSHADE

Check based on a standard sun shade length of 48":

Bending of bars:

Bar section properties based on vertical orientation:

$I_x = 0.25"*2"^3/12 = 0.1667\ in^4$

$S_x = I/1" = 0.1667\ in^3$

Live concentrated load:

$M_1 = 48"*50/4 + 0.05pli*48"^2/8 = 614.4\#"$

$f_b = 614.4\#"/0.1667\ in^3 = 3,686\ psi$

Determine allowable stress from ADM Table 2-24

$F_T = 18\ ksi$ (line 2)

F_C = from ADM Table 2-24 line 13:

$d/t\sqrt{(L_b/d)} = 2"/0.25"\sqrt{(0.5*48"/2")} = 27.7$

$F_C = 27.9 - 0.531[d/t\sqrt{(L_b/d)}] = 27.9-0.531*27.7 = 13.19ksi$

$M_a = S*F_c = 0.1667*13.19ksi = 2,199\#"$

Allowable uniform loads on blades:

$U = 10*M_a/L^2 = 10*2,199\#"/48^2 = 9.54pli = 114plf$

Bars are attached to end bars with 1/8" x 2" fillet welds

Weld strength: $V_w = F_{sw}L_{we}/n_u$

$V_w = 7,500psi*1/8"*2"/1.95 = 962\#$ each

Blade strength will not control allowable loads on standard 4' sunshades.

Check load combinations on blades:

$D+L = 6.6+20 = 20.6plf$

$D+0.75(L+S) = 6.6+0.75(6.6+8.9) = 18.2plf$

snow controls over ice

since wind is uplift only check

$0.6D+W = 0.6*6.6-19.53 = -15.6plf$

$0.6D+W_1+0.75I = 0.6*6.6-37.2+.75*6.4 = -28.4plf$

Concentrated live load = 200#

Load to each bar = 200/4bars = 50#/bar

Shear force at bar ends:

downward

$V = .05pli*51"/2+50 = 51.3\#$

24" PROJECTION SUNSHADE
Check Bull nose section

Check local bending of bull nose:

Concentrated load:
$M = 200\#*6"/5 = 240\#"$

Resisting width = 1'+6"
$S = 18"*0.125^2/6 = 0.04687\text{in}^3$
$f_b = 240\#"/0.04687 = 5,120 \text{ psi}$

Check for wind load:
$M = W*0.5*0.5^2/10 = 0.0125W\#"/\text{ft}$

Allowable stress from ADM Table 2-21 for 6061-
T6 extrusion
$F_{bt} = F_{bc} = 28 \text{ ksi}$

Check for bending between supports:
$I_{xx} = 1.80 \text{ in}^4$
$S_{xx} = 1.05 \text{ in}^3$
determine allowable stress F_{cb}:
$b/t = 0.125/5" = 40$
$F_{cb} = 27.3-0.292*40 = 15.62 \text{ ksi}$

$M_a = 1.05*15.62\text{ksi} = 16,401\#" = 1,367\#'$
$U_a = 1,367\#'*8/4'^2 = 683\text{plf}$
Bending of bull nose section will not control sunshade loading

Attachment to end angles with (4) #8 screws:
#8 countersunk screws:
$P_{nov} = (0.27+1.45t_1/D)Dt_1F_{ty1}$ ADM eq 5.4.2.2-2
$P_{nov} = (0.27+1.45*0.125/0.1339)0.1339*0.125*25\text{ksi} = 679\#$
$P_a = 679/3 = 226\#$

$Z_a = 2F_{tu1}Dt_1/n_u$ ADM Eq 5.4.3-1
$Z_a = 2*30\text{ksi}*0.1339*0.125/3 = 335\#$ per screw

Screw shear:
$V_s = 0.65*33.7\text{ksi}*0.014\text{in}^2 = 307\#$

Connection strength = $4*226\# = 904\#$ each end
$U = 904\#/(4'/2) = 452\text{psf}$ (Will not control loading)
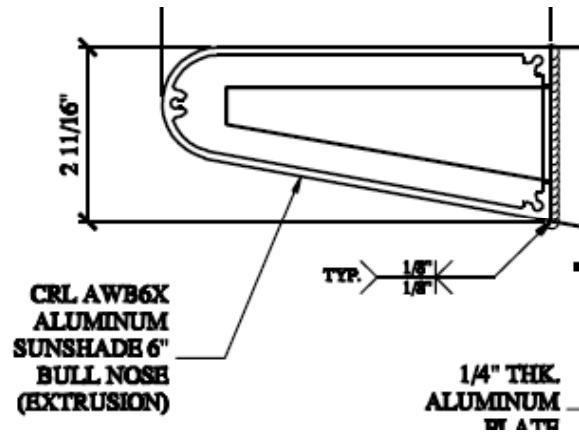
24" PROJECTION SUNSHADE
ATTACHEMENT TO WALL:
Out rigger bar is welded to wall plate.
Weld strength in accordance with ADM Section 7.
3/16" fillet weld all around bar, 5356 weld filler

$V_w = F_{sw}L_{we}/n_u$

$V_w = 17ksi*6"*2*(0.707*(3/16))/1.95 = 13.87k$

$S_w = 2*(0.707*3/16)*6^2/6 = 1.591in^3$

$M_{wa} = 1.591 in^3*17ksi/1.95 = 13.87k"$

Check strength of weld affected bar:

$S = 0.375"*6^2/6 = 2.25 in^3$

$M_{bw} = 2.25*6.5ksi = 14.625k"$

Weld strength will control bar loading.

Allowable uniform load on bar:
2' projection and 4' sun shade length:

$U = 13.87k"*2/(24^2) = 18.16pli = 578plf$

$u = 578plf/2' = 289psf$

weld strength will not control sun shade loading.

Determine Anchor loads:
For shear:

$V = U*2'*L/2$ for 4' section: $V = 4U$ psf

where: $U = D+ S$ or W; or $U = D+0.75(S+W)$

let u = greater of W, S or 0.75(W+S) psf

$V = 4*(3.3+u) = 13.2+4u$

From $\sum M$ about edge of the wall plate = 0:

$0 = 12"*V - (1.5"+3.03")*T$

solving for T:

$T = (12"*V)/4.53 = [12"*(13.2+4u)]/4.53$

$T = 35+10.6u$

Anchor strength:
8mm Hilti HSL-3 embed depth 2-3/8"
Allowable loads from Hilti Technical data and ESR 1545:

$T = 1,167\#$ (see next page)

$V = 0.65*2,107/1.6 = 856\#$

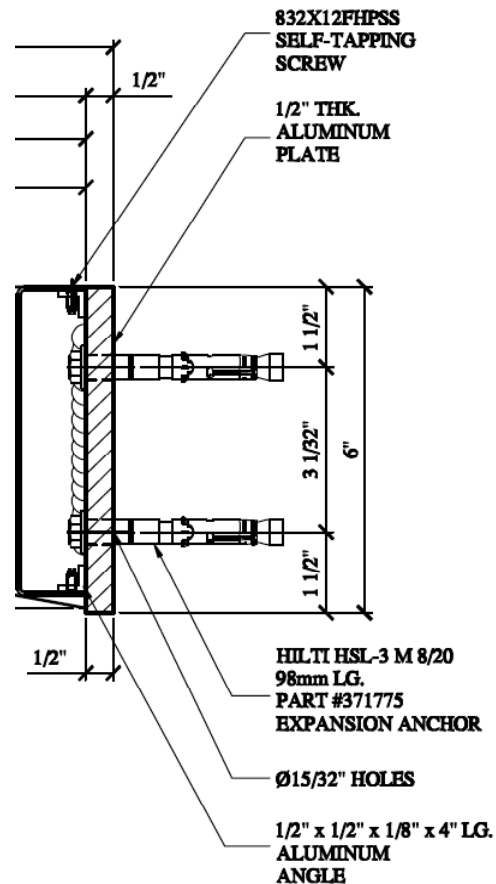Substitute into above equations and solve for u:

$V = 856\# = 13.2+4u$

$u = (856-13.2)/4 = 210.7$ psf

from T:

$T = 1,167\# = 35+10.6u$

$u = (1,167-35)/10.6 = 106.8psf$

Tension will control allowable loading

832X12FHPSS
SELF-TAPPING
SCREW

1/2" THK.
ALUMINUM
PLATE

1/2"

1 1/2"

3 1/32"

6"

1 1/2"

1/2"

HILTI HSL-3 M 8/20
98mm LG.
PART #371775
EXPANSION ANCHOR

Ø15/32" HOLES

1/2" x 1/2" x 1/8" x 4" LG.
ALUMINUM
ANGLE

24" PROJECTION SUNSHADE

Table 5 - HSL-3 Allowable Static Tension (ASD), Normal Weight Cracked Concrete (lb)[1,3,4]

Nominal Anchor Diameter	Embedment Depth hef		Concrete Compressive Strength[2]							
			f'_c = 2000 psi		f'_c = 3000 psi		f'_c = 4000 psi		f'_c = 6000 psi	
	mm	(in.)	Condition A	Condition B	Condition A	Condition B	Condition A	Condition B	Condition A	Condition B
M8	60	2.36	1,167	1,167	1,429	1,429	1,650	1,650	2,021	2,021
M10	70	2.76	1,867	1,867	2,286	2,286	2,640	2,640	3,233	3,233
M12	80	3.15	3,214	2,785	3,936	3,411	4,545	3,939	5,567	4,825
M16	100	3.94	4,492	3,893	5,501	4,768	6,352	5,505	7,780	6,743
M20	125	4.92	6,277	5,440	7,688	6,663	8,877	7,694	10,873	9,423
M24	150	5.91	8,252	7,152	10,106	8,759	11,670	10,114	14,292	12,387

1 Values are for single anchors with no edge distance or spacing reduction. For other cases, see ESR-1545 Section 4.2 Eq. 5.

2 Values are for normal weight concrete. For sand-lightweight concrete, multiply values by 0.85. For all-lightweight concrete, multiply values by 0.75. See ACI 318-05 Section D.3.4.

3 Condition A applies where the potential concrete failure surfaces are crossed by supplementary reinforcement proportioned to tie the potential concrete failure prism into the structural member. Condition B applies where such supplementary reinforcement is not provided,   or where pullout or pryout strength governs.

4 Allowable static tension loads for 2,500 psi are calculated by multiplying the pullout strength N_{pn} by the strength reduction ϕ factor of 0.65 and dividing by an α of 1.4 according to ICC ESR-1545 Section 4.2. See Table 2 for N_{pn}. This load may be adjusted for other concrete strengths according to ICC ESR-1545 Section 4.1.3 by using the following equation.

$$N_{pn,cr,f'c} = N_{pn,cr} \sqrt{\frac{f'c}{2500}}$$

Concrete breakout strength in shear:
$V_{cbg} = A_{vc}/A_{vco}(\varphi_{ec,V}\ \varphi_{ed,V}\varphi_{c,V}\varphi_{h,V})V_b$
$A_{vc} = 4.5*2.375^2 = 25.38$
$A_{vco} = 4.5(c_{a1})^2 = 4.5(2.375)^2 = 25.38$
$\varphi_{ec,V} = 1/[1+2e'_v/3c_{a1}] = 1/[1+2*0/(3*2.375)] = 1.0$
$\varphi_{ed,V} = 1.0\ \ (c_{a2} \geq 1.5c_{a1})$
$\varphi_{c,V} = 1.4$ uncracked concrete
$\varphi_{h,V} = \sqrt{(1.5c_{a1}/h_a)} = \sqrt{(1.5*2.375/2.375)} = 1.225$
$V_b = [8(l_e/d_a)^{0.2}\sqrt{d_a}]l\sqrt{f'_c}(c_{a1})^{1.5} = [8(2.375/0.313)^{0.2}\sqrt{0.313}]1.0\sqrt{2500}(2.375)^{1.5} = 1,228\#$
$V_{cb} = 25.38/25.38*1.0*1.4*1.225*1,228\# = 2,107\#$

Concrete breakout will control shear strength.

Check bearing strength on bolt holes:
allowable bearing strength from ADM Table 2-24 line 5: F_B = 31 ksi
B = 0.5"*0.313"*31ksi = 4,852# (bearing on plate won't control loading)

MAXIMUM ALLOWABLE LOADS ON SUN SHADE WITH 24" PROJECTION:
L = 300#
S = 100psf
W = 100psf downward and 106psf uplift
S + W = 133 psf

WALL REACTIONS:
Shear: V = 4*(3.3+u) = 13.2+4u
Tension: T = 35+10.6u
where: u = greater of W, S or 0.75(W+S) psf

For Sun Shade with 36" projection:
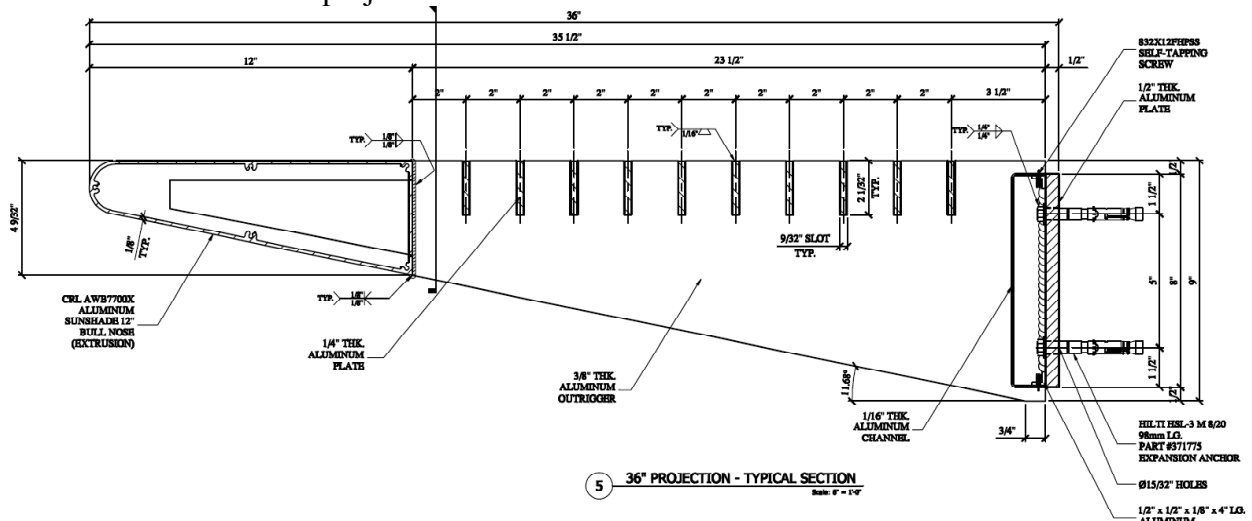
5 36" PROJECTION - TYPICAL SECTION

Strength of sun shade bars are the same as previously calculated and therefore will not control the allowable loads.
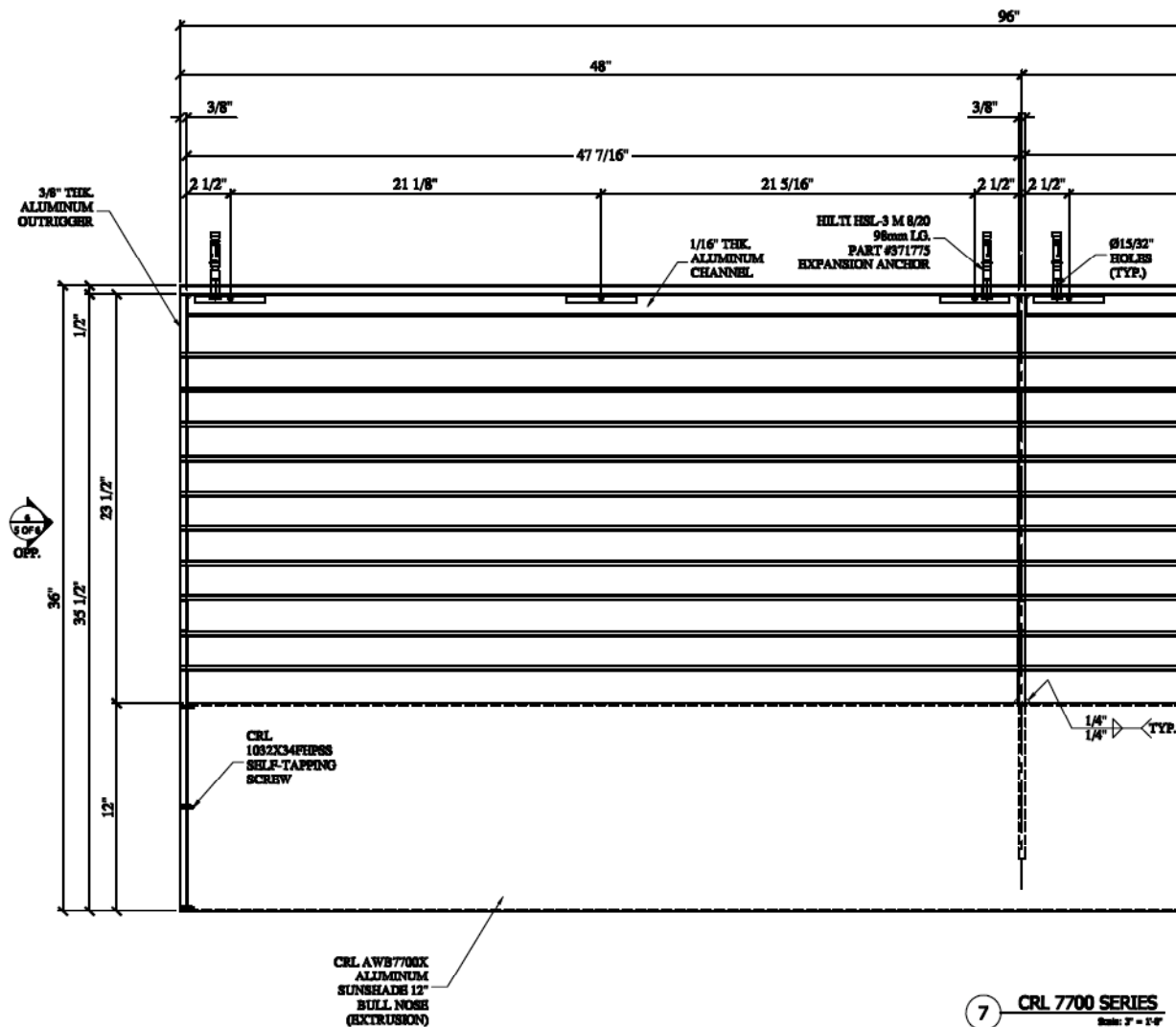
7 CRL 7700 SERIES

36" PROJECTION SUN SHADE
Check Bull nose section

Check local bending of bull
nose:

Concentrated load:
$M = 200\# * 11"/5 = 440\#"$

Resisting width = 2*1'
$S = 24" * 0.125^2/6 = 0.0625 \text{in}^3$
$f_b = 440\#"/0.0625 = 7{,}040 \text{ psi}$

Check for wind load:
$M = W * 0.5 * 0.5^2/10 = 0.0125W\#"/\text{ft}$

Allowable stress from ADM Table 2-21 for 6061-T6 extrusion
$F_{bt} = F_{bc} = 28 \text{ ksi}$

Check for bending between supports:
$I_{xx} = 8.094 \text{ in}^4$
$S_{xx} = 3.000 \text{ in}^3$
determine allowable stress F_{cb}:
$b/t = 0.125/5" = 40$
$F_{cb} = 27.3 - 0.292 * 40 = 15.62 \text{ ksi}$

$M_a = 3.0 * 15.62\text{ksi} = 46{,}860\#" = 3{,}905\#'$
$U_a = 3{,}905\#' * 8/4'^2 = 1{,}952 \text{plf}$
Bending of bull nose section will not control sunshade loading

Attachment to end angles with (5) #8 screws:
#8 countersunk screws:
$P_{nov} = (0.27 + 1.45t_1/D)Dt_1F_{ty1}$ ADM eq 5.4.2.2-2
$P_{nov} = (0.27 + 1.45 * 0.125/0.1339)0.1339 * 0.125 * 25\text{ksi} = 679\#$
$P_a = 679/3 = 226\#$

$Z_a = 2F_{tu1}Dt_1/n_u$ ADM Eq 5.4.3-1
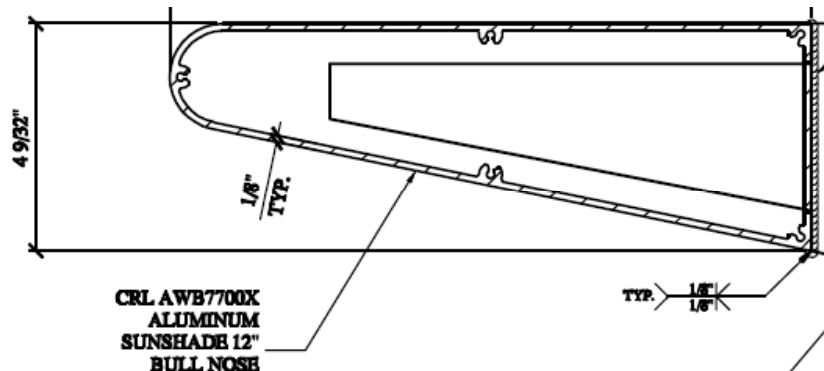$Z_a = 2 * 30\text{ksi} * 0.1339 * 0.125/3 = 335\#$ per screw

Screw shear:
$V_s = 0.65 * 33.7\text{ksi} * 0.014\text{in}^2 = 307\#$

Connection strength = 5*226# = 1,130# each end
U = 1,130#/(4'/2) = 565psf (Will not control loading)

CRL AWB7700X
ALUMINUM
SUNSHADE 12"
BULL NOSE

36" PROJECTION SUN SHADE
ATTACHEMENT TO WALL:
Out rigger bar is welded to wall plate.
Weld strength in accordance with ADM Section 7.
3/16" fillet weld all around bar, 5356 weld filler
$V_w = F_{sw}L_{we}/n_u$
$V_w = 17ksi*8"*2*(0.707*(3/16))/1.95 = 18.49k$
$S_w = 2*(0.707*3/16)*8^2/6 = 2.828in^3$

$M_{wa} = 2.828\ in^3*17ksi/1.95 = 24.66k"$

Check strength of weld affected bar:
$S = 0.375"*8^2/6 = 4\ in^3$
$M_{bw} = 4*6.5ksi = 26.0k"$

Weld strength will control bar loading.

Allowable uniform load on bar:
3' projection and 4' sun shade length:
$U = 24.66k"*2/(36^2) = 38pli = 456.7plf$
$u = 456.7plf/2' = 228.3\ psf$

weld strength will not control sun shade loading.

Determine Anchor loads:
For shear:
$V = U*3'*L/2$ for 4' section: $V = 6U$ psf
where: $U = D+ S$ or W; or $U = D+0.75(S+W)$
$D = 3.3psf$
let u = greater of W, S or 0.75(W+S) psf
$V = 6*(3.3+u) = 19.8+6u$
From $\sum M$ about edge of the wall plate = 0:
$0 = 18"*V - (1.5"+5")*T$
solving for T:
$T = (18"*V)/6.5 = [18"*(19.8+6u)]/6.5$
$T = 54.8+16.62u$

Anchor strength:
8mm Hilti HSL-3 embed depth 2-3/8"
Allowable loads from Hilti Technical data and ESR 1545, see page 6:
$T = 1,167\#$
$V = 0.65*2,107/1.6 = 856\#$

Substitute into above equations and solve for u:
$V = 856\# = 19.8+6u$
$u = (856-19.8)/6 = 139.4$ psf
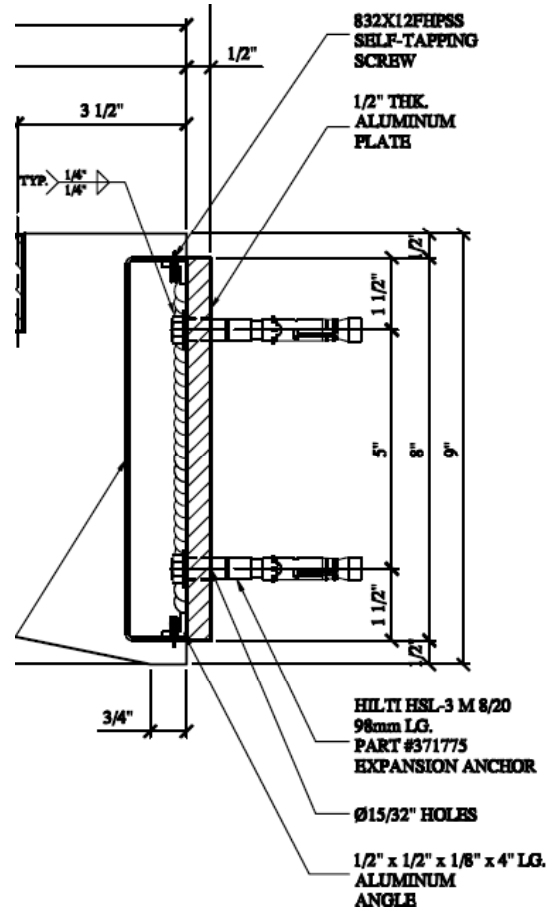from T:
$T = 1,167\# = 54.8+16.62u$
$u = (1,167-54.8)/16.62 = 97.0$ psf
Tension will control allowable loading

MAXIMUM ALLOWABLE LOADS ON SUN SHADE WITH 36" PROJECTION:
L = 300#
S = 95psf
W = 95psf downward and 100psf uplift
S + W = 125 psf

WALL REACTIONS:
Shear: $V = (19.8 + 6u)$
Tension: $T = 54.8 + 16.62u$
where: u = greater of W, S or 0.75(W+S) psf

For Sun Shade with 42" projection:

(1) 42" PROJECTION - TYPICAL SECTION
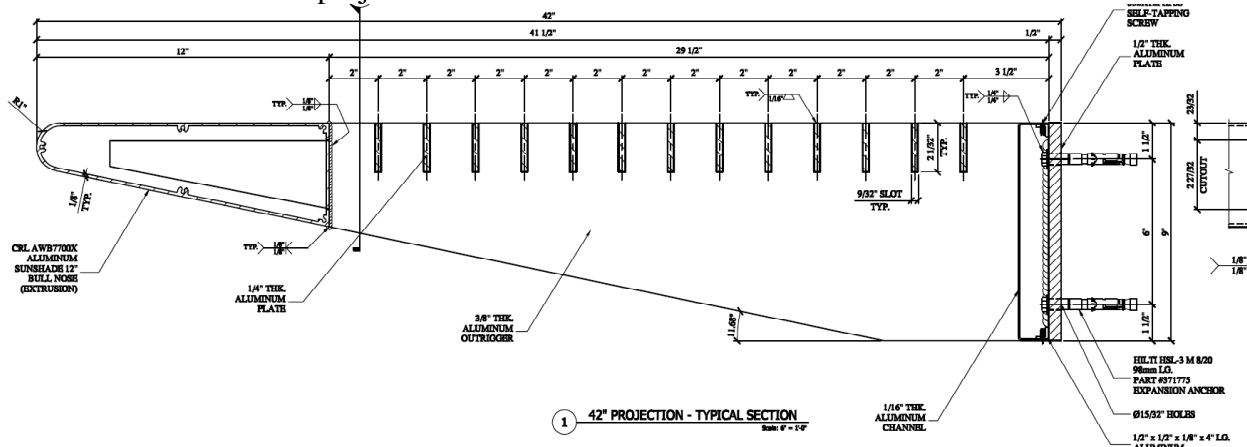
Strength of sun shade bars are the same as previously calculated and therefore will not control the allowable loads.

Bull nose section is the same as for the 36" projection and will not control sun shade loading.

ATTACHEMENT TO WALL:
Out rigger bar is welded to wall plate.
Weld strength in accordance with ADM Section 7.
3/16" fillet weld all around bar, 5356 weld filler

$V_w = F_{sw}L_{we}/n_u$

$V_w = 17ksi*9"*2*(0.707*(3/16))/1.95 = 20.8k$

$S_w = 2*(0.707*3/16)*9^2/6 = 3.579in^3$

$M_{wa} = 3.579 \ in^3*17ksi/1.95 = 31.2k"$

Check strength of weld affected bar:

$S = 0.375"*9^2/6 = 5.0625 \ in^3$

$M_{bw} = 5.0625*6.5ksi = 32.9k"$

Weld strength will control bar loading.

Allowable uniform load on bar:
3.5' projection and 4' sun shade length:

$U = 31.2k"*2/(42^2) = 35.4pli = 424.5plf$

$u = 424.5plf/2' = 212.2 \ psf$

Weld strength will not control sun shade loading.

42" Projection Sun Shade
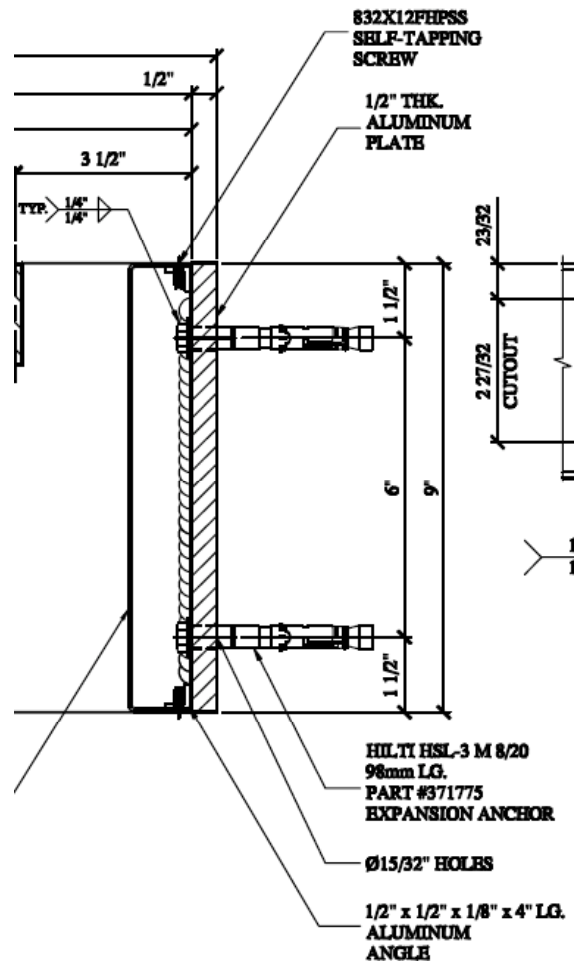
Determine Anchor loads:
For shear:
$V = U*3.5'*L/2$ for 4' section: $V = 7U$ psf
where: $U = D + S$ or W; or $U = D + 0.75(S+W)$
$D = 3.3$ psf
let u = greater of W, S or 0.75(W+S) psf
$V = 7*(3.3+u) = 23.1 + 7u$
From $\sum M$ about edge of the wall plate = 0:
$0 = 21"*V - (1.5"+6")*T$
solving for T:
$T = (21"*V)/7.5 = [21"*(23.1+7u)]/7.5$
$T = 66.36 + 19.6u$

Anchor strength:
8mm Hilti HSL-3 embed depth 2-3/8"
Allowable loads from Hilti Technical data and ESR 1545, see page 6:
$T = 1,167\#$
$V = 0.65*2,107/1.6 = 856\#$

Substitute into above equations and solve for u:
$V = 856\# = 23.1 + 7u$
$u = (856-23.1)/7 = 119$ psf
from T:
$T = 1,167\# = 66.6 + 19.6u$
$u = (1,167-66.6)/19.6 = 56.1$ psf
Tension will control allowable loading

MAXIMUM ALLOWABLE LOADS ON SUN SHADE WITH 42" PROJECTION:
$L = 300\#$
$S = 55$ psf
$W = 55$ psf downward and 60psf uplift
$S + W = 73$ psf

WALL REACTIONS:
Shear: $V = (23.1+7u)$
Tension: $T = 66.6 + 19.6u$
where: u = greater of W, S or 0.75(W+S) psf