25 March 2021

C.R. Laurence Co., Inc.
2200 E. 55th ST
Los Angeles, CA 90058-0923

SUBJ: CRL UNIVERSAL WALL MOUNTED GLASS AWNING BRACKET
GAB24, GAB36, GAB48

The CRL universal wall mounted glass awning bracket utilizes stainless steel fittings to construct wall mounted cantilevered glass awnings using 9/16" two ply laminated tempered glass. 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 Brackets are 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 (ASD level loads) or snow load

Higher uniform loads may be allowed depending on glass strength and size as shown herein, refer to the awning size/load tables. Wind loads determined per ASCE/SEI 7-16 (2018 IBC) shall be adjusted to ASD level.

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 Glass Awning Brackets will meet applicable requirements of the 2018 International Building Codes, and 2019 California Building Codes. A qualified design professional must evaluate the suitability for a specific installation taking into consideration the specific installation conditions and loading. Stainless steel components are designed in accordance with SEI/ASCE 8-02 *Specification for the Design of Cold-Formed Stainless Steel Structural Members* or AISC Design Guide 27 *Structural Stainless Steel* as applicable. Anchorages to wood are designed in accordance with the National Design Specification for Wood Construction.

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Signature Page

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Professional Certification. I hereby certify that these documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the State of Maryland,
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STATE OF MINNESOTA
I hereby certify that this plan, specification. or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.
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Date Lic. No. 58604

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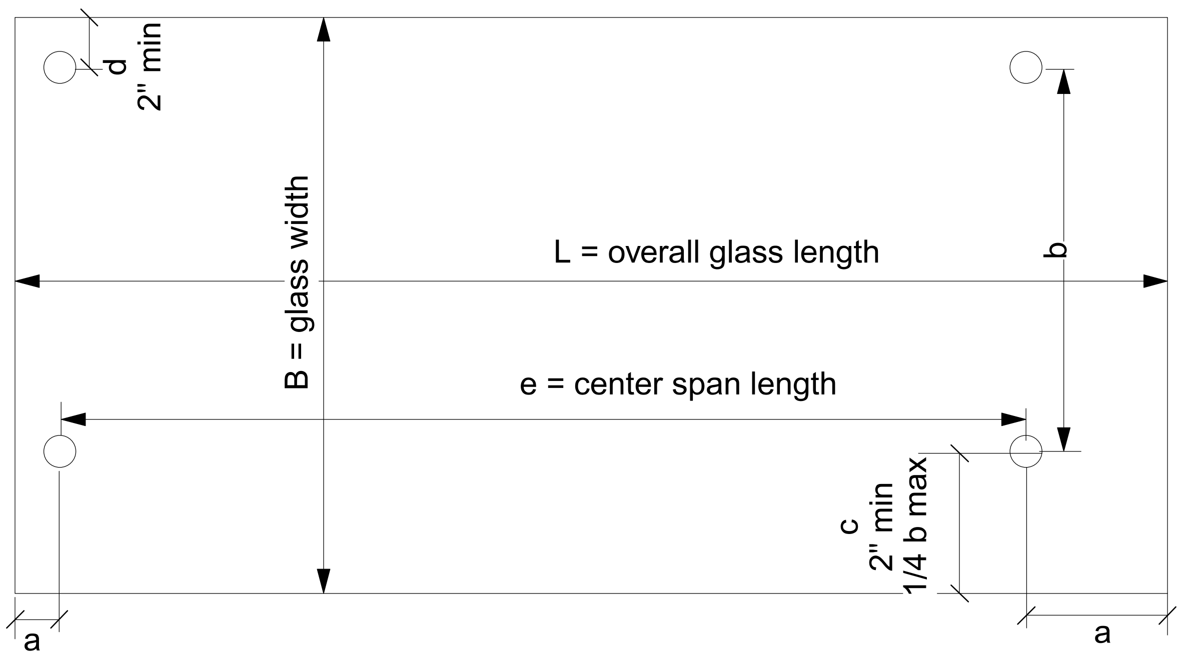
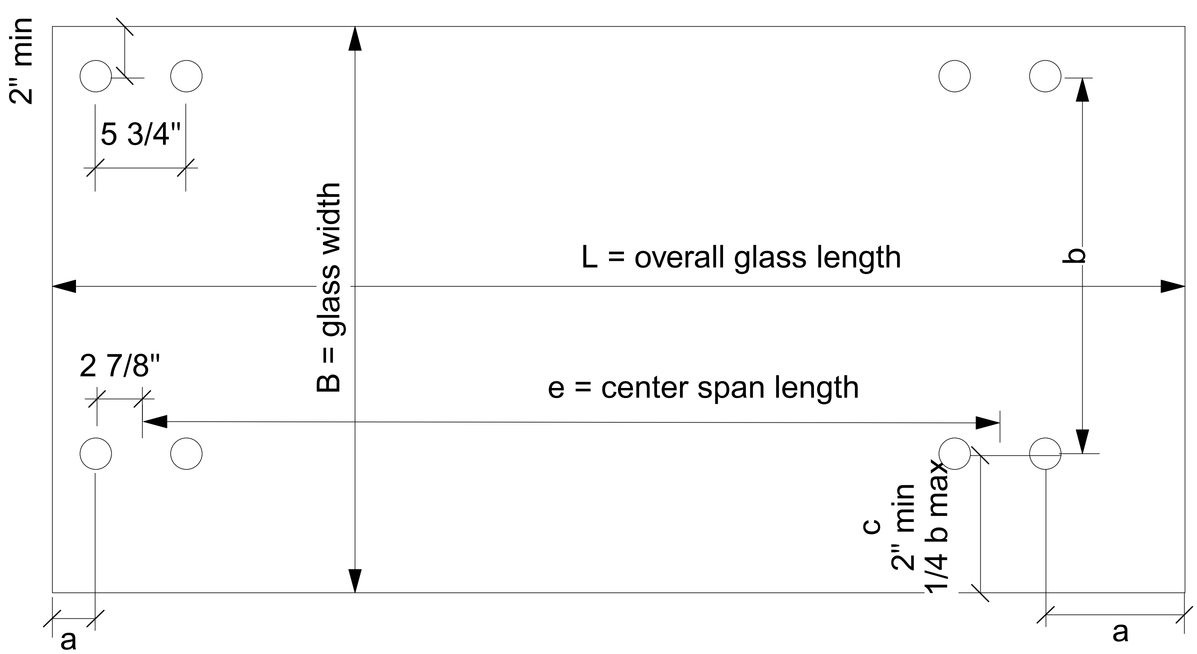
CRL GLASS AWNING SUPPORT SYSTEM
Support hardware for flat panel awnings such as tempered laminated glass.



Dimensions a and c ≥ 2”.
Dimension b is either 17”, 29” or 41”
Dimension d ≥ 2”
Dimension e based on allowable bracket load and glass strength.



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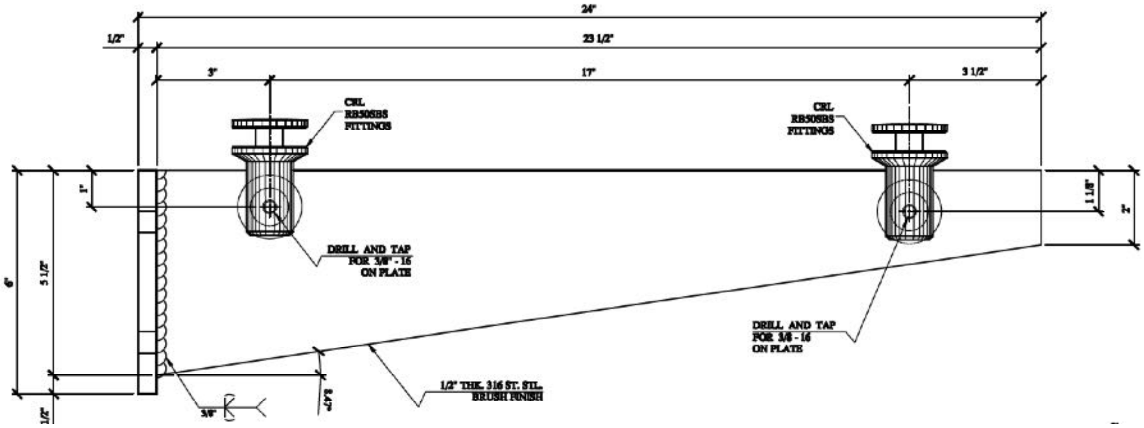
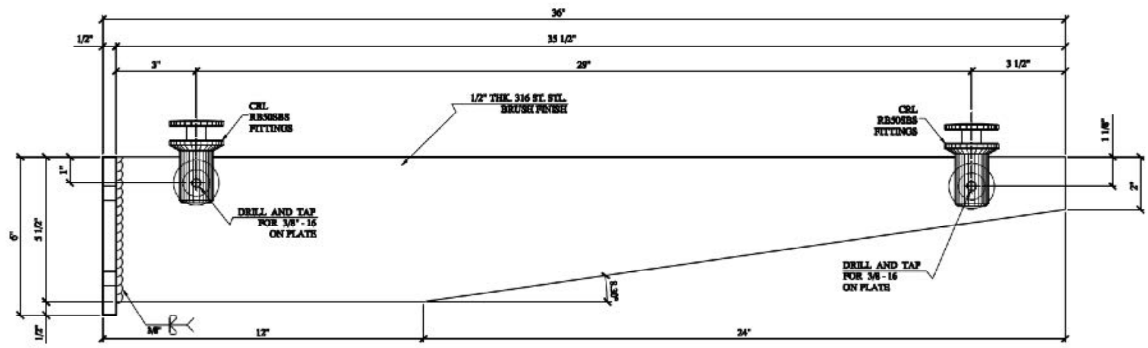
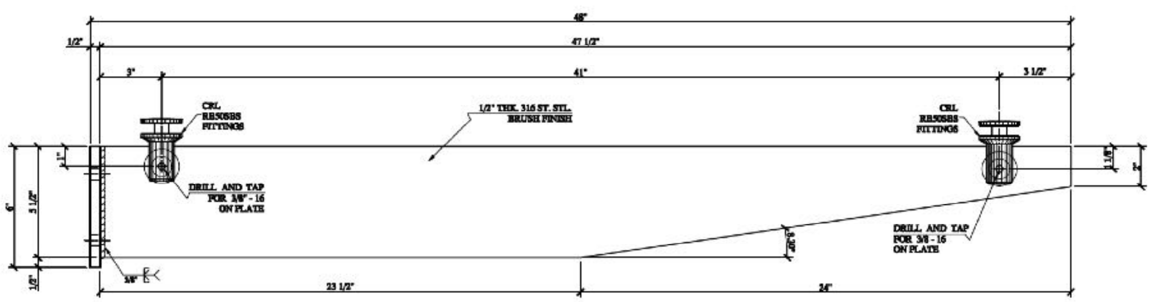


GAB24 Bracket



GAB36 Bracket



GAB48 Bracket

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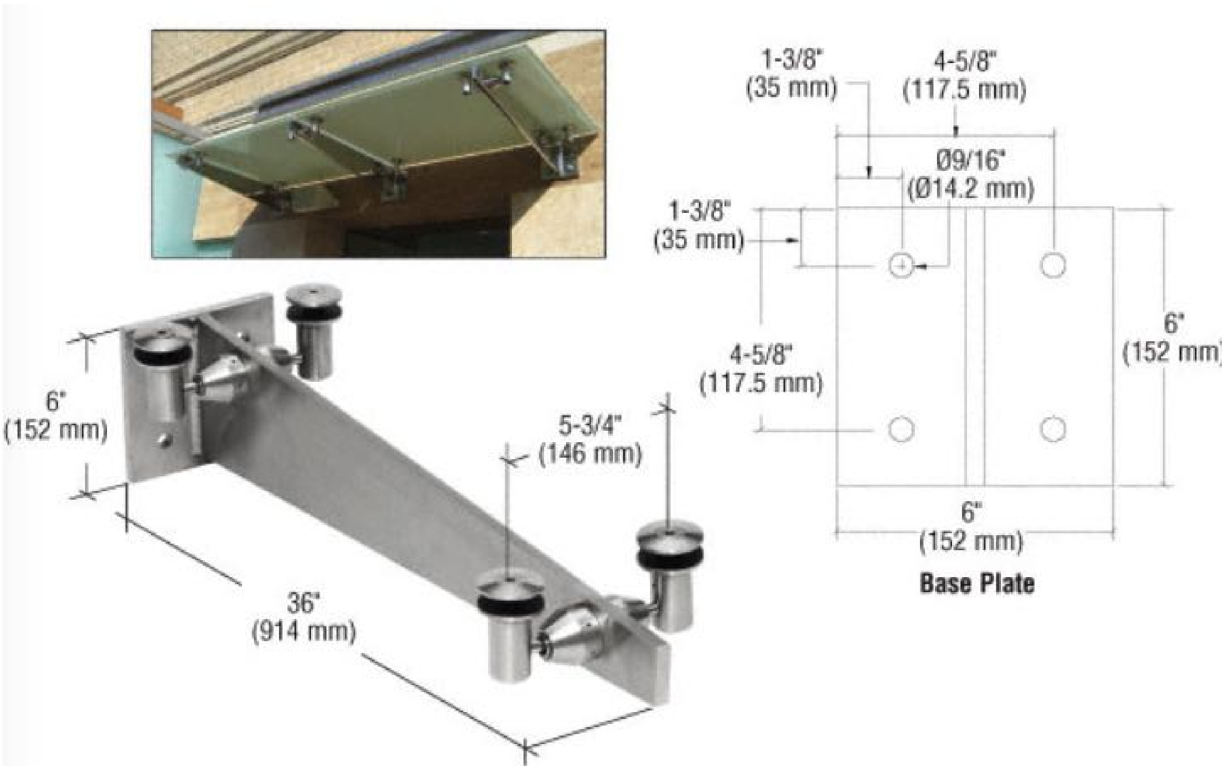
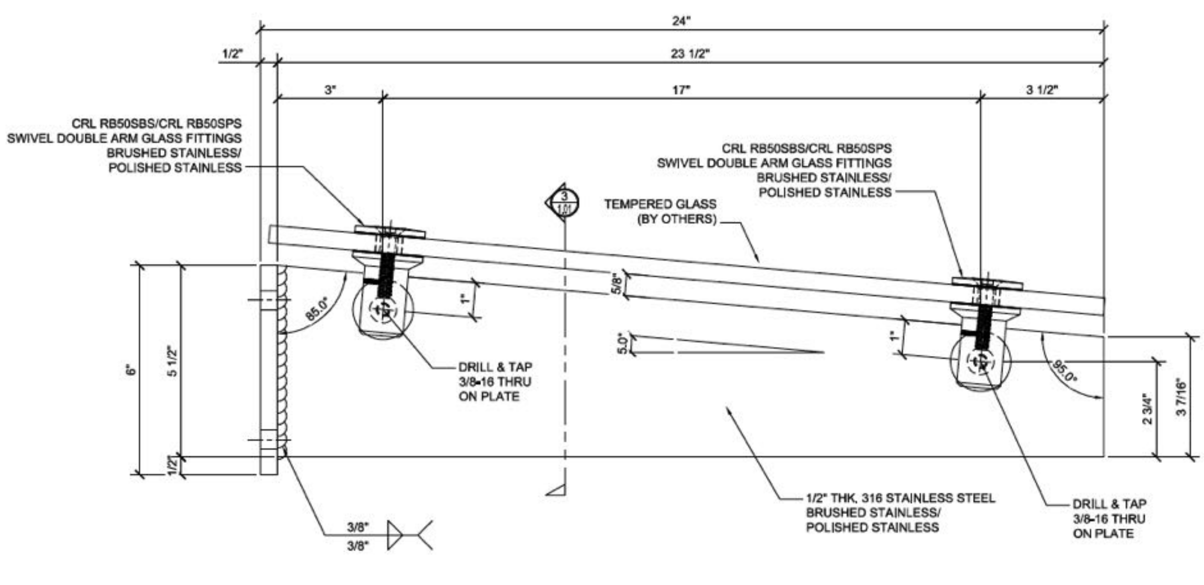


SLOPED BRACKETS:
Sloped brackets provided a slope of 1 to 12 away from the wall.



① CRL GABS24 - 24" GLASS AWNING BRACKET - SLOPE

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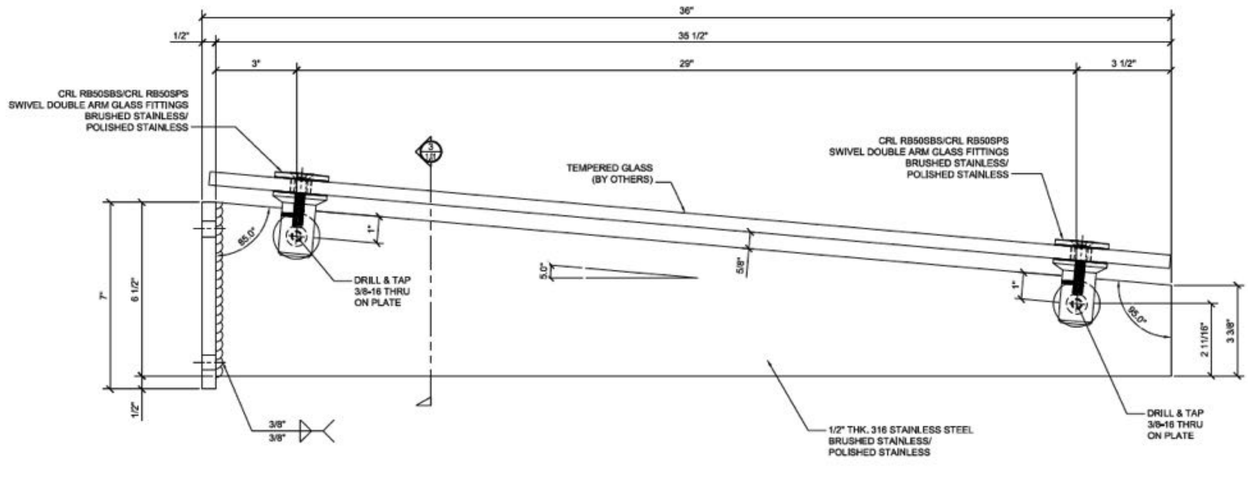
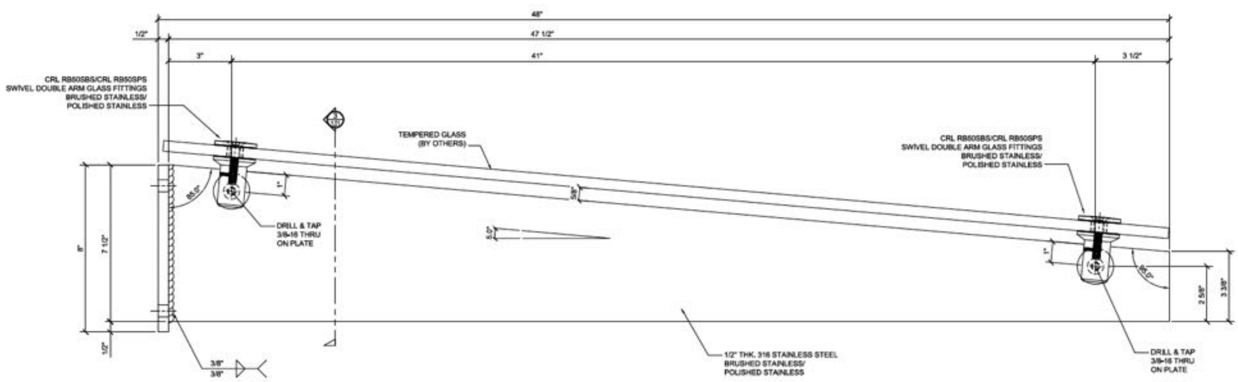


① CRL GABS36 - 36" GLASS AWNING BRACKET - SLOPE



① CRL GABS48 - 48" GLASS AWNING BRACKET - SLOPE

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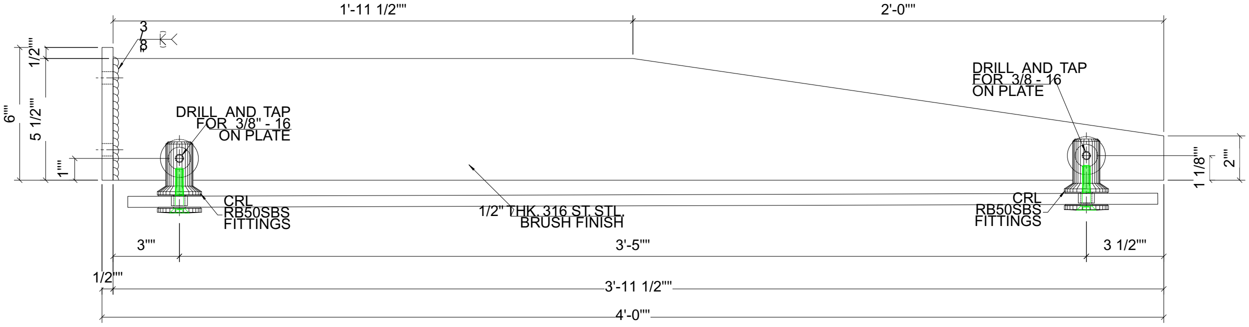
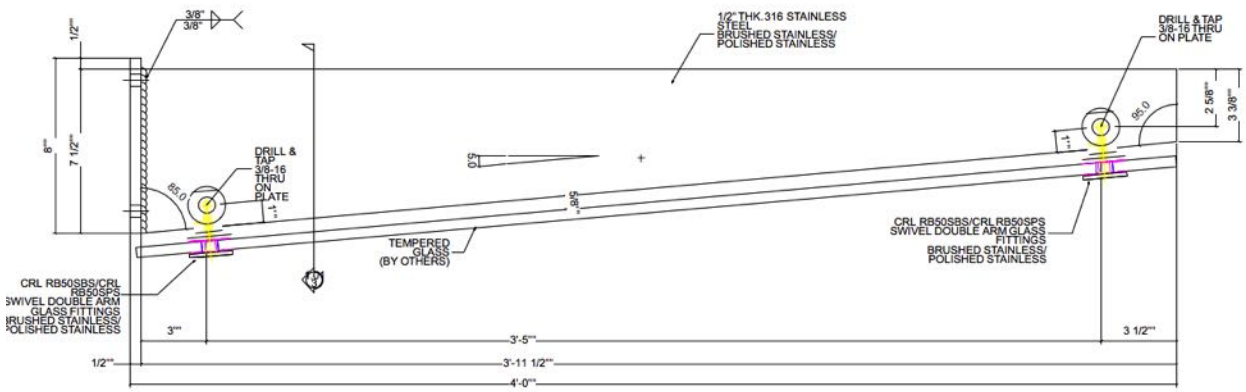
INVERTED BRACKET CONDITION

The brackets, level or sloped may be installed inverted with the glass underneath. When the sloped glass is installed inverted the drainage will be towards the building and a wall gutter will be required.





Allowable loading on the bracket and glass will be the same for the inverted case as for the standard installation.

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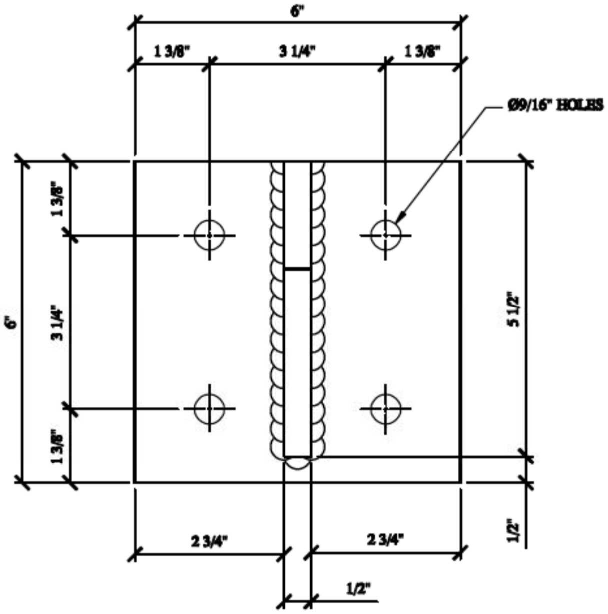
WALL MOUNT



All bracket sizes use the same wall mount. Bracket bar is welded to the wall plate which is bolted to the wall.

Fabricated from 304 stainless steel

Check strength of bar weld to wall plate:
3/8" bevel weld with convex finish both sides.
Weld filler is E316

The weld will provide full penetration weld and develop full bar strength.

Tension strength of weld:
$P_n = LtF_{ua}$ = 6"*0.5"*75ksi = 225k

Shear strength of weld at wall plate:
$V_n = (0.7\text{-}0.009L/t)tLF_{ua}$
V_n = (0.7-0.009*6/.75)(2*0.375")*6"*75ksi = 211.95k
or:
$V_n = 0.75t_wLF_{xx}$ = 0.75*(0.707*.375*2)*6"*75ksi = 178.96k

V_s = 0.65*178.96k = 116.3k ≤ 0.55*211.95 = 116.57k

Allowable moment on the bracket based on weld strength:

M_n = 6"/2*116.3k = 348.9k"

Strength of bar at edge of weld:
$Z = 0.5\text{"}*6\text{"}^2/4 = 4.5\ in^3$
$øM_n = 0.9*4.5in^3*30ksi$ = 121.5k" (bar yield strength controls load).

Maximum factored moment on the bar [1.2D+(1.6S or 1.6W)] or [1.2D+0.75(W+S)]
or for uplift [0.9D+1.6W]
M_u < 121.5k"

Design attachment to wall for the imposed moment:
Loads resisted by couple formed between bolts and plate edge, rotation about edge of plate.

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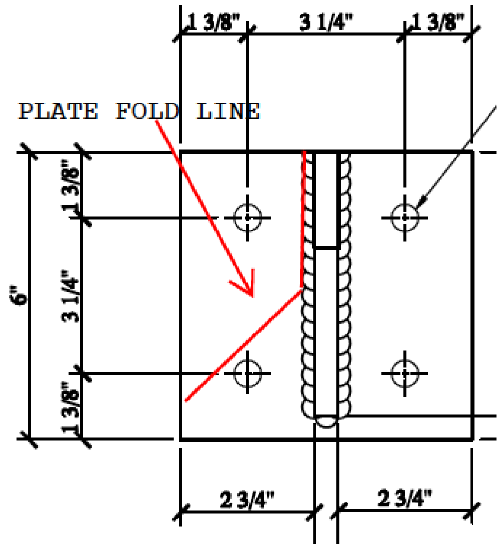

Maximum bolt tension based on plate bending:
Plate bending will occur along a diagonal line from top edge face of bar to edge of plate near other bolt.

bend length = 2.75”+2.75”*√2 = 6.64”
Moment arm = 1.375”
$Z = 6.64\text{”}*0.5^2/4 = 0.415\text{in}^3$
$øM_{np} = 0.9*45\text{ ksi}*0.415\text{in}^3 = 16{,}807\#\text{”}$

Maximum bolt tension based on wall plate bending :
$M = T*1.375\text{”} = øM_n = 16{,}807\#\text{”}$
T =16,807#”/1.375 = 12,223#

Check maximum bolt tension based on bracket plate strength:
Bolt tension from ∑M about edge of wall plate:
$M = 0 = 4.625\text{”}*T*2 + 1.375\text{”}*(1.375/4.625)*T*2 + M_u$
T = 121,000#”/[2*4.625+1.375*1.375/4.625] = 12,527#

Check strength based on anchor alternatives:
1/2” Bolts:
$A_t = 0.1419\text{ in}^2$
$F_{nt} = 100{,}000$ psi DIN 933-A2 or stronger
$øP_n = øA_tF_{nt} = 0.75*0.1419\text{in}^2*100{,}000\text{psi} = 10{,}642\#$
Shear load will be carried by the bolts closest to the compression face of the couple which will be lightly loaded in tension so no reduction for shear load is required.

For bolting to steel frame the maximum moment based on the bolt tension:
$M_s = 10{,}642\#*[2*4.625+1.375*1.375/4.625] = 102{,}793\#\text{”}$
Or for ASD loading combinations, $M_a = 102{,}793\text{”}\#/(2*0.75) = 68{,}500\text{”}\#$

For bolting to wood:
For through bolts the maximum bolt tension can be the same as for steel provided proper bearing plates are used on the nut side (3” x 3” x 1/4” plates or equivalent round washer).

For 1/2” Lag screws into Douglas Fir or Southern Pine:
W = 378#/in,
Minimum embedment depth of 5” (Lag into 6x beam or solid block)
$W' = W*C_D = 375\#\text{”}*1.15$ for snow loads or 375#”*1.6 for wind loads (ASD level)
$T_{a5} = 5\text{”}*378\#\text{”}*1.15 = 2{,}175\#$ for snow loads
$M_{alag} = 2{,}175\#*\#*[2*4.625+1.375*1.375/4.625] = 21{,}008\#\text{”}$

$T_{a5} = 5\text{”}*378\#\text{”}*1.6 = 3{,}024\#$ for wind loads
$M_{alag} = 3{,}024\#*\#*[2*4.625+1.375*1.375/4.625] = 29{,}208\#\text{”}$

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For bolting to concrete:
Hilti Kwik Bolt TZ in accordance with ESR-1917.
1/2" diameter with 4" minimum embedment

Minimum conditions used for the calculations:
$f'_c \geq 3{,}000$ psi
edge distance = 2.75" minimum
2 bolt group (consider only anchors in full tension load)
For concrete breakout strength:
$N_{cbg} = [A_{Nc}/A_{Nco}]\varphi_{ed,N}\varphi_{c,N}\varphi_{cp,N}N_b$
A_{Ncg}= (2.75"+1.5*4")*(1.5*4"*2+3.25) = 133.4in^2 For anchor group
A_{Nco}= 9*4^2 = 144in^2
$C_{ac,min}$ = 1.5*4" = 6
C_{ac} = 2.5*4" = 10
$\varphi_{ed,N} = 1.0$
$\varphi_{c,N}$ = 1.4 (post installed)
$\varphi_{cp,N}$= 6/10 = 0.6 ($c_{a,min} \leq c_{ac}$)
$N_b = 17*1.0*\sqrt{3000}*4^{1.5}$ = 7,449#
N_{cb} = 133.4/144*1.0*1.4*0.6*7,449 = 5,798#
based on concrete breakout strength.
Pullout strength = 2*5,760# = 11,520#
Steel strength:
N_{ts} = 92,000psi*0.101in^2 = 9,292# (each)

Concrete breakout strength in shear:
$V_{cb} = A_{vc}/A_{vco}(\varphi_{ed,V}\varphi_{c,V}\varphi_{h,V}V_b$
$A_{vc} = 3(c_{a1})*4" = 3(2.75")*4" = 33.0$
$A_{vco} = 4.5(c_{a1})^2 = 4.5(2.75)^2 = 34.0$
$\varphi_{ed,V}$= 1.0 (affected by only one edge)
$\varphi_{c,V}$= 1.4 uncracked concrete
$\varphi_{h,V} = \sqrt{(1.5c_{a1}/h_a)} = \sqrt{(1.5*2.75/4)} = 1.016$
$V_b = [7(l_e/d_a)^{0.2}\sqrt{d_a}]\lambda\sqrt{f'_c}(c_{a1})^{1.5} = [7(2/0.5)^{0.2}\sqrt{0.5}]1.0\sqrt{3000}(2.75)^{1.5}$ =1,631#
V_{cb} = 33.0/34.0*1.0*1.4*1.016*1,631# = 2,252#

Design moment for LRFD load combinations:
$øM_n$ = 0.75*11,520*4.625" = 39,960#"
Allowable moment for ASD load combinations:
M_a = 39,960"#/1.6 = 24,975"#

Limit based on RB50F glass fitting strength (see page 29)
u ≤ 2*429 = 858# for two fittings per bracket
u ≤ 4*429 = 1,716# for four fittings per bracket
For higher loads heavy duty spider fittings may be used in place of the RB50F fittings

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SUMMARY OF ALLOWABLE BRACKET LOADS BASED ON ANCHORAGE

Table 1A:	Load Limit	Bracket Total Load lbs*		
Anchor	M_a"#	GAB24	GAB36	GAB48
Steel	102793	8566	5711	4283
Concrete	24975	2081	1388	1041
Wood-snow	21008	1751	1167	875
Wood-wind	29208	2434	1623	1217
Table Formula	M_a"#	2×Ma"#/24"	2×Ma"#/36"	2×Ma"#/48"

Glass width B is matched to bracket length.
For each size bracket determine maximum allowable loads on awning:
Based on M = R*L/2 or R = 2M/L
where R is total allowable load on bracket and L = bracket length and glass width.
*May be limited by the glass fitting strength.

FOR GLASS WIDTHS OTHER THAN THE BRACKET LENGTH:

Table 1B:	Load Limit	Bracket Total Load lbs*				
Anchor	M_a"#	$B_{glass} = 24$	$B_{glass} = 36$	$B_{glass} = 48$	$B_{glass} = 54$	$B_{glass} = 60$
Steel	102793	8566	5711	4283	3807	3426
Concrete	24975	2081	1388	1041	925	833
Wood-snow	21008	1751	1167	875	778	700
Wood-wind	29208	2434	1623	1217	1082	974
Table Formula	M_a"#	2×Ma"#/ 24"	2×Ma"#/ 36"	2×Ma"#/ 48"	2×Ma"#/ 54"	2×Ma"#/ 60"

B_{glass} = glass width measured from face of wall to outside edge of glass. This may be larger than the actual glass width.
Linear interpolation is permitted.
Allowable loads for other glass widths may be calculated from the equation:
$R_a = 2M_a/B_{glass}$
*May be limited by the glass fitting strength.

The total loads shall not exceed the loads above for the load combinations:
S + D
W + D
W - D (negative pressure) or
0.5S+ W + D positive wind or
S + 0.5W + D positive wind

D = 6.5 psf of 9/16
D = 8.9 psf for 11/16
D = 10.0 psf for 13/16

R = L*B*u/2

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For GAB24:
Glass width, B = 24”
Bracket weight: D_b = [0.5”*(6+2)/2]*24”*0.28#/ci +2*1.3# = 16#
For 9/16” laminated glass (1/4”+.05”+1/4”) D_g = 2*2.9+0.5 = 6.3 psf
L = glass length (ft)
M_{Df} = 16#*12”+(6.3psf*2’*L/2)*12” = 192#”+(75.6L)#”
Snow load or Wind (ASD level) load
S_b = (Spsf*2’*L/2) = S*L plf
W_b = (Wpsf*2’*L/2) = W*L plf
M_{bS} = S*L plf*12”
M_{bW} = W*L plf*12”

For service loads (Steel or concrete)
M_s = 1.2*(192#”+(75.6L)#”) + 1.6(S*L#*12”) = 230.4#”+90.72L+19.2S*L or
M_s = 1.2*(192#”+(75.6L)#”) + 1.6(W*L#*12”) = 230.4#”+90.72L+19.2W*L or
M_s = 1.2*(192#”+(75.6L)#”) + 0.75[(S+W)*L#*12”] = 230.4#”+90.72L+9(S+W)*L or
M_s = 0.9*(192#”+(75.6L)#”) + 1.6(W*L#*12”) = 172.8#”+68.0L+19.2W*L for uplift

Based on glass strength the maximum bracket spacing, e = 8’-0” for 1/2” glass and 25 psf wind (ASD level) or snow load. The maximum cantilever length, d = 4’-0”

Check brackets based on the maximum allowable length of 16’ (4’+8’+4’) with 25 psf load.
M_s = 230.4 + 90.72*16’ + 19.2*25psf*16’ = 9,362#” or
M_s = 230.4#”+90.72*16+9(25+25)*16 = 8,882#”
M_s = 172.8#”+68.0*16 - 19.2*25*16 = -6,419#” for uplift

For allowable loads (wood)
M_a = (192#”+(75.6L)#”) + (S*L#*12”) = 192#”+75.6L+12S*L or
M_a = (192#”+(75.6L)#”) + (W*L#*12”) = 192#”+75.6L+12W*L or
M_a = (192#”+(75.6L)#”) + 0.75[(S+W)*L#*12”] = 192#”+75.6L+9(S+W)*L or
M_a = 0.6(192#”+(75.6L)#”) + (W*L#*12”) = 115.2#”+45.36L+12W*L for uplift

Check brackets based on the maximum allowable length of 16’ (4’+8’+4’) with 25 psf load.
M_a = 192#”+75.6*16+12*25*16 = 6,202#” or
M_a = 192#”+75.6*25+9(25+25)*16 = 6,882#” or
M_a = 115.2#”+ 45.36*16 - 12*25*16 = -3,959#” for uplift

Attachments to wood, concrete or steel are adequate for the maximum canopy size and 25 psf wind (ASD level) or snow loads.

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For GAB36:
Glass width, B = 36”
Bracket weight: D_b = [0.5”*{(6+2)/2*24”+12*6}]*0.28#/ci +2*1.3# = 26.1#
For 9/16” laminated glass (1/4”+.05”+1/4”) D_g = 2*2.9+0.5 = 6.3 psf
L = glass length (ft)
M_{Df} = 26.1#*18”+(6.3psf*3’*L/2)*18” = 469.8#”+(170.1L)#”
Snow load or Wind (ASD level) load
S_b = (Spsf*3’*L/2) = 1.5S*L plf
W_b = (Wpsf*3’*L/2) = 1.5W*L plf
M_{bS} = 1.5S*L plf*18” = 27SL
M_{bW} = 1.5W*L plf*18” = 27SL

For service loads (Steel or concrete)
M_s = 1.2*(469.8#”+(170.1L)#”) + 1.6(S*L#*27) = 563.76#”+204.12L+43.2SL or
M_s = 1.2*(469.8#”+(170.1L)#”) + 1.6(W*L#*27) = 563.76#”+204.12L+43.2WL or
M_s = 1.2*(469.8#”+(170.1L)#”)+0.75[(S+W)L#*27]=563.76#”+204.12L+20.25(S+W)L
M_s = 0.9*(469.8#”+(170.1L)#”) + 1.6(W*L#*27) = 422.82#”+153.09L+43.2W*L uplift

Based on glass strength the maximum bracket spacing, e = 8’-0” for 1/2” glass and 25 psf wind (ASD level) or snow load. The maximum cantilever length, d = 4’-0”

Check brackets based on the maximum allowable length of 16’ (4’+8’+4’) with 25 psf load.
M_s = 563.76#”+204.12*16+43.2*25*16 = 21,110#”
M_s = 563.76#”+204.12*16+20.25(25+25)*16 = 20,030#”
M_s = 422.82#”+153.09*16 -43.2*25*16 = -14,408#” uplift

For allowable loads (wood)
M_a = (469.8#”+(170.1L)#”) + (S*L#*27”) = 469.8#”+170.1L+27S*L or
M_a = (469.8#”+(170.1L)#”) + (W*L#*27”) = 469.8#”+170.1L+27W*L or
M_a = (469.8#”+(170.1L)#”) + 0.75[(S+W)*L#*27] = 469.8#”+170.1L+20.25(S+W)*L or
M_a = 0.6(469.8#”+(170.1L)#”) + (W*L#*27) = 281.88#”+102.06L+27W*L for uplift

Check brackets based on the maximum allowable length of 16’ (4’+8’+4’) with 25 psf load.
M_a = 469.8#”+170.1*16+27*25*16 = 13,991#” or
M_a = 469.8#”+170.1*16+20.25(25+25)*16 = 19,391#”
M_a = 281.88#”+102.06*16 -27*25*16 = -8,885#”

Attachments to wood, concrete or steel are adequate for the maximum canopy size and 25 psf wind (ASD level) or snow loads.

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For GAB48:
Glass width, B = 48”
Bracket weight: D_b = [0.5”*{(6+2)/2*24”+24*6}]*0.28#/ci +2*1.3# = 36.2#
For 9/16” laminated glass (1/4”+.05”+1/4”) D_g = 2*2.9+0.5 = 6.3 psf
L = glass length (ft)
M_{Df} = 36.2#*20”+(6.3psf*4’*L/2)*24” = 724#”+(302.4L)#”
Snow load or Wind (ASD level) load
S_b = (Spsf*4’*L/2) = 2S*L plf
W_b = (Wpsf*4’*L/2) = 2W*L plf
M_{bS} = 2S*L plf*24” = 48SL
M_{bW} = 2W*L plf*24” = 48SL

For service loads (Steel or concrete)
M_s = 1.2*(724#”+(302.4L)#”) + 1.6(S*L#*48) = 868.8#”+362.88L+76.8SL or
M_s = 1.2*(724#”+(302.4L)#”) + 1.6(W*L#*48) = 868.8#”+362.88L+76.8WL or
M_s = 1.2*(724#”+(302.4L)#”) +0.75[(S+W)L#*48]=868.8#”+362.88L+36(S+W)L
M_s = 0.9*(724#”+(302.4L)#”) + 1.6(W*L#*48) = 651.6#”+272.16L+76.8W*L uplift

Based on glass strength the maximum bracket spacing, e = 8’-0” for 1/2” glass and 25 psf wind (ASD level) or snow load. The maximum cantilever length, d = 4’-0”

Check brackets based on the maximum allowable length of 16’ (4’+8’+4’) with 25 psf load.
M_s = 868.8#”+362.88*16+76.8*25*16 = 37,395#” or
M_s = 868.8#”+362.88*16+36(25+25)*16 = 35,475#”
M_s = 651.6#”+272.16*16 - 76.8*25*16 = -25,714#” uplift

For allowable loads (wood)
M_a = (724#”+(302.4L)#”) + (S*L#*48”) = 724#”+302.4L+48S*L or
M_a = (724#”+(302.4L)#”) + (W*L#*48”) = 724#”+302.4L+48W*L or
M_a = (724#”+(302.4L)#”) + 0.75[(S+W)*L#*48] = 724#”+302.4L+36(S+W)*L or
M_a = 0.6(724#”+(302.4L)#”) + (W*L#*48) = 434.4#”+181.44L+48W*L for uplift

Check brackets based on the maximum allowable length of 16’ (4’+8’+4’) with 25 psf load.
M_a = 724#”+302.4*16+48*25*16 = 24,762#” or
M_a = 724#”+302.4*16+36 (25+25)*16 = 34,362#” > 21,008#”
M_a = 434.4#”+181.44*16 -48*25*16 = -15,863#”

L_{wood} ≤ 21,008/34,362*16 = 9.78’ = 9’-9”
For attachment to wood maximum length L = 9’-9”

Attachments to concrete and steel are adequate for the maximum canopy size and 25 psf wind (ASD level) or snow loads.

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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. Allowable glass stress based on ASTM E1300-12a appendices X5 and X7.

Allowable glass edge stresses: 10,600 psi for 3 sec load duration

wind load: 0.93*10,600 = 9,860 psi (60 sec)
live load: = 6,000 psi
snow load: 0.43*10,600 = 4,558 psi (30 day)
dead load: 0.31*10,600 = 3,286 psi (permanent)

Determine effective thickness of the laminated glass for stresses and deflections based on ASTM E1300-12a appendix X11.

$h_1 = h_2 = 0.219''$ (for 1/4" glass plies)
$h_v = 0.06''$ (typical interlayer thickness)
a = minimum glass dimension, width or length - 48" for this sample calculation
$h_s = 0.5(h_1+h_2)+h_v = 0.5(0.219*2)+0.06 = 0.279''$
$h_{s;1} = h_{s;2} = (h_s h_1)/(h_1+h_2) = (0.279*0.219)/(2*0.219) = 0.1395$
$I_s = h_1 h^2_{s;2} + h_2 h^2_{s;1} = 2*(0.219*0.279''^2) = 0.034$
$\Gamma = 1/[1+9.6(EI_s h_v)/(Gh^2_s a^2)]$
For heat and size use interlayer shear modulus of 70 psi (T ≤ 133 F°)
$\Gamma = 1/[1+9.6(10{,}400{,}000*0.034*0.06)/(70*0.279^2*48^2)] = 0.0658$

effective thickness for deflection:
$h_{ef;w} = (h_1^3 + h^3_2 + 12\Gamma I_s)^{1/3} = (0.219^3 + 0.219^3 + 12*0.0658*0.034)^{1/3} = 0.363 \le 0.498$

effective thickness for glass stress:
$h_{1;ef;\sigma} = [h_{ef;w}^3/(h+2\Gamma h_{s;1})]^{1/2} = [0.363^3/(0.219+2*0.0658*0.1395)]^{1/2} = 0.449 \le 0.498$

$I_e = h_{ef;w}^3 = 0.363^3 = 0.0478\ in^4/ft$

$S_e = 2\ h_{1;ef;\sigma}{}^2 = 2*0.449^2 = 0.403\ in^3/ft$

Bending strength of glass for the given thickness:

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

Allowable bending moment on glass is:

M_{as} = 9,600 psi*0.403 in³/ft = 3,868.8"#/ft short duration loads
M_{alt} = 0.43*9,600 psi*0.403 in³/ft = 1,664"#/ft = 138.6'#/ft 1 month loads
M_{aper} = 0.31*9,600 psi*0.403 in³/ft = 1,199"#/ft = 99.9'#/ft permanent loads

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Table 2	h_1, h_2	h_v		$h_{s;1}$ $h_{s;2}$		I_s	h_s	Allowable Moment , M_{ga}, ("#/ft)				
6mm	0.219	0.06		0.1395		0.0085	0.279					
6mm	0.219	0.06		0.1395		0.0085	0.279					
Short Dim. B	**Γ PVB**	**Γ SGP**	**$h_{ef;w}$ PVB**	**$h_{ef;w}$ SGP**	**$h_{1;ef;\sigma}$ PVB**	**$h_{1;ef;\sigma}$ SGP**	wind PVB	wind SGP	snow PVB	snow SGP	Dead PVB	Dead SGP
24	0.058	0.590	0.300	0.433	0.338	0.461	2258	4182	1044	1933	753	1394
36	0.121	0.764	0.322	0.463	0.364	0.479	2607	4525	1205	2092	869	1508
48	0.197	0.852	0.345	0.476	0.388	0.487	2964	4670	1370	2159	988	1556
54	0.237	0.879	0.356	0.481	0.398	0.489	3131	4712	1447	2178	1043	1570
60	0.278	0.900	0.367	0.484	0.408	0.490	3286	4743	1519	2192	1095	1581
66	0.317	0.916	0.377	0.486	0.417	0.492	3428	4766	1585	2203	1143	1588
72	0.356	0.928	0.386	0.488	0.425	0.493	3558	4784	1645	2211	1186	1594

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/a where B is always the smaller dimension.
When B/e < 0.33 C_e may be taken as 0.125, C_e is maximum of 0.1606 at B/e = 1.0
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
$M_c = P*d$
d = length of cantilever past the supports
Dead load equivalent load = 6.3/(0.31/0.83) = 16.9 (adjusted to 60 sec load equivalent)
For a design load of W = 25 psf (wind (ASD level))
U = 25+16.9 = 41.9 psf
Based on assumed b/e ≤ 0.33 and width B = 24", PVB interlayer
$e = [(2{,}258"\#/12)*8/41.9psf]^{1/2} = 5.994'$
e = 2,258"#*4/50 = 180.6" concentrated loads won't control
$d = [(2{,}258"\#/12)*2/41.9psf]^{1/2} = 2.997'$ Cantilevered length
d = 2'*2,258"#/50 = 90" concentrated loads won't control

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The allowable uniform load may be calculated using:

$U_s = [(M_{ga}/C_e)/e^2]$ or

$U_s = [(M_{ga}/(4C_e))/d^2]$

or for long term loads:

$U_{lt} = [(138.6/C_e)/e^2]$ or

$U_{lt} = [(138.6/(4C_e))/d^2]$

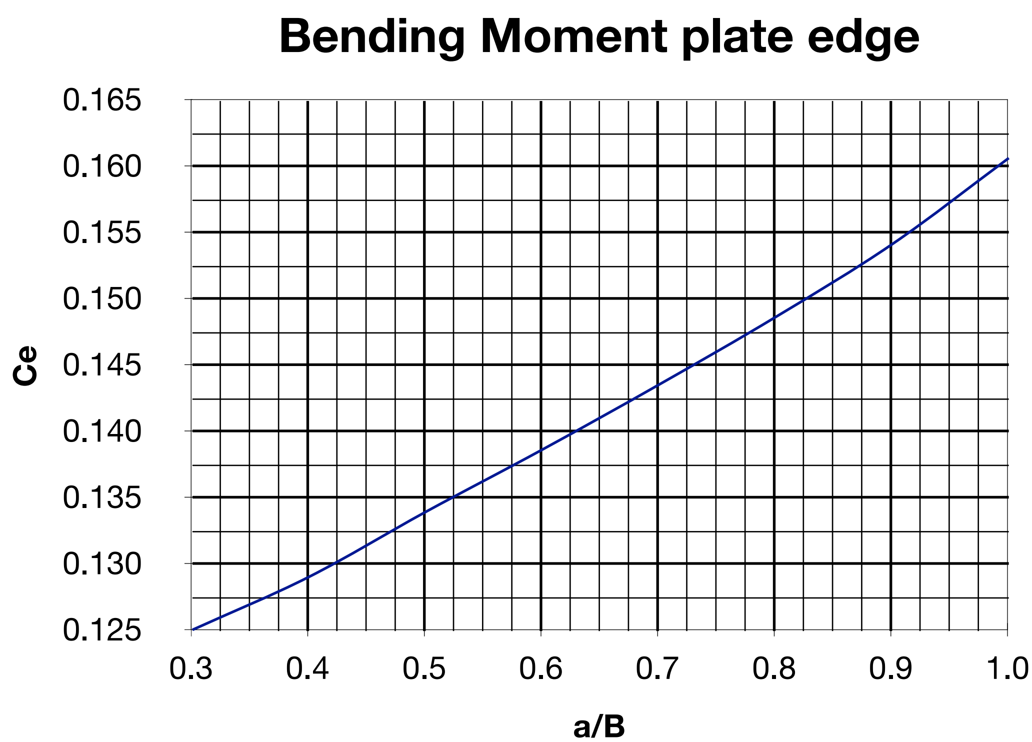
or for permanent loads:

$U_{per} = [(99.9/C_e)/e^2]$ or

$U_{per} = [(99.9/(4C_e))/d^2]$

For multiple types of load:

$U_s/M_{as} + U_{lt}/M_{alt} + U_{per}/M_{aper} \leq 1.0$



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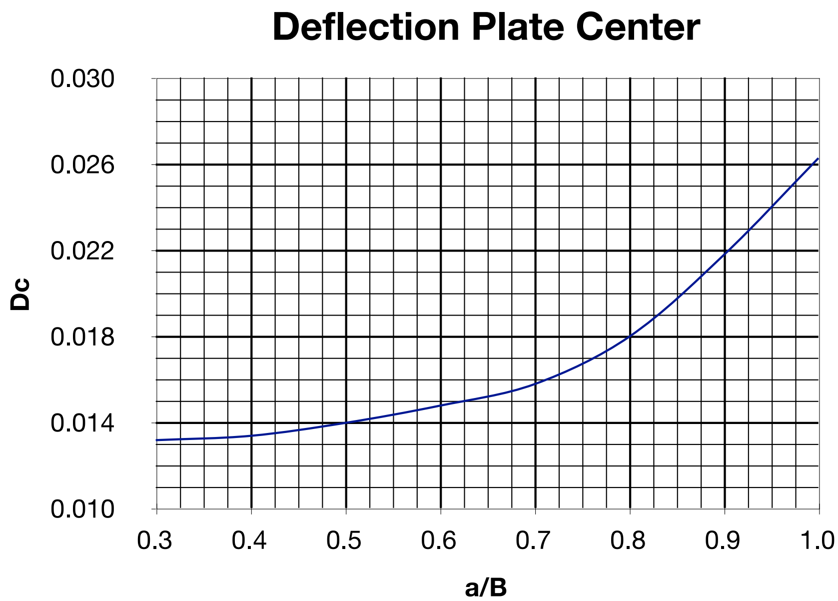
GLASS DEFLECTIONS

SINGLE SPAN WITH SHORT CANTILEVERS.
For awning supported with two brackets and glass cantilever less than 6" or 0.12 x glass length whichever is greater.



As this represents a simplification based on zero cantilever length the true glass deflection is overestimated. This overestimate becomes greater as the cantilever length increases. For cantilevers longer than this use the CANTILEVERED ENDS case.

NOTE:
Visual sagging of the glass will occur at the design loads.
For longer glass spans sagging from dead loads may be visible.

Glass deflections assuming minimal end overhangs-
For dead loads, L in inches

$$\Delta = \frac{\eta 12(1-\nu^2)u\ psi*e^4}{Et^3} =$$

$$\frac{\eta(1-0.22^2)u/12\ psf*e^4}{10{,}400{,}000*h_{ef;w}^3}$$

u = uniform load:

maximum recommended deflection for dead loads = L/480 = e/480

$$\Delta_D = \frac{e}{480} = \frac{\eta(1-0.22^2)6.5psf/12\ psf*e^4}{10{,}400{,}000*h_{ef;w}^3}$$

solving for e:

$e = 272.2*(\eta)^{1/3}*h_{ef;w}$

Glass deflection for 20 psf unit load:

$$\Delta_{10} = \frac{\eta(1-0.22^2)20/12\ psf*e^4}{10{,}400{,}000*h_{ef;w}^3} = \frac{\eta e^4}{6557377*h_{ef;w}^3} =$$

Glass deflection for 6.5 psf dead load:

$$\Delta_{10} = \frac{\eta(1-0.22^2)6.5/12\ psf*e^4}{10{,}400{,}000*h_{ef;w}^3} = \frac{\eta e^4}{20176545*h_{ef;w}^3} =$$

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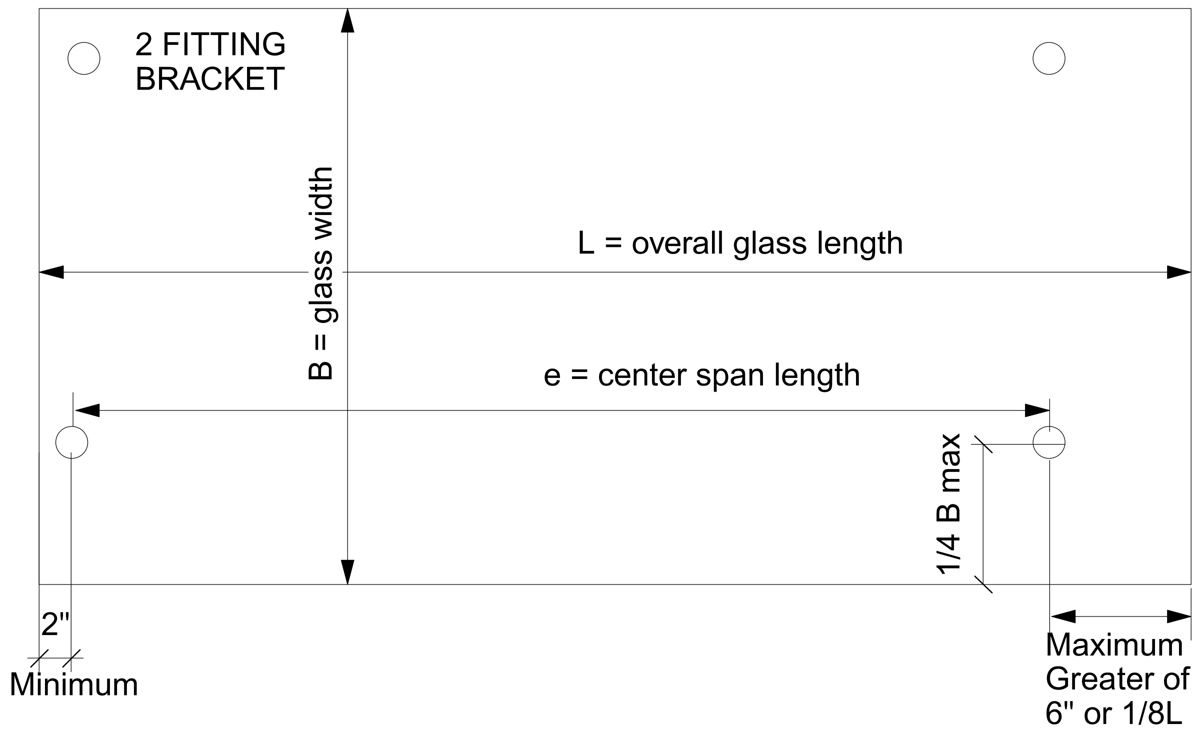
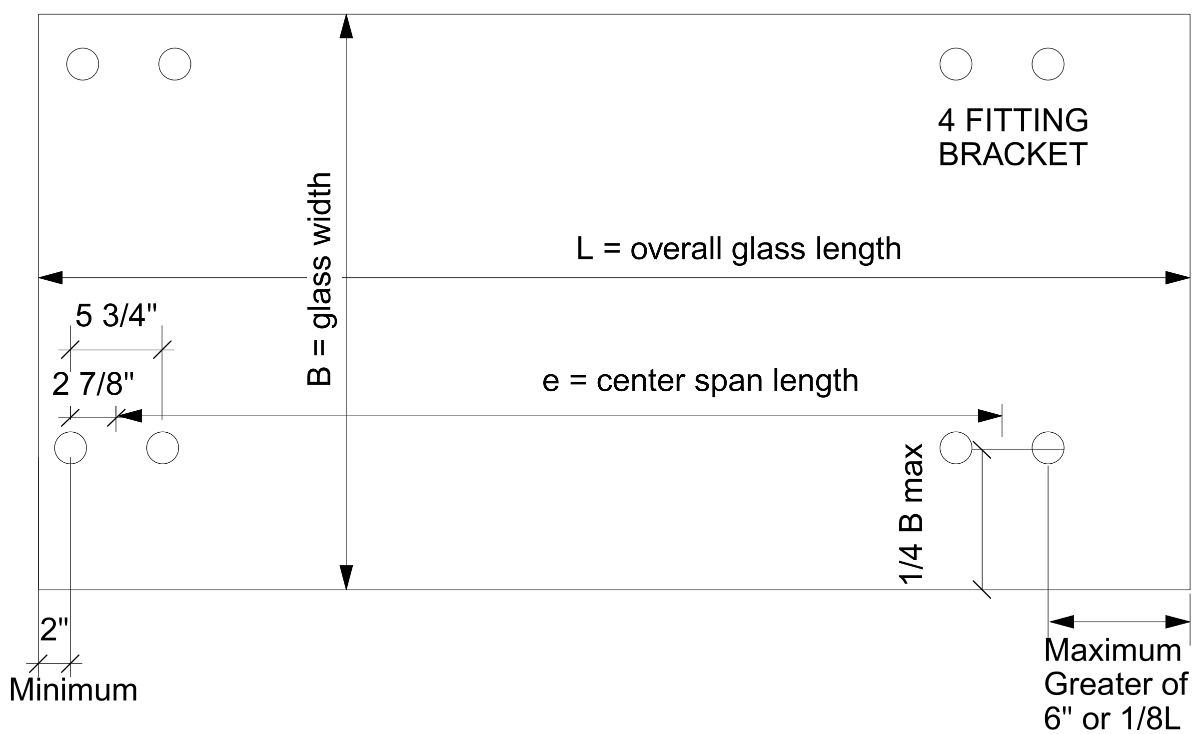
AWNING DIMENSIONS - SHORT CANTILEVERS

For use of these equations and the following tables to determine the allowable glass loads and deflections the awning dimensions shall be within the limits shown in this figure.





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LOAD/DEFLECTION TABLES - SHORT CANTILEVERS

Glass width B		9/16" Lam. Temp. Glass		$h_{ef;w}$ PVB	$h_{ef;w}$ SGP	$h_{1;ef;\sigma}$ PVB	$h_{1;ef;\sigma}$ SGP	Cantilevered ends under 6" or 1/8th of length					
24				0.3000	0.4330	0.3380	0.4610	PVB	SGP	PVB	SGP		
e	b/e	Ce	η	Δd 6.5psf	Δd 6.5psf	σ dead 6.5psf	σ dead 6.5psf	Δu 20psf	Δu 20psf	σ u 20psf	σ u 20	L/480	L/175
24.0	1.00	0.1606	0.0263	0.0160	0.0053	219	118	0.0493	0.0164	675	363	0.0500	0.1371
36.0	0.67	0.1424	0.1550	0.4779	0.1589	438	235	1.4704	0.4890	1346	724	0.0750	0.2057
48.0	0.50	0.1339	0.0140	0.1364	0.0454	731	393	0.4198	0.1396	2250	1210	0.1000	0.2743
60.0	0.40	0.1290	0.0134	0.3188	0.1060	1101	592	0.9809	0.3262	3387	1821	0.1250	0.3429
72.0	0.33	0.1260	0.0133	0.6561	0.2182	1548	832	2.0188	0.6714	4765	2561	0.1500	0.4114

To calculate the deflection for loads other than 20 psf:
Find deflection, Δ_u for the glass width and spans, b, b/e from the tables above.
Multiply table deflection by the desired load (U) divided by 20
$\Delta = \Delta_u * U/20$
For total deflection add Δ_d
Similar for stress:
$\sigma = \sigma_u * U/20$
Verify stress is acceptable based on load combinations (all must be checked):
$\sigma_s/4558 + \sigma_d/3286 \leq 1.0$ for snow loads or
$\sigma_w/9600 + \sigma_d/3286 \leq 1.0$ for wind loads (positive pressure) or
$\sigma_w/9600 - \sigma_d/3286 \leq 1.0$ for wind loads (negative pressure) or
$0.5*\sigma_s/4558 + \sigma_w/9600 + \sigma_d/3286 \leq 1.0$ for snow loads with positive wind or
$\sigma_s/4558 + 0.5\sigma_w/9600 + \sigma_d/3286 \leq 1.0$ for snow loads with positive wind

Glass width B		9/16" Lam. Temp. Glass		$h_{ef;w}$ PVB	$h_{ef;w}$ SGP	$h_{1;ef;\sigma}$ PVB	$h_{1;ef;\sigma}$ SGP	Cantilevered ends under 6" or 1/8th of length					
36				0.3220	0.4630	0.3640	0.4790	PVB	SGP	PVB	SGP		
e	b/e	Ce	η	Δd 6.5psf	Δd 6.5psf	σ dead 6.5psf	σ dead 6.5psf	Δu 20psf	Δu 20psf	σ u 20psf	σ u 20	L/480	L/175
36.0	1.00	0.1606	0.0263	0.0656	0.0221	425	246	0.2018	0.0679	1309	756	0.0750	0.2057
48.0	0.75	0.1460	0.0167	0.1316	0.0443	688	397	0.4049	0.1362	2116	1222	0.1000	0.2743
60.0	0.60	0.1386	0.0148	0.2847	0.0958	1020	589	0.8761	0.2947	3138	1812	0.1250	0.3429
72.0	0.50	0.1339	0.0140	0.5585	0.1879	1419	819	1.7185	0.5781	4366	2521	0.1500	0.4114
84.0	0.43	0.1310	0.0136	1.0052	0.3381	1889	1091	3.0928	1.0404	5814	3357	0.1750	0.4800

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Glass width B		9/16" Lam. Temp. Glass		$h_{ef;w}$ PVB	$h_{ef;w}$ SGP	$h_{1;ef;\sigma}$ PVB	$h_{1;ef;\sigma}$ SGP	Cantilevered ends under 6" or 1/8th of length					
48				0.3450	0.4760	0.3880	0.4870	PVB	SGP	PVB	SGP		
e	b/e	Ce	η	Δ d 6.5psf	Δ d 6.5psf	σ dead 6.5psf	σ dead 6.5psf	Δ u 20psf	Δ u 20psf	σ u 20psf	σ u 20	L/480	L/175
48.0	1.00	0.1606	0.0263	0.1685	0.0642	666	423	0.5185	0.1974	2048	1300	0.1000	0.2743
60.0	0.80	0.1486	0.0180	0.2816	0.1072	962	611	0.8663	0.3299	2961	1880	0.1250	0.3429
72.0	0.67	0.1424	0.0155	0.5028	0.1914	1328	843	1.5469	0.5890	4086	2594	0.1500	0.4114
78.0	0.62	0.1395	0.0150	0.6701	0.2552	1527	969	2.0620	0.7851	4698	2982	0.1625	0.4457
84.0	0.57	0.1374	0.0146	0.8773	0.3340	1744	1107	2.6995	1.0278	5367	3406	0.1750	0.4800

Glass width B		9/16" Lam. Temp. Glass		$h_{ef;w}$ PVB	$h_{ef;w}$ SGP	$h_{1;ef;\sigma}$ PVB	$h_{1;ef;\sigma}$ SGP	Cantilevered ends under 6" or 1/8th of length					
54				0.3560	0.4810	0.3980	0.4890	PVB	SGP	PVB	SGP		
e	b/e	Ce	η	Δ d 6.5psf	Δ d 6.5psf	σ dead 6.5psf	σ dead 6.5psf	Δ u 20psf	Δ u 20psf	σ u 20psf	σ u 20	L/480	L/175
54.0	1.00	0.1606	0.0263	0.2457	0.0996	801	530	0.7559	0.3065	2464	1632	0.1125	0.3086
60.0	0.90	0.1541	0.0218	0.3104	0.1258	949	628	0.9550	0.3872	2918	1933	0.1250	0.3429
66.0	0.82	0.1495	0.0182	0.3794	0.1538	1113	738	1.1673	0.4732	3426	2269	0.1375	0.3771
72.0	0.75	0.1460	0.0167	0.4930	0.1999	1294	857	1.5169	0.6150	3982	2638	0.1500	0.4114
84.0	0.64	0.1410	0.0151	0.8258	0.3348	1701	1127	2.5411	1.0302	5234	3467	0.1750	0.4800

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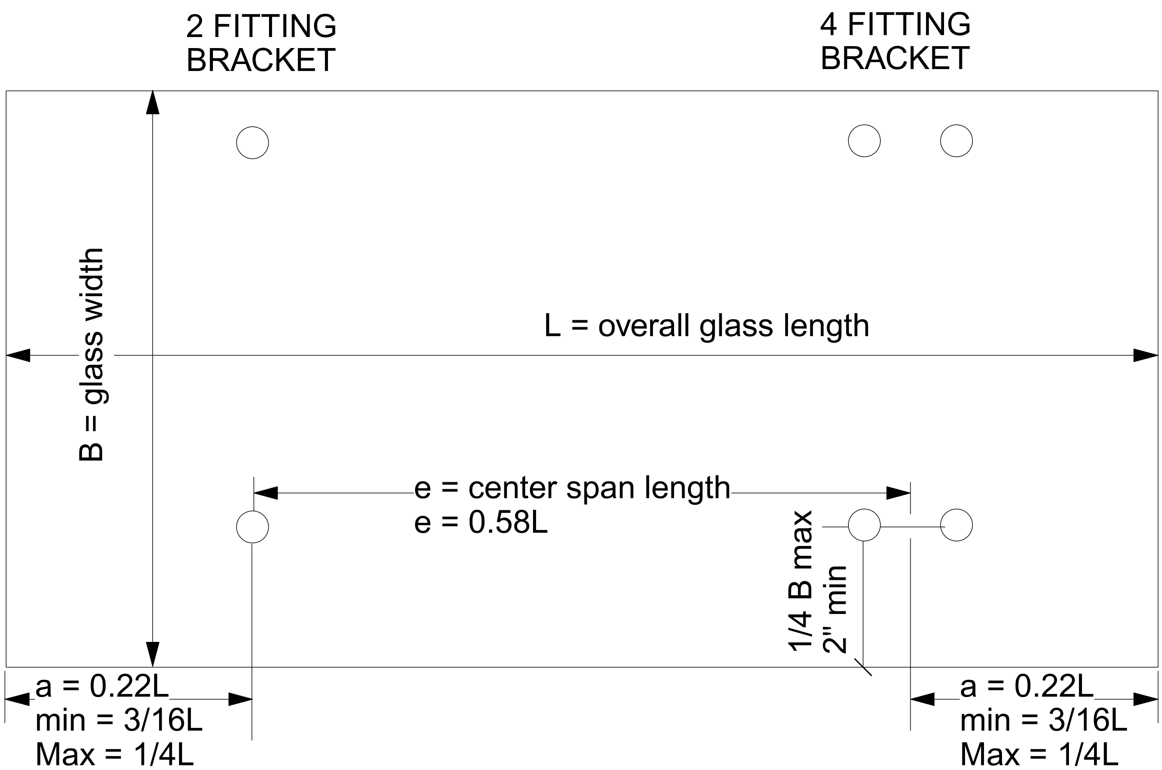
SINGLE SPAN WITH BALANCED CANTILEVERS
The awnings may be constructed with balanced cantilevers so that under dead load or uniform transient loads the glass will be nearly level. This occurs at cantilever length = 0.22 L
As this may not be practical for most installations the assumption of minimal dead load or balanced load deflections may be applied to awnings with cantilevers between 3/16 L and 0.25L.

If the cantilever is on one end only treat awning as the short cantilever case and multiply dead load deflection by 0.5.

To determine the allowable snow and wind loads assume that only the main span e is loaded using the tables or the equations with the dead load deflection and stresses assumed as 0.

Cantilevers greater than 0.25L are beyond the scope of this report and require special analysis.



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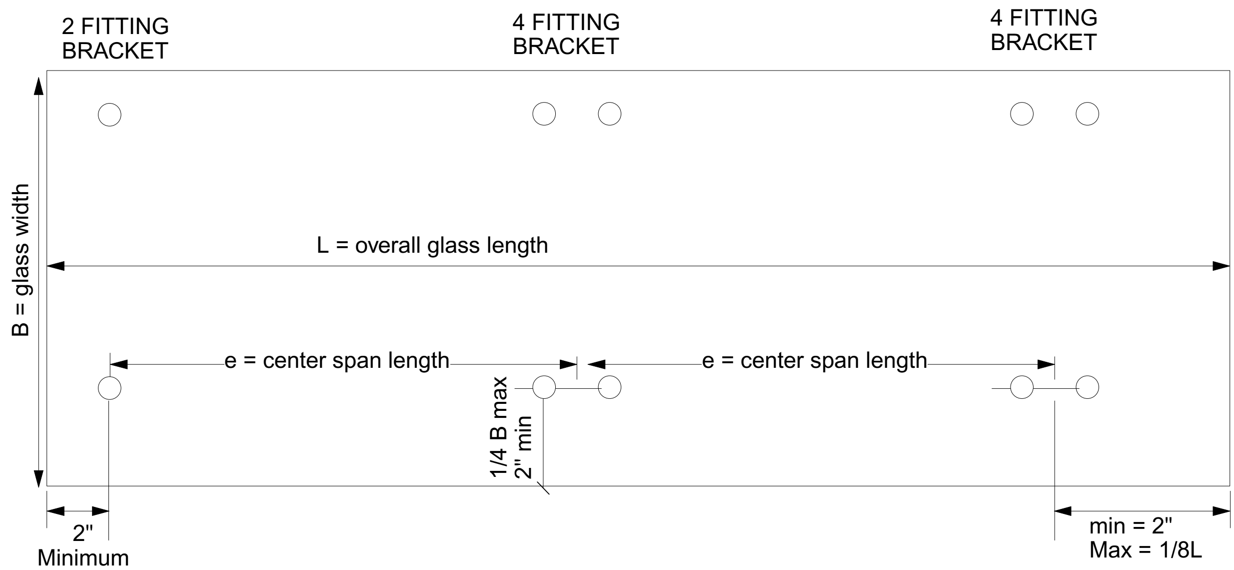
DOUBLE SPAN
Installation using 3 brackets on a single glass light.
Assume 50% of total load is on center bracket.
Check allowable loads on glass same as for the cantilevered case.
Peak moment occurs over the center support.
Deflections may be taken as 0.7 times the single span case.



Center bracket must use four fittings.
Unbalanced spans are outside the scope of this report.

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DERIVATION OF CANTILEVERED SPAN RECOMMENDATION

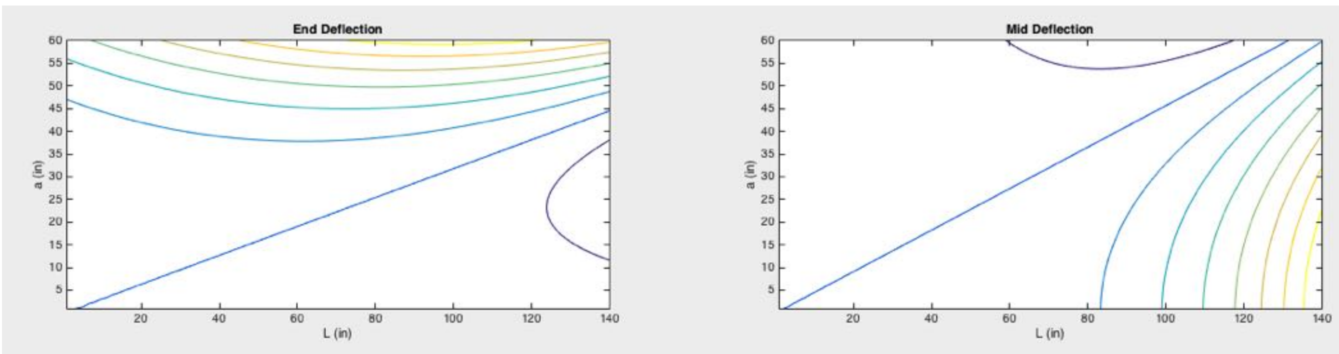
Contour plots below show deflection from 6.5psf dead load on double cantilevered awnings. Blue linear lines represent 0 deflection.

Equations used for calculating deflection are:

Mid Deflection = $W/(48EI)*(5e^4/8-3a^2e^2/2)-wa^2/(24EI)(3e^2/4)$

End Deflection = $Wa/(24EI)*(4a^2e-e^3+3a^3)+Wa^3/(24EI)*(4e+3a)$

Where W is the applied line load, e is support spacing and a is the cantilever length.



Find relationship between e and a.

For zero end deflection

a = 0.3091e

For zero mid deflection

a = 0.4545e

For ideal installation for nearly flat glass, average equations to distribute deflection between ends and mid span.

a=(0.3091+0.4545)/2*e = 0.3818e

Relate total span (L) to ideal cantilever length (a)

a= 0.3818(L-2a)

a = 0.2165L

Ideally 56.7% of the total awning length should be between the supports and 21.65% cantilevered past the support on each side for the flattest awning.

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11/16" GLASS

Table 3	h_1, h_2	h_v		$h_{s;1}$ $h_{s;2}$		I_s	h_s	Allowable Moment , M_{ga}, ("#/ft)				
8mm	0.292	0.06		0.1760		0.0181	0.352					
8mm	0.292	0.06		0.1760		0.0181	0.352					
Short Dim.	**Γ PVB**	**Γ SGP**	**$h_{ef;w}$ PVB**	**$h_{ef;w}$ SGP**	**$h_{1;ef;\sigma}$ PVB**	**$h_{1;ef;\sigma}$ SGP**	wind PVB	wind SGP	snow PVB	snow SGP	Dead PVB	Dead SGP
24	0.044	0.519	0.390	0.546	0.439	0.585	3807	6749	1760	3120	1269	2249
36	0.094	0.708	0.413	0.588	0.465	0.613	4258	7415	1968	3428	1419	2471
48	0.156	0.812	0.437	0.609	0.491	0.625	4753	7715	2197	3566	1584	2571
54	0.189	0.845	0.450	0.616	0.503	0.629	4997	7803	2310	3607	1665	2601

Glass width B		11/16" Lam. Temp. Glass		**$h_{ef;w}$ PVB**	**$h_{ef;w}$ SGP**	**$h_{1;ef;\sigma}$ PVB**	**$h_{1;ef;\sigma}$ SGP**	Cantilevered ends under 6" or 1/8th of length					
24				0.3900	0.5460	0.4390	0.5850	PVB	SGP	PVB	SGP		
e	**b/e**	Ce	η	Δd 6.5psf	Δd 6.5psf	σ dead 6.5psf	σ dead 6.5psf	Δu 20psf	Δu 20psf	σu 20psf	σu 20	L/480	L/175
24.0	1.00	0.1606	0.0263	0.0073	0.0027	130	73	0.0224	0.0082	400	225	0.0500	0.1371
36.0	0.67	0.1424	0.1550	0.2175	0.0793	259	146	0.6693	0.2439	798	449	0.0750	0.2057
48.0	0.50	0.1339	0.0140	0.0621	0.0226	434	244	0.1911	0.0696	1334	751	0.1000	0.2743
60.0	0.40	0.1290	0.0134	0.1451	0.0529	653	368	0.4465	0.1627	2008	1131	0.1250	0.3429
72.0	0.33	0.1260	0.0133	0.2986	0.1088	918	517	0.9189	0.3349	2824	1591	0.1500	0.4114

Glass width B		11/16" Lam. Temp. Glass		**$h_{ef;w}$ PVB**	**$h_{ef;w}$ SGP**	**$h_{1;ef;\sigma}$ PVB**	**$h_{1;ef;\sigma}$ SGP**	Cantilevered ends under 6" or 1/8th of length					
36				0.4160	0.5880	0.4650	0.6130	PVB	SGP	PVB	SGP		
e	**b/e**	Ce	η	Δd 6.5psf	Δd 6.5psf	σ dead 6.5psf	σ dead 6.5psf	Δu 20psf	Δu 20psf	σu 20psf	σu 20	L/480	L/175
36.0	1.00	0.1606	0.0263	0.0304	0.0108	261	150	0.0936	0.0331	802	462	0.0750	0.2057
48.0	0.75	0.1460	0.0167	0.0610	0.0216	421	242	0.1878	0.0665	1296	746	0.1000	0.2743
60.0	0.60	0.1386	0.0148	0.1321	0.0468	625	360	0.4063	0.1439	1923	1107	0.1250	0.3429
72.0	0.50	0.1339	0.0140	0.2590	0.0917	869	500	0.7970	0.2822	2675	1539	0.1500	0.4114
84.0	0.43	0.1310	0.0136	0.4662	0.1651	1158	666	1.4343	0.5079	3562	2050	0.1750	0.4800

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Glass width B		11/16" Lam. Temp. Glass		$h_{ef;w}$ PVB	$h_{ef;w}$ SGP	$h_{1;ef;\sigma}$ PVB	$h_{1;ef;\sigma}$ SGP	Cantilevered ends under 6" or 1/8th of length					
48				0.4370	0.6090	0.4910	0.6250	PVB	SGP	PVB	SGP		
e	b/e	Ce	η	Δ d 6.5psf	Δ d 6.5psf	σ dead 6.5psf	σ dead 6.5psf	Δ u 20psf	Δ u 20psf	σ u 20psf	σ u 20	L/480	L/175
48.0	1.00	0.1606	0.0263	0.0829	0.0306	416	257	0.2551	0.0943	1279	789	0.1000	0.2743
60.0	0.80	0.1486	0.0180	0.1385	0.0512	601	371	0.4263	0.1575	1849	1141	0.1250	0.3429
72.0	0.67	0.1424	0.0155	0.2474	0.0914	829	512	0.7612	0.2812	2552	1575	0.1500	0.4114
78.0	0.62	0.1395	0.0150	0.3297	0.1218	953	588	1.0146	0.3749	2934	1811	0.1625	0.4457
84.0	0.57	0.1374	0.0146	0.4317	0.1595	1089	672	1.3283	0.4908	3351	2068	0.1750	0.4800

Glass width B		11/16" Lam. Temp. Glass		$h_{ef;w}$ PVB	$h_{ef;w}$ SGP	$h_{1;ef;\sigma}$ PVB	$h_{1;ef;\sigma}$ SGP	Cantilevered ends under 6" or 1/8th of length					
54				0.4500	0.6160	0.5030	0.6290	PVB	SGP	PVB	SGP		
e	b/e	Ce	η	Δ d 6.5psf	Δ d 6.5psf	σ dead 6.5psf	σ dead 6.5psf	Δ u 20psf	Δ u 20psf	σ u 20psf	σ u 20	L/480	L/175
54.0	1.00	0.1606	0.0263	0.1216	0.0474	501	321	0.3743	0.1459	1542	986	0.1125	0.3086
60.0	0.90	0.1541	0.0218	0.1537	0.0599	594	380	0.4728	0.1843	1827	1168	0.1250	0.3429
66.0	0.82	0.1495	0.0182	0.1878	0.0732	697	446	0.5779	0.2253	2145	1372	0.1375	0.3771
72.0	0.75	0.1460	0.0167	0.2441	0.0952	810	518	0.7511	0.2928	2493	1594	0.1500	0.4114
84.0	0.64	0.1410	0.0151	0.4089	0.1594	1065	681	1.2581	0.4905	3277	2096	0.1750	0.4800

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13/16" GLASS

Table 4	h_1, h_2	h_v		$h_{s;1}$ $h_{s;2}$		I_s	h_s	Allowable Moment , M_{ga}, ("#/ft)				
10mm	0.355	0.06		0.2075		0.0306	0.415					
10mm	0.355	0.06		0.2075		0.0306	0.415					
Short Dim.	Γ PVB	Γ SGP	$h_{ef;w}$ PVB	$h_{ef;w}$ SGP	$h_{1;ef;\sigma}$ PVB	$h_{1;ef;\sigma}$ SGP	wind PVB	wind SGP	snow PVB	snow SGP	Dead PVB	Dead SGP
24	0.037	0.470	0.469	0.640	0.527	0.690	5481	9391	2534	4341	1827	3130
36	0.079	0.666	0.491	0.694	0.552	0.727	6019	10427	2783	4820	2006	3475
48	0.132	0.780	0.517	0.722	0.580	0.744	6633	10915	3066	5046	2211	3638
54	0.161	0.818	0.530	0.730	0.593	0.749	6945	11062	3210	5113	2314	3686

Glass width B		13/16" Lam. Temp. Glass		$h_{ef;w}$ PVB	$h_{ef;w}$ SGP	$h_{1;ef;\sigma}$ PVB	$h_{1;ef;\sigma}$ SGP	Cantilevered ends under 6" or 1/8th of length					
24				0.4690	0.6400	0.5270	0.6900	PVB	SGP	PVB	SGP		
e	b/e	Ce	η	Δd 6.5psf	Δd 6.5psf	σ dead 6.5psf	σ dead 6.5psf	Δu 20psf	Δu 20psf	σ u 20psf	σ u 20	L/480	L/175
24.0	1.00	0.1606	0.0263	0.0042	0.0016	90	53	0.0129	0.0051	278	162	0.0500	0.1371
36.0	0.67	0.1424	0.1550	0.1251	0.0492	180	105	0.3849	0.1515	554	323	0.0750	0.2057
48.0	0.50	0.1339	0.0140	0.0357	0.0141	301	175	0.1099	0.0432	926	540	0.1000	0.2743
60.0	0.40	0.1290	0.0134	0.0834	0.0328	453	264	0.2567	0.1010	1393	813	0.1250	0.3429
72.0	0.33	0.1260	0.0133	0.1717	0.0676	637	372	0.5284	0.2079	1960	1143	0.1500	0.4114

Glass width B		13/16" Lam. Temp. Glass		$h_{ef;w}$ PVB	$h_{ef;w}$ SGP	$h_{1;ef;\sigma}$ PVB	$h_{1;ef;\sigma}$ SGP	Cantilevered ends under 6" or 1/8th of length					
36				0.4910	0.6940	0.5520	0.7270	PVB	SGP	PVB	SGP		
e	b/e	Ce	η	Δd 6.5psf	Δd 6.5psf	σ dead 6.5psf	σ dead 6.5psf	Δu 20psf	Δu 20psf	σ u 20psf	σ u 20	L/480	L/175
36.0	1.00	0.1606	0.0263	0.0185	0.0065	185	107	0.0569	0.0202	569	328	0.0750	0.2057
48.0	0.75	0.1460	0.0167	0.0371	0.0131	299	172	0.1142	0.0404	920	530	0.1000	0.2743
60.0	0.60	0.1386	0.0148	0.0803	0.0284	443	256	0.2471	0.0875	1365	787	0.1250	0.3429
72.0	0.50	0.1339	0.0140	0.1575	0.0558	617	356	0.4847	0.1717	1898	1094	0.1500	0.4114
84.0	0.43	0.1310	0.0136	0.2835	0.1004	822	474	0.8723	0.3089	2528	1457	0.1750	0.4800

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Glass width B		13/16” Lam. Temp. Glass		$h_{ef;w}$ PVB	$h_{ef;w}$ SGP	$h_{1;ef;\sigma}$ PVB	$h_{1;ef;\sigma}$ SGP	Cantilevered ends under 6” or 1/8th of length					
48				0.5170	0.7220	0.5800	0.7440	PVB	SGP	PVB	SGP		
e	b/e	Ce	η	Δ d 6.5psf	Δ d 6.5psf	σ dead 6.5psf	σ dead 6.5psf	Δ u 20psf	Δ u 20psf	σ u 20psf	σ u 20	L/480	L/175
48.0	1.00	0.1606	0.0263	0.0501	0.0184	298	181	0.1541	0.0566	917	557	0.1000	0.2743
60.0	0.80	0.1486	0.0180	0.0837	0.0307	431	262	0.2574	0.0945	1325	805	0.1250	0.3429
72.0	0.67	0.1424	0.0155	0.1494	0.0549	594	361	0.4597	0.1688	1829	1111	0.1500	0.4114
78.0	0.62	0.1395	0.0150	0.1991	0.0731	683	415	0.6127	0.2250	2102	1278	0.1625	0.4457
84.0	0.57	0.1374	0.0146	0.2607	0.0957	781	474	0.8022	0.2945	2402	1460	0.1750	0.4800

Glass width B		11/16” Lam. Temp. Glass		$h_{ef;w}$ PVB	$h_{ef;w}$ SGP	$h_{1;ef;\sigma}$ PVB	$h_{1;ef;\sigma}$ SGP	Cantilevered ends under 6” or 1/8th of length					
54				0.5300	0.7300	0.5930	0.7490	PVB	SGP	PVB	SGP		
e	b/e	Ce	η	Δ d 6.5psf	Δ d 6.5psf	σ dead 6.5psf	σ dead 6.5psf	Δ u 20psf	Δ u 20psf	σ u 20psf	σ u 20	L/480	L/175
54.0	1.00	0.1606	0.0263	0.0744	0.0285	361	226	0.2291	0.0877	1110	696	0.1125	0.3086
60.0	0.90	0.1541	0.0218	0.0941	0.0360	427	268	0.2894	0.1108	1315	824	0.1250	0.3429
66.0	0.82	0.1495	0.0182	0.1150	0.0440	502	314	0.3537	0.1354	1543	967	0.1375	0.3771
72.0	0.75	0.1460	0.0167	0.1494	0.0572	583	365	0.4597	0.1759	1794	1124	0.1500	0.4114
84.0	0.64	0.1410	0.0151	0.2503	0.0958	766	480	0.7701	0.2947	2358	1478	0.1750	0.4800

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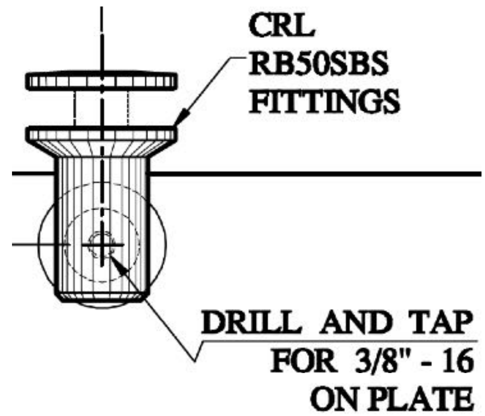
RB50F
fittings are connected together with
1/4” stainless steel threaded rods.



V_s = 0.65*40.5 ksi*0.049 in^2/1.6 = 806#
T_s = 0.75*67.5ksi*0.0318 in^2/1.6 = 1,006#

Torsion strength of swivel when clamped:
= 0.65*1,006#*13/16 = 531”#

Moment strength of swivel:
Bending in rod to fixed fitting:
rod diameter = 3/8”, A = 0.11 in^2
Z = 0.375^3/6 = 0.0088 in^3
F_b = 65 ksi (longitudinal compression)
M_n = 65 ksi*0.0088 in^3 = 572#”

Service loads on swivel:
Allowable load will be controlled by the bending strength of the connection rod:
M_s = 0.9M_n/1.6 = (0.9*572#”/1.6) = 322#”

For lateral loading, M = V*2.25”
V = 322#”/2.25 = 143# per swivel

For normal loads, M = H*0.75”
H = 322#”/0.75” = 429#

Check strength of fixed bracket to support (1/4” threaded rod)
M_s = R*T_s = 13/16”*1,006# = 1,584#”

For lateral loading, M = V*2.25”
V = 1,584#”/2.25 = 704# per swivel (limited to 143# from connector rod strength)

For normal loads, M = H*2.5”
H = 1,584#”/2.5” = 633.6# (limited to 429# by connector rod strength.

Maximum vertical load per fitting = 429#
Maximum allowable load on awning:
u ≤ 4*429/(B*L) = 1,716/(B*L) for two fittings per bracket
u ≤ 8*429/(B*L) = 3,432/(B*L) for two fittings per bracket

For higher loads substitute spider fittings for the RB50F fittings

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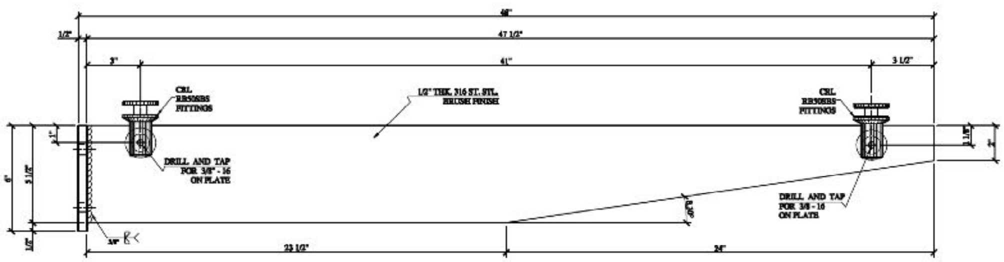
FEA MODEL

SCIA Engineer is used to create a FEA model of representative pane of glass so that the results can be compared to analytical method used in this report.



The panels assumed in the model are a 48”x48” and a 24”x48” panel that would be used with the outrigger shown above. 9/16” glass is assumed with an effective thickness of 0.433”. The model incorporates the bearing only pressure plates used at the standoffs. This models the stress near the holes and the partial fixity at each standoff. The model uses a 3rd order non linear analysis that accounts for large deflections and pressure only reactions.

Using FEA model with 20psf uniform load:
48” wide panel
Estimated deflection = 0.159”
Estimated max stress = 1,260psi (Max stress is at the edge of glass which is assumed in the analytical method)
24” wide panel
Estimated deflection = 0.086”
Estimated max stress = 970psi (Max stress is at standoff by edge stress is only slightly lower at 961psi)
Using analytical method used in this report:
48” wide panel
Estimated deflection = 0.197” (24% higher than calculated by FEA model)
Estimated stress = 1,300psi (3% higher than calculated by FEA model)
24” wide panel
Estimated deflection = 0.1396” (29% higher than calculated by FEA model)
Estimated max stress = 1,210psi (25% higher than calculated by FEA model)

Discussion:
The estimated stress varies from slightly conservative to very conservative. The deflection was shown to be overestimated by a fair margin. The discrepancy is because of the partial fixity assumed in the FEA model is not assumed in this report’s design method. Since the actually level of fixity will vary by application and reduce with higher glass thicknesses, it is appropriate to conservatively assume the standoffs do not provide rotational fixity. The design method in this report is supported by the FEA modelling. FEA result diagrams are shown on the following pages.

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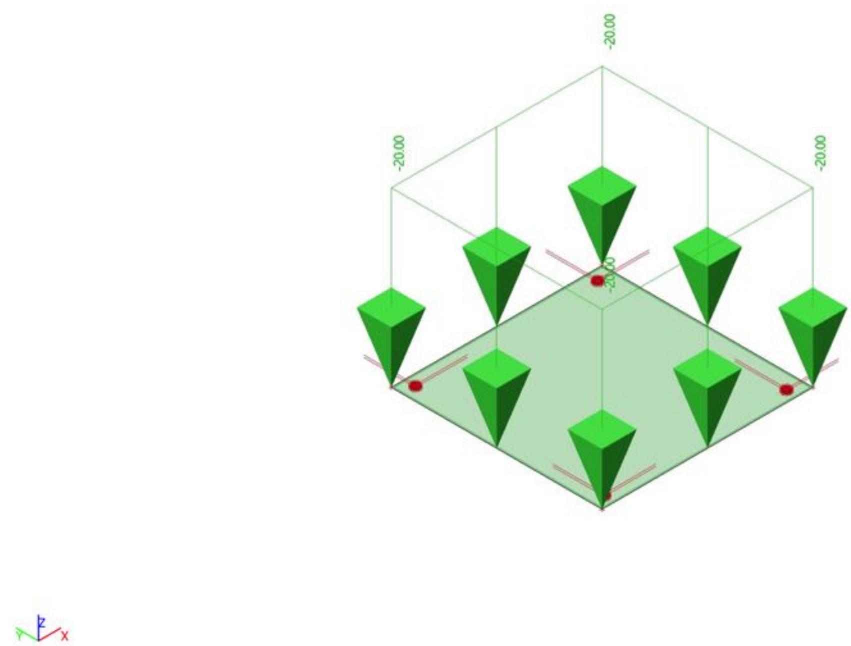
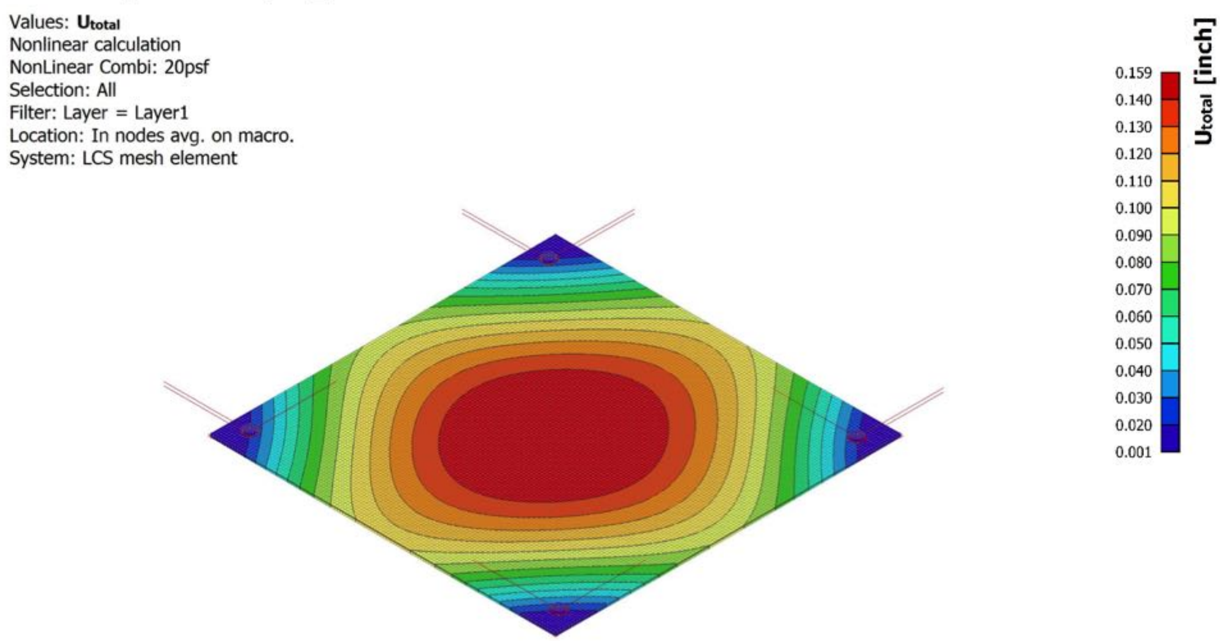
1. 20psf / Tot. value



2. 3D displacement; U_total



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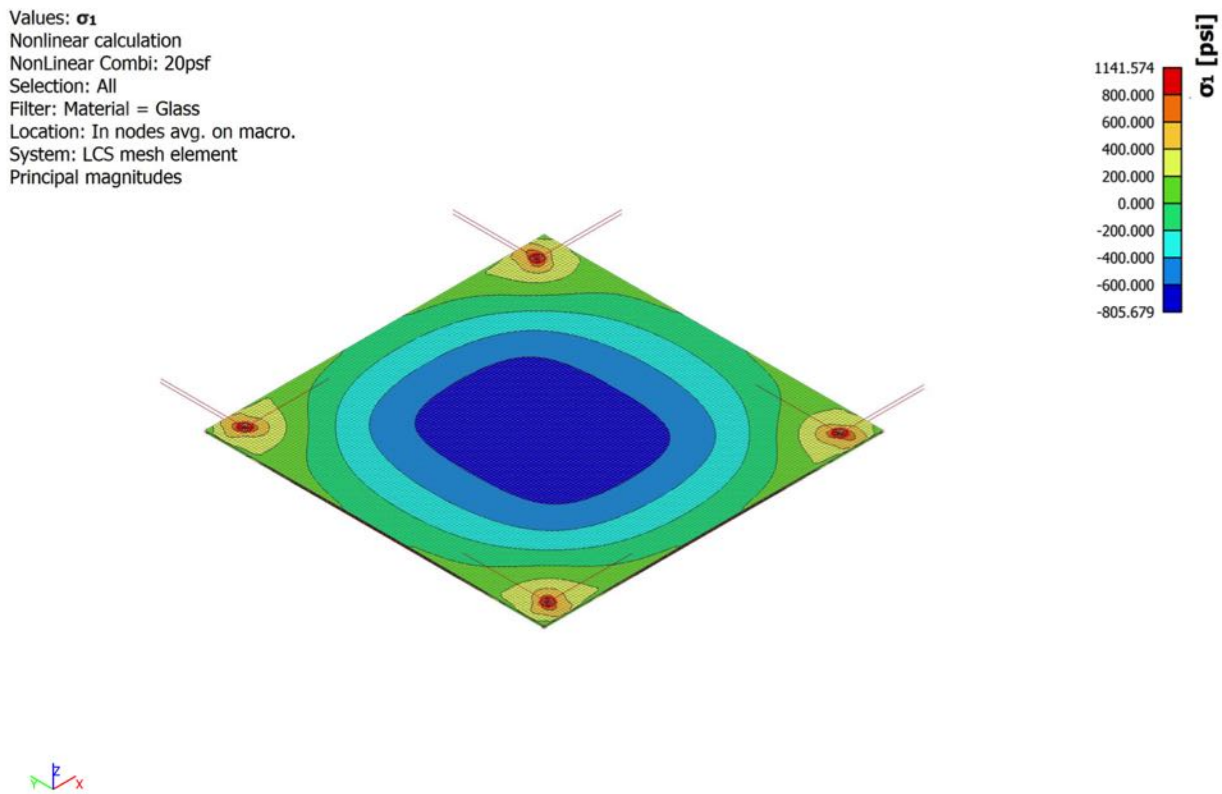
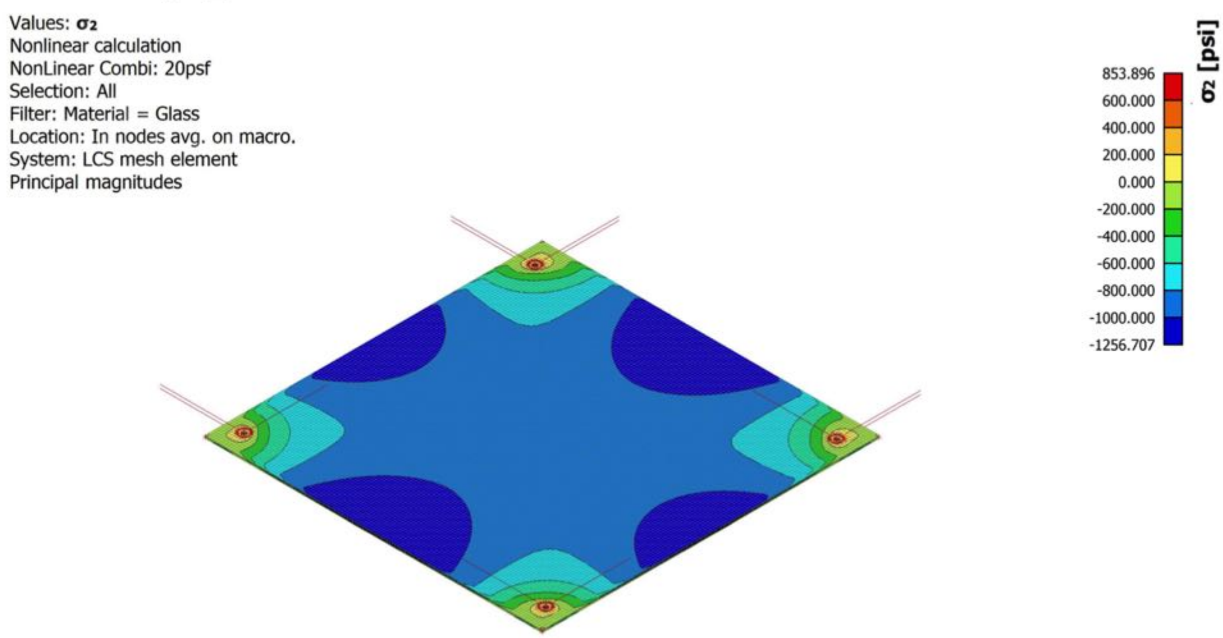
3. 3D stress; σ_1



4. 3D stress; σ_2



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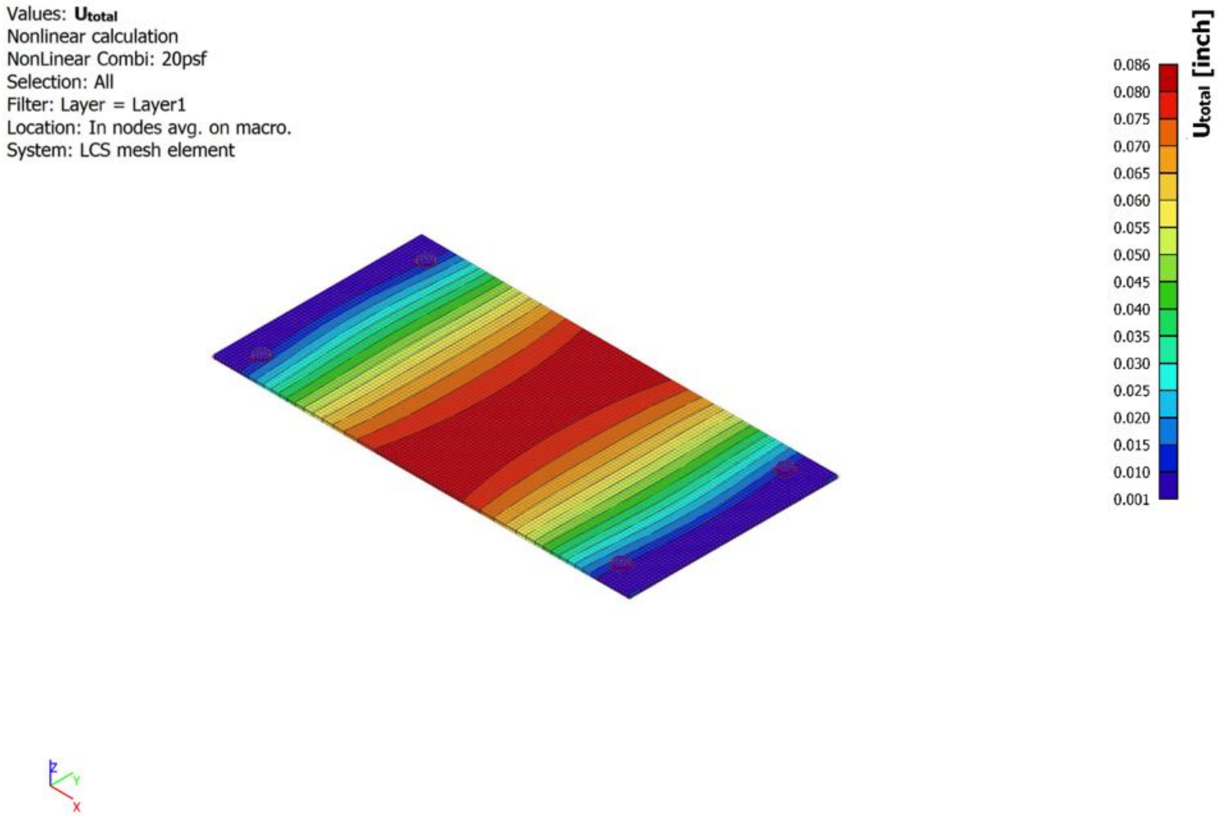
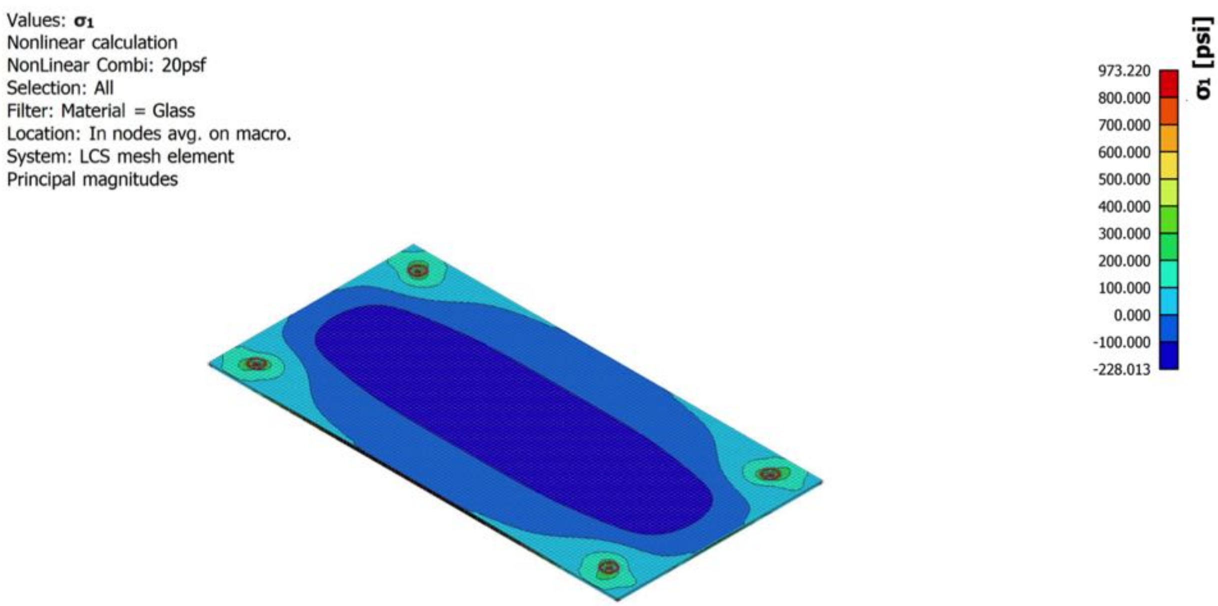
5. 3D displacement; U_total



6. 3D stress; σ_1



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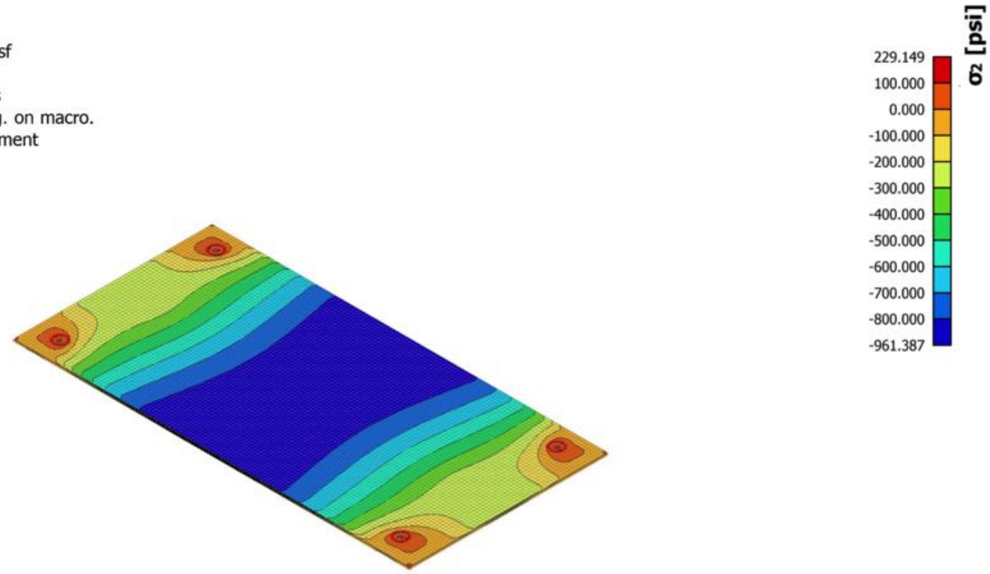
7. 3D stress; σ_2

Values: σ_2
Nonlinear calculation
NonLinear Combi: 20psf
Selection: All
Filter: Material = Glass
Location: In nodes avg. on macro.
System: LCS mesh element
Principal magnitudes



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