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SUBJ: GLASS AWNING SUPPORT SYSTEM

The Glass Awning Support System utilizes stainless steel fittings to construct frameless tempered laminated glass awnings. The system is intended for interior and exterior weather exposed applications and is suitable for use in all natural environments. The system may be used for residential, commercial and industrial applications. The Glass Awning Support System is designed for the following criteria:

The design loading conditions are:
Concentrated load = 50 lbs any direction, any location
Uniform load = 25 psf vertical, live, wind or snow load

The glass awning is not intended to support significant concentrated live loads or personnel. It shall not be used to walk, stand or step on.

The Awning Support System will meet or exceed all requirements of the 1997 Uniform Building Code, 2000, 2003 and 2006 International Building Codes, and 2007 California Building Code. Stainless steel components are designed in accordance with SEI/ASCE 8-02 Specification for the Design of Cold-Formed Stainless Steel Structural Members. Wood components and anchorage to wood are designed in accordance with the National Design Specification for Wood Construction.

Contents — Page

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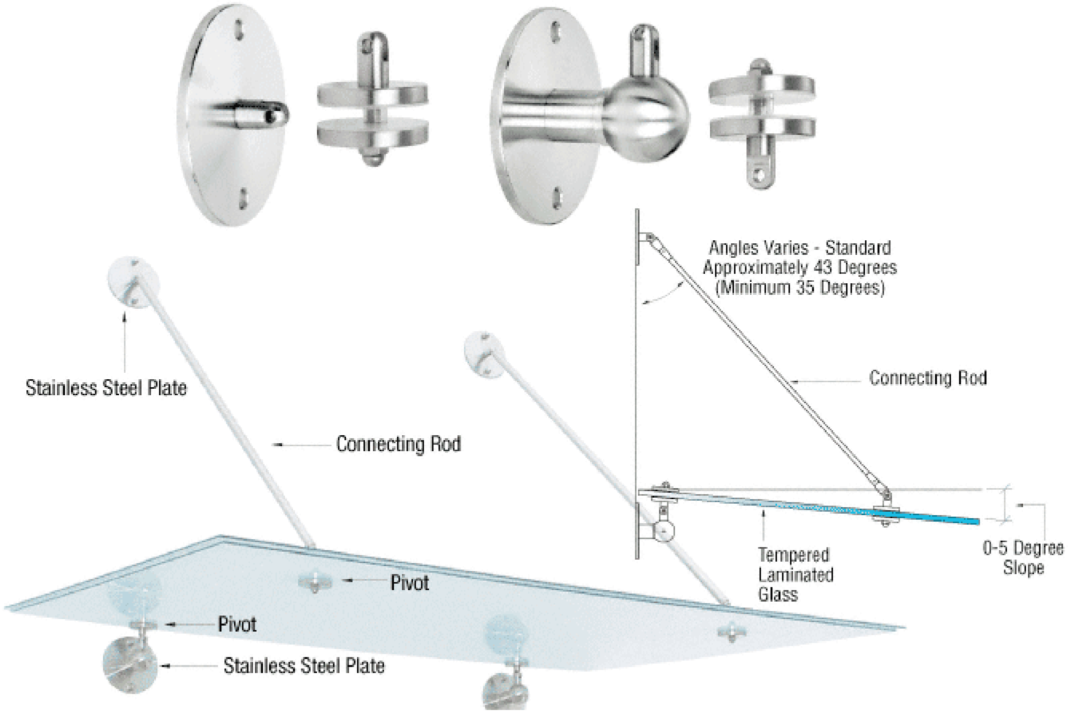
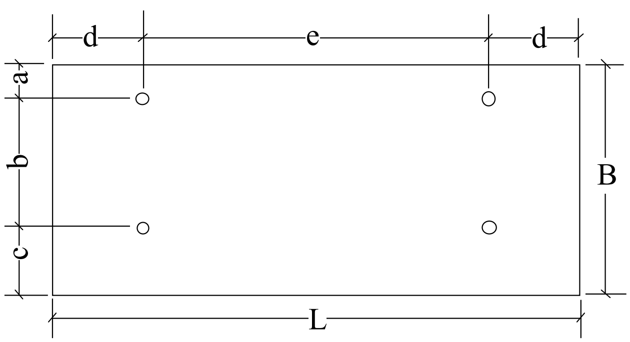
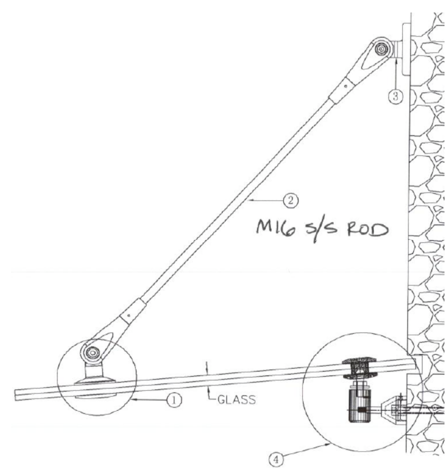
CRL GLASS AWNING SUPPORT SYSTEM



Support hardware for flat panel awnings such as laminated glass.





Support Rod: 1/2" (12 mm) diameter stainless steel

$I = 0.00307 \text{ in}^4$, $A = 0.196 \text{ in}^2$

$r = 0.125$ in

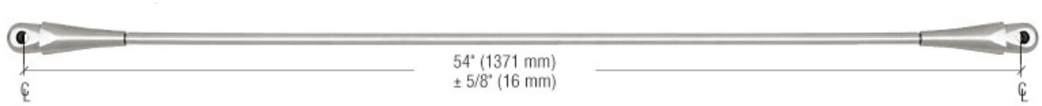
Maximum allowable rod length: 62"

$kl/r = 0.5*62"/0.125" = 256$

$F_a = 12\pi^2E/[23(kl/r)^2] = 2{,}121$ psi (allowable compression stress)

$P_a = 2{,}121 \text{ psi}*0.31 \text{ in}^2 = 658\#$ compression force (wind uplift)

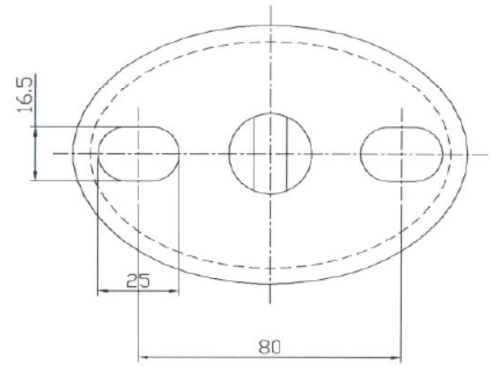
$T_a = øA_nF_y/1.6 = 0.85*0.196*45\text{ksi}/1.6 = 4{,}686\#$



Typical hanger rod

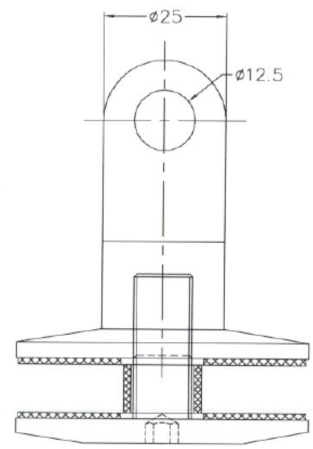
Wall Mount

The wall plate is mounted to the wall with two 3/8" anchors, type dependent on the wall construction. Typical strength of 3/8" anchor is minimum of 500# each for tension and shear.



Reaction from tie bar:
V = T for bar at 45° angle (typical)
V/1000 + T/1000 = 1.0
V = T = 500#

Check connector bar strength:
1/2" x 1" bar $Z = 0.5*1^2/4 = 0.25$ in^3, $F_y = 28$ ksi
$M_S = 0.9*0.25$ in^3*28 ksi/1.6 = 3,937#"
okay for 500# tie bar load.



For 4' wide glass:
load to rod:
1/2*4'*L/2*W = LW = 500# allowable
where W = total uniform load and L = awning length
For W = 31 psf (6 psf dead load +25 psf live load)
L_{max} = 500/31 = 16' Limited to 9' by glass strength

Tie rod to glass connection bracket: Connector bar strength is same as for wall bracket therefore okay by inference.

Bottom cap screws into top side bracket:
1/2" threaded stud with minimum 1/2" thread depth.
Strength = 1.107in^2*0.5"*21 ksi = 11.6 k for thread stripping
T = 0.196 in^2*56 ksi*0.75/1.6 = 5,145# for stud strength

Bracket bar for receiving clevis eye.
Z = 0.25"*1"^{2}/4 = 0.0625in^3
M_s = 0.9*0.0625in^3*45ksi/1.6 = 1,582#"
H_a = (1,582#"/1.6)/1.125" = 879# > 378# strength is adequate.

5/8" diameter bracket bar:
M_s = 0.9*0.0407in^3*45 ksi/1.6 = 1,030#"
H = 1,030#"/1.125" = 915# doesn't control strength
1/4" connector pin strength:
V_s = 0.85*25ksi*0.049in^2/1.6 = 650# > 630# okay

Bottom Wall Mount
Bottom plate standoff for pivot: assume 630# D+L total load

M = 630#*2.625" = 1,654"#

Bottom plate: f_b = 1,654"#/0.0414 in^3 = 39.9 ksi
Top Plate: F_b = 42 ksi per SEI/ASCE 8-02

Top plate standoff for pivot

$M = 630\#*0.75" = 473"\#$

$f_b = 473"\#/0.0123\ in^3 = 38.5\ ksi$

Maximum tributary area per plate: 630#/25 psf = 25.2 sf for bottom plate.
Determine maximum tributary area to support rod:
Maximum rod length is 54" (rod may not be longer for 1/2" diam. based on kl/r limits).
Minimum angle of rod to horizontal is 35°.

From geometry:

$a+b = 54"\cos 35° = 44.23"$

$b = 44.23" – 2.8125" = 41.4175"$

$h = 54"\sin 35° = 30.97"$

$c_{max} = 12"$ so $B_{max} = 44.23"+14" = 58.23"$

For an allowable bar compressive load of 658#

Max Vertical load V = 658#*sin35° = 377#

Uplift from wind check based on 25 psf wind load

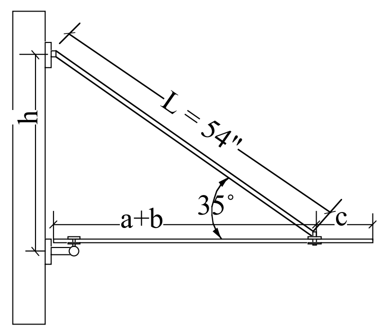
Up = 25 psf – 0.6*6.5psf = 21.1 psf

Max tributary area = 377#/21.1psf = 17.9 sf

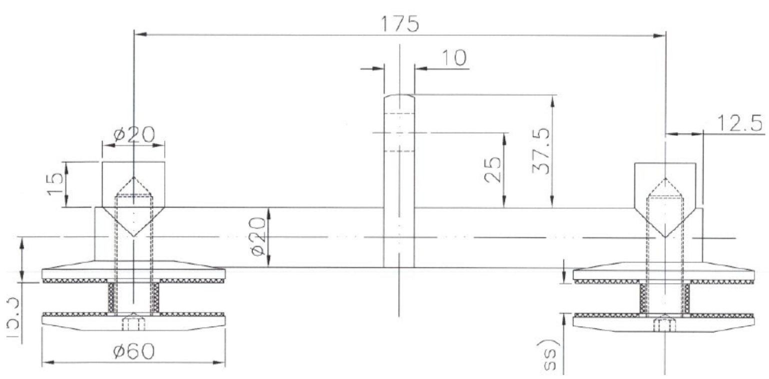
Determine maximum L for B = 58" (4'10")

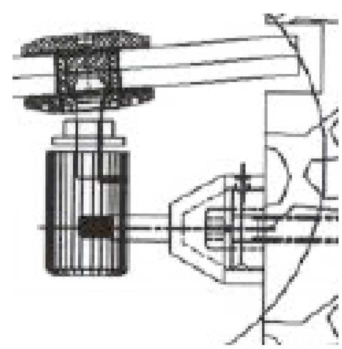
$f = (41.2"^2/2+14"*48.2")/41.2" = 37" = 3.08'$

$L = 17.9/3.08*2 = 11.61'$



Double bracket (Two adjacent awning panes)





Bending on connection bar between double bracket and wall mount.

$Z = 0.5^3/6 = 0.0208\ in^3$

$M_S = 0.0208*50\ ksi*0.9/1.6 = 586\#"$

$P = 586\#"/1" = 586\#$

293# allowable for each pane:

Maximum pane size based on 31 psf total load

293#/31psf*4 = 37.8 sf.

GLASS STRENGTH

Glass is fully tempered 2 layer laminated safety glass conforming to the specifications of ANSI Z97.1, ASTM C 1048-97b and CPSC 16 CFR 1201. The minimum Modulus of Rupture for the glass F_r is 24,000 psi. Glass not used in guardrails may be designed for a safety factor of 2.5 in accordance with ASTM E1300-00.

Adjustment for laminated glass (both layers equal) = 1.7 single layer strength
Allowable glass bending stress: 24,000/2.5 = 9,600 psi. – Tension stress
Allowable bearing stress = 24,000 psi/2.5 = 9,600 psi.

Bending strength of glass for the given thickness:

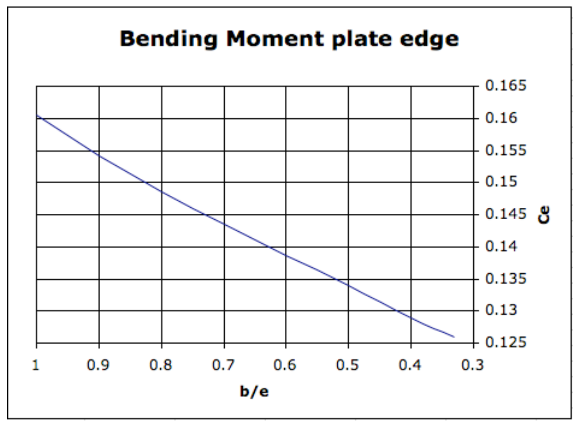
$$S = \frac{12'' * (t)^2}{6} = 2 * (t)^2 \text{ in}^3/\text{ft}$$

The effective section modulus for 2 layers of 1/4" glass:

$S = 1.7*2*(0.223)^2 = 0.169$ in^3/ft for long term loads (dead oad) or
$S = 2*(2*0.223)^2 = 0.3978$ in^3/ft for short duration loads, (wind, snow or live).

Allowable bending moment on glass is:

$M_{al} = 9{,}600$ psi*0.169 in^3/ft = 1,622"#/ft
$M_{as} = 9{,}600$ psi*0.3978 in^3/ft = 3,819"#/ft = 318.25'#/ft



Maximum bending moment will occur at center edge of the glass light:
$M_{ec} = C_e*w*e^2$
C_e is from graph based on b/e where b is always the smaller dimension.
When b/e < 0.33 C_e may be taken as 0.125
For concentrated loads
$M_l = 2C_ePe$ for concentrated load P at the light center edge
$M_c = U*d^2/2$ at support axis
$M_c = P*d$
Dead load equivalent load = 0.3978/0.169*6.3 = 14.8
For a design load of W = 25 psf (live or wind) or P = 50 lb load
U = 25+14.8 = 39.8psf
Based on assumed b/e ≤ 0.33

$e = [(3{,}819''\#/12)*8/39.8\text{psf}]^{1/2}$ = 8' = 96"
e = 3,819"#*4/50 = 305.5" = 25.46' concentrated loads won't control
$d = [(3{,}819''\#/12)*2/39.8\text{psf}]^{1/2}$ = 4' = 48" Cantilevered length
d = 3,819"#/50 = 76" concentrated loads won't control

The allowable uniform load may be calculated using:

$U = [(318.25/C_e)/e^2]$ or
$U = [(318.25/(4C_e))/d^2]$

For a design load of W = 25 psf (live or wind) or P = 50 lb load
Assume b/e ≤ 0.5, $C_e \le 0.134$

e = $[(318.25/0.134)/25psf]^{1/2}$ = 9.75' = 9' 9" Controls for e
e = 318.25#/(2*0.134)/50 = 23.75'
d = $[(318.25'\#/(4*0.134))/25psf]^{1/2}$ = 4.87' = 4' –10.5" Controls for d
d = 318.25'#/(4*0.134*50) = 11.88'

For maximum L = 10'

b = $[(318.25)/(0.134)/(5'*25psf)]^{1/2}$ = 4.36' = 4' - 4.25"
For b = 41.4175", L ≤ $[(318.25)/(0.134)/(3.45^2*25psf)*2$ = 15.96' = 15' – 11.5"
c = $[(318.25)/(4*0.134)/(5'*25psf)]^{1/2}$ = 2.179' = 2'- 2"

MAXIMUM PANEL SIZE:
Maximum width B = 4'10" from hanger geometry + cantilever from glass bending
Maximum length L = 10' from glass bending strength

Panel dimensions: Illustrative for typical panel.

Dim maximum	for 4' x 6' panel
a = 2-13/16"	fixed length for all panel sizes
b ≤ 41.4175" For L ≤ 109"	35.3/8"
39.6"≤b≤41.4175" For 109" <L≤120"	
c ≤ 14"	9-13/16"
B=a+b+c≤58"	48"
d ≤ 27"	13-3/8"
e ≤ 88.5"	45-1/4"
L = 2d+e ≤ 132"	72"

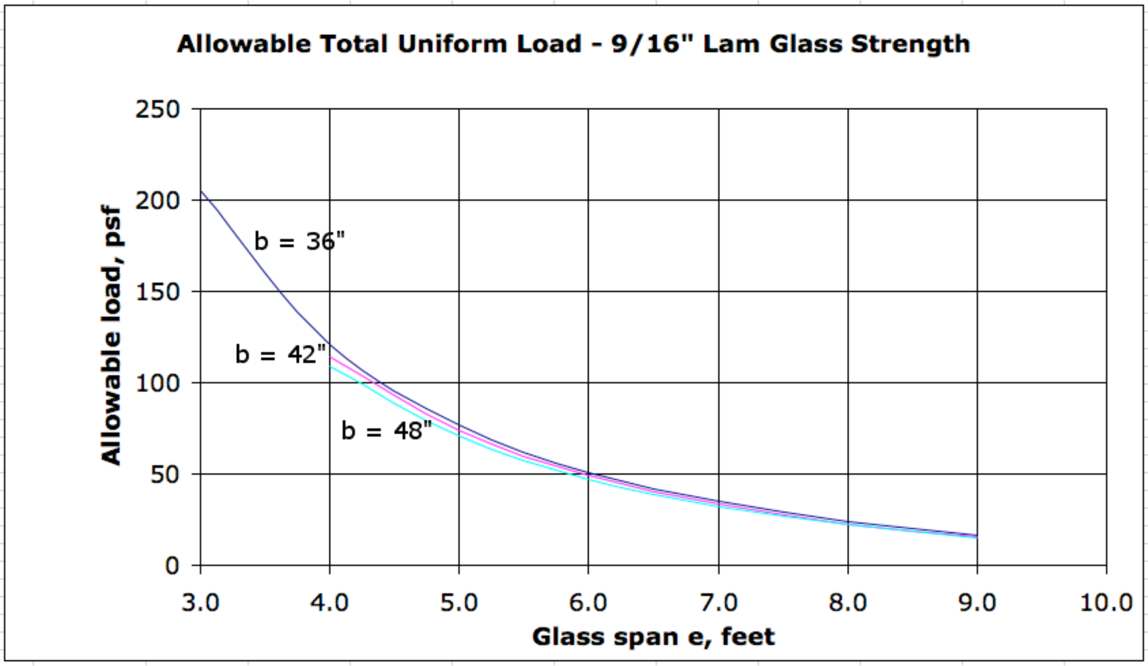
MAXIMUM ALLOWABLE LOADS:
500# per connection point
Total awning pane: 2,000# total, dead plus live or snow or wind for support strength.
Limited by glass strength to 1,500# total for 2 ply 1/4" laminated glass (9/16" total).

Double bracket: 586# total, 293# each pane tributary to bracket.

DESIGN CRITERIA
IBC Section 3105 Awnings and Canopies
IBC Section 2404.4

Allowable awning loads:
Total loads are based on controlling load combination (use D = 14.8 psf):
D+S or $S_{allowable}$ = U-14.8
D+W or $W_{allowable}$ = U-14.8
D+0.75(S+W) or $S_{allowable}+W_{allowable}$ = 1.333U-19.3
0.6D+W (wind uplift case) $W_{allowable}$ = U- 8.9
The allowable load shall be the lesser of the allowable load on the bracket based on total awning size (L*B) and the allowable load for the glass based on glass span (e*b).

Wind loading shall be determined in accordance with ASCE/SEI 7-05 Chapter 6 for roof overhangs or as required by the applicable building code.



Allowable load on awning based on hardware strength.

Unifrom Load	(L) Awning	length (ft)					
Awning width	4	5	6	7	8	9	10
2	250.0	200.0	166.7	142.9	125.0	111.1	100.0
2.5	200.0	160.0	133.3	114.3	100.0	88.9	80.0
3	166.7	133.3	111.1	95.2	83.3	74.1	66.7
3.5	142.9	114.3	95.2	81.6	71.4	63.5	57.1
4	125.0	100.0	83.3	71.4	62.5	55.6	50.0
4.5	111.1	88.9	74.1	63.5	55.6	49.4	44.4
4.83	103.5	82.8	69.0	59.2	51.8	46.0	41.4