03 April 2013

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, 2009 and 2012 International Building Codes 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 F593-98 Group 1 or 2, any condition with the same allowable loads. Anchorage shall be verified for the specific installation conditions.

The supporting structure shall be adequate to support the reactions as shown herein or as calculated for the specific installation conditions.

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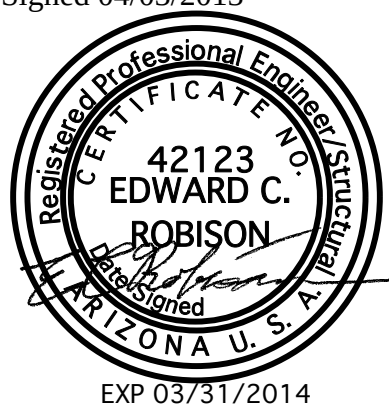
Signed 04/03/2013



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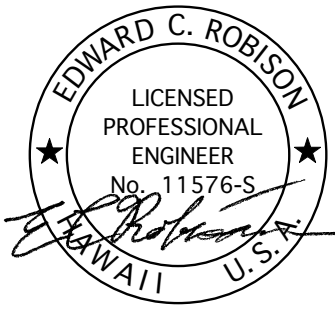

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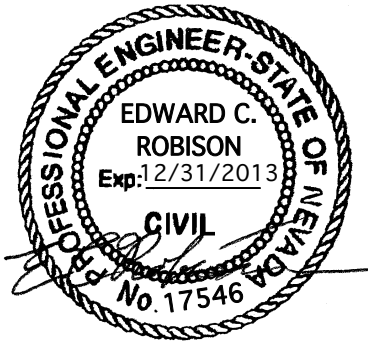

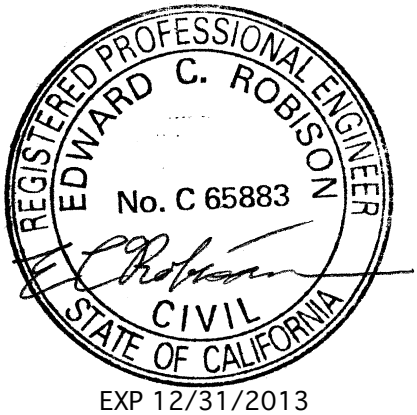

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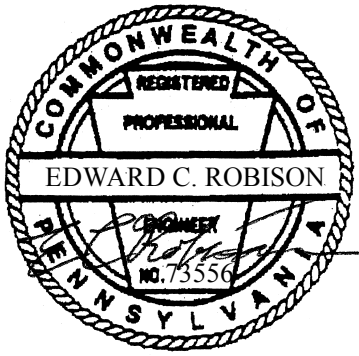

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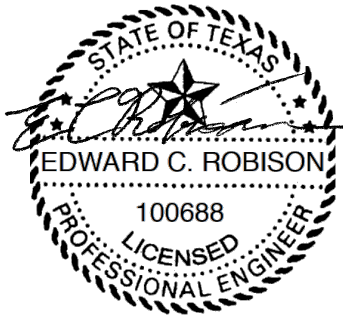

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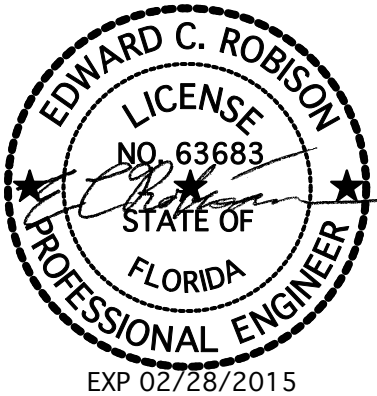

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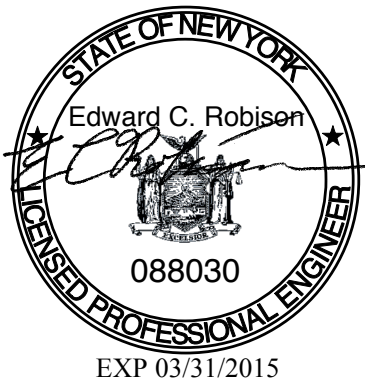

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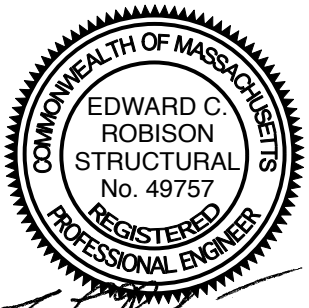

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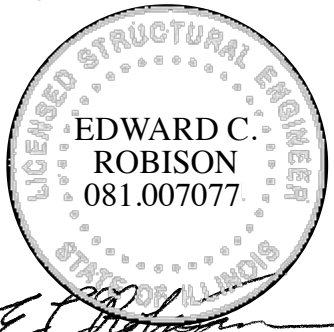

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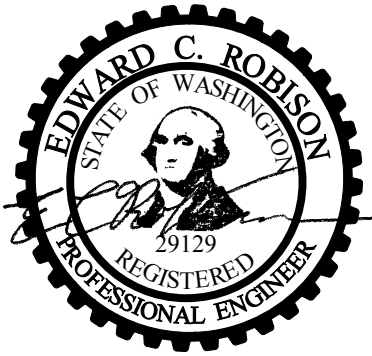

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WIND LOADING ON SUNSCREENS
Calculated in accordance with SEI/ASCE 7-05 Section 6.4 SIMPLIFIED PROCEDURE.

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)

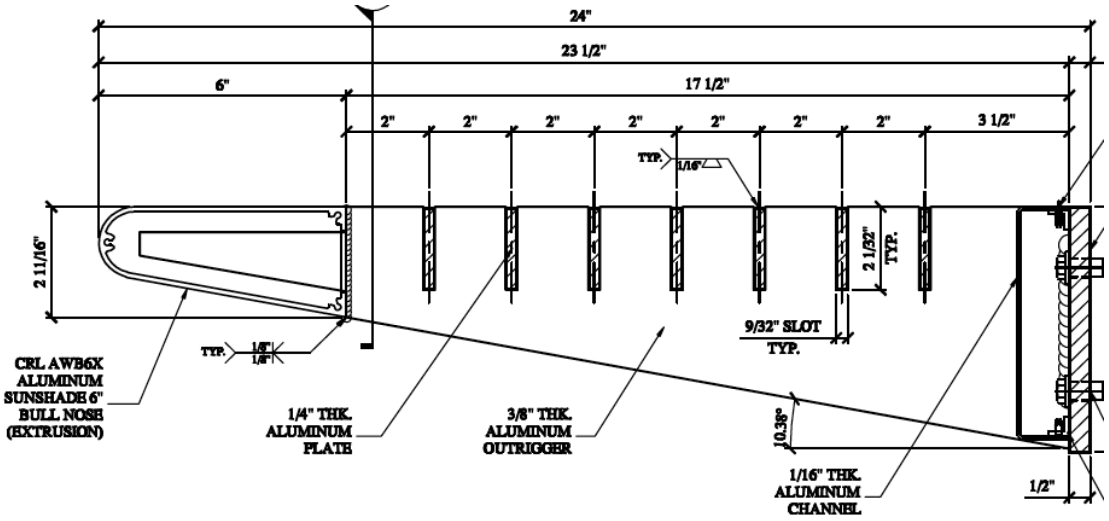
The wind load will cause a vertical uplift force

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} = 5psf 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

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24" PROJECTION SUNSHADE

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

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:
$M_l = 48"*50/4 + 0.05pli*48"^2/8 = 614.4\#"$
$f_b = 614.4\#"/0.1667\ in^3 = 3{,}686$ 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
$0.6D+W_I+0.75I = 0.6*6.6-37.2+.75*6.4 = -28.4plf$

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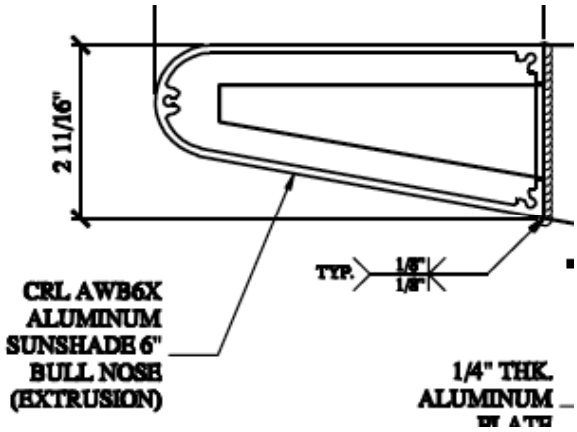
24" PROJECTION SUNSHADE

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#

Check Bull nose section



Check local bending of bull nose:

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

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

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

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

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

$M_a = 1.05*15.62ksi = 16{,}401\#" = 1{,}367\#'$
$U_a = 1{,}367\#'*8/4'^2 = 683plf$
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
$P_{nov} = (0.27+1.45*0.125/0.1339)0.1339*0.125*25ksi = 679\#$
$P_a = 679/3 = 226\#$

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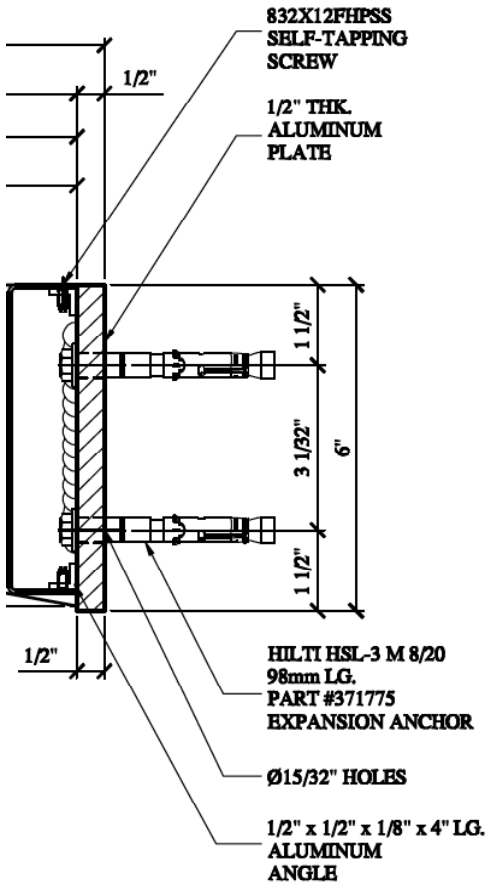
24" PROJECTION SUNSHADE
$Z_a = 2F_{tu1}Dt_1/n_u$ ADM Eq 5.4.3-1
Z_a = 2*30ksi*0.1339*0.125/3 = 335# per screw

Screw shear:
V_s = 0.65*33.7ksi*0.014in^2 = 307#

Connection strength = 4*226# = 904# each end
U = 904#/(4'/2) = 452psf (Will not control loading)

ATTACHMENT 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 ∑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

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24" PROJECTION SUNSHADE

Note: The strength of the anchor shall be checked for specific installation conditions.
Other anchor types may be used if designed for the specific installation conditions.

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

TABLE 5—EXAMPLE ALLOWABLE STRESS DESIGN VALUES FOR ILLUSTRATIVE PURPOSES[1,2,3,4,5,6,7,8,9,10]

Nominal Anchor Diameter	Effective Embedment		Allowable Tension (lbs)
	mm	inches	f'_c = 2500 psi
M8	60	2.36	1,846
M10	70	2.76	2,417
M12	80	3.15	2,946
M16	100	3.94	4,122
M20	125	4.92	5,751
M24	150	5.91	7,572

[1]Single anchor with static tension load only.
[2]Concrete determined to remain uncracked for the life of the anchorage.
[3]Load combinations from ACI 318 Section 9.2 (no seismic loading).
[4]30% dead load and 70% live load, controlling load combination 1.2D + 1.6L
[5]Calculation of weighted average for α = 0.3*1.2 + 0.7*1.6 = 1.48
[6] f'_c = 2,500 psi (normal weight concrete).
[7] $c_{a1} = c_{a2} \geq c_{ac}$
[8] $h \geq h_{min}$
[9]Values are for Condition B where supplementary reinforcement in accordance with ACI 318-11 D.4.3 is not provided.
[10] ϕ factor is 0.65

Concrete breakout strength in shear:
$V_{cbg} = A_{vc}/A_{vco}(\varphi_{ec,V}\varphi_{ed,V}\varphi_{c,V}\varphi_{h,V})V_b$
$A_{vc} = 4.5*2.375^2 = 25.38$
$A_{vco} = 4.5(c_{a1})^2 = 4.5(2.375)^2 = 25.38$

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$\varphi_{ec,V} = 1/[1+2e'_v/3c_{a1}] = 1/[1+2*0/(3*2.375)] = 1.0$
$\varphi_{ed,V}= 1.0$ ($c_{a2} \geq 1.5c_{a1}$)
$\varphi_{c,V}= 1.4$ 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
W+S = 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

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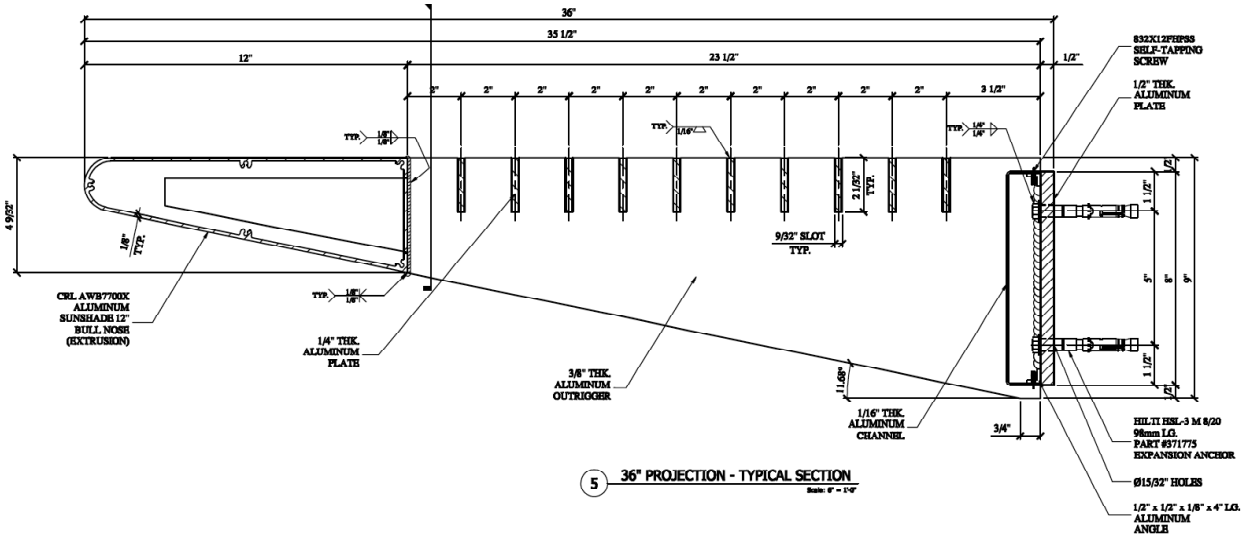
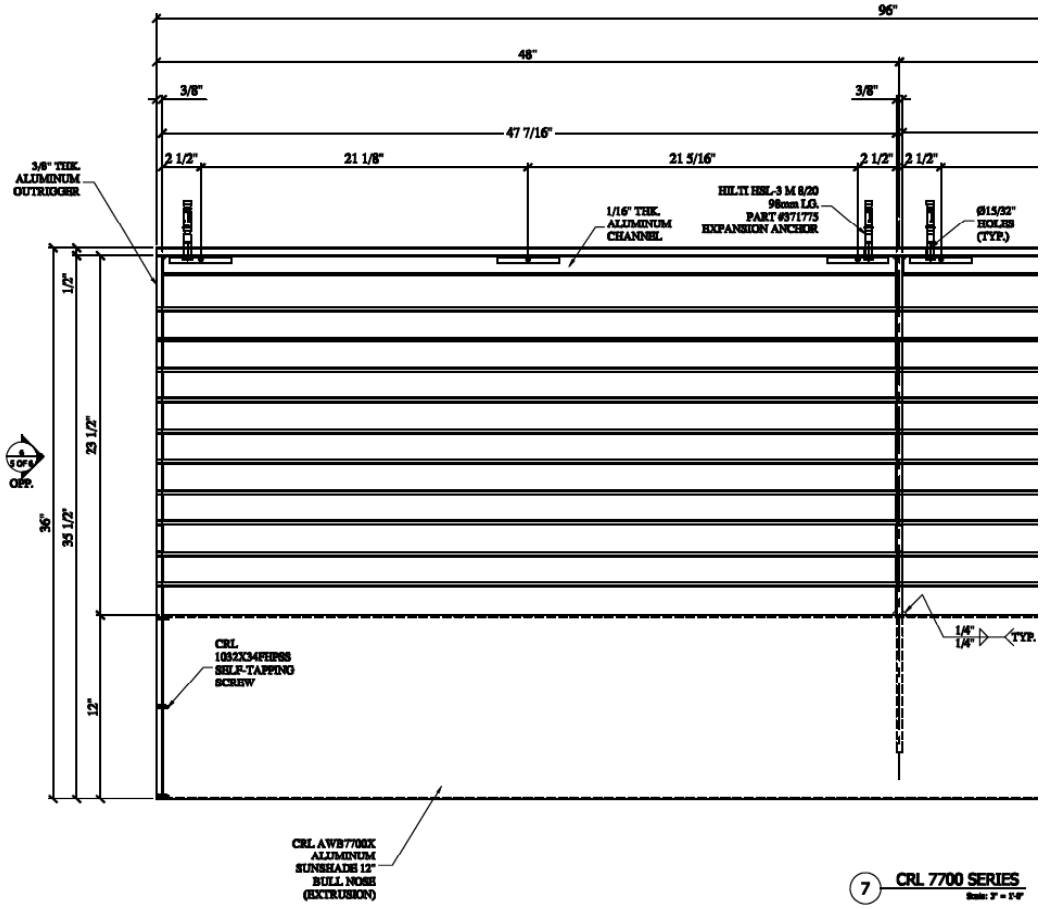
For Sun Shade with 36" projection:



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



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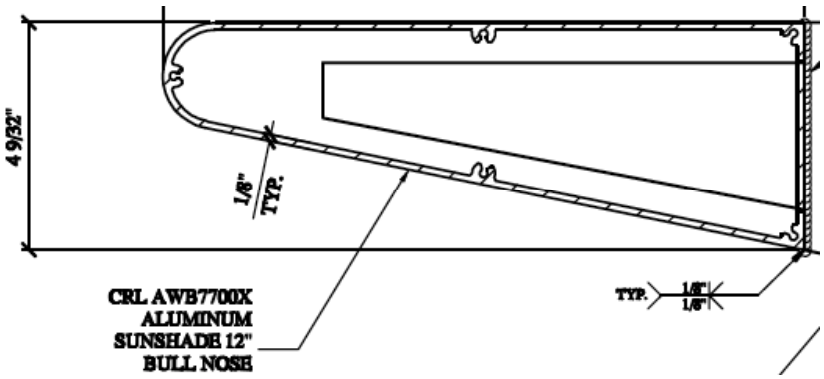
36" PROJECTION SUN SHADE
Check Bull nose section



Check local bending of bull nose:

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

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

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

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

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

$M_a = 3.0*15.62ksi = 46{,}860\#" = 3{,}905\#'$
$U_a = 3{,}905\#'*8/4'^2 = 1{,}952plf$
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
$P_{nov} = (0.27+1.45*0.125/0.1339)0.1339*0.125*25ksi = 679\#$
$P_a = 679/3 = 226\#$

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

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

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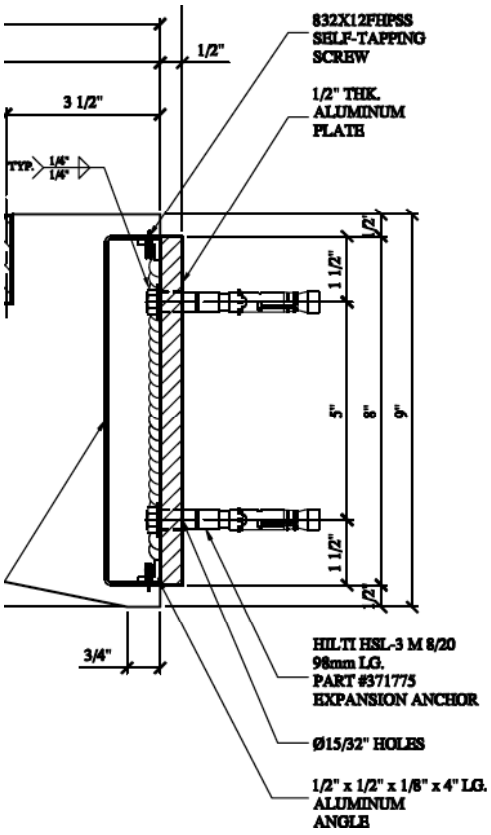
36" PROJECTION SUN SHADE

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

ATTACHMENT 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 ∑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#

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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

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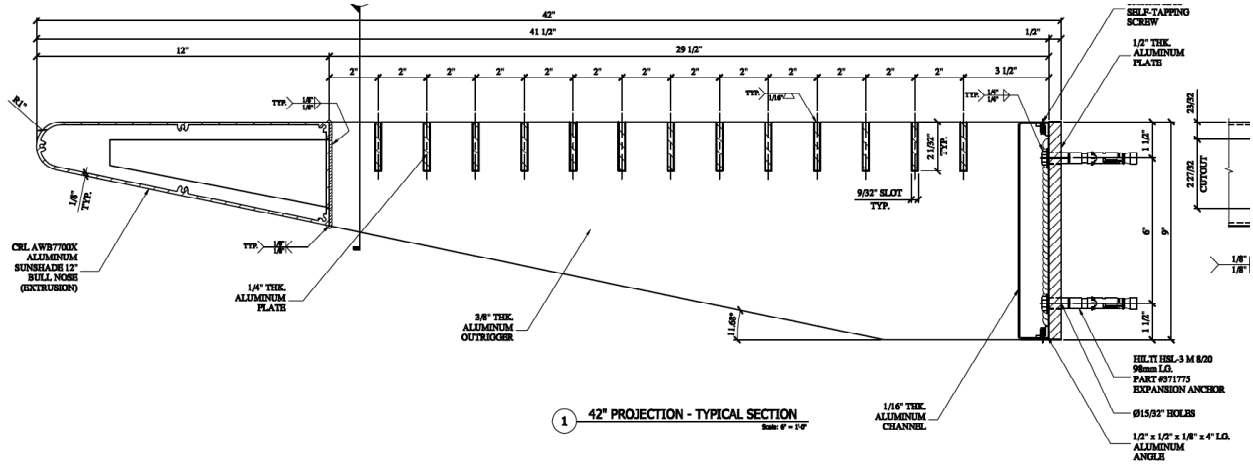
For Sun Shade with 42" projection:



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.

ATTACHMENT 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.

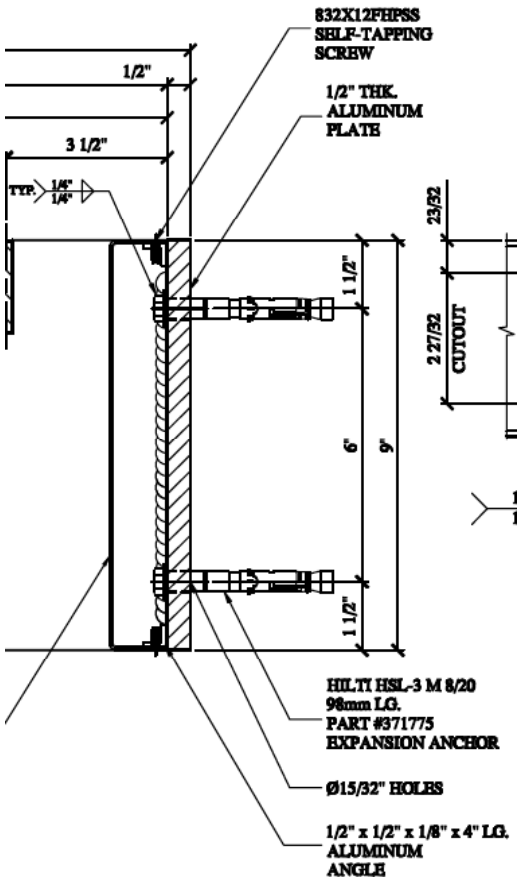
Allowable uniform load on bar:

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.



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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 = 3.3psf
let u = greater of W, S or 0.75(W+S) psf
V = 7*(3.3+u) = 23.1+7u
From ∑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 = 55psf
W = 55psf 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

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