Edward C. Robison, P.E.

29 DEC 2017

MLevel
1625-9 Sismet Road
Mississauga, Ontario Canada L4W 1VD
ATTN: Milan Mitrovic

SUBJ: MRAIL MLEVEL GUARD SYSTEM
GLASS BALUSTRADE GUARDS

The MRail standoff railing system is an engineered guardrail system that utilizes point supported glass balustrades. When constructed in accordance with the attached details and installation guidelines the guardrail will safely support the following loading conditions:

200 pound point load on top rail, vertical or horizontal or
50 plf load on top rail, vertical or horizontal or
25 psf uniform load on glass panel horizontal or
50 lb conc load on 1 sf or
Wind load - 5 psf interior installations or as specified,
For exterior installations wind loads must be determined by a qualified engineer.

For single family residential construction only the 200# concentrated top rail load, 50# concentrated load and wind load are applicable (non-concurrent).

The SRS is to be used with tempered glass only, laminated or monolithic. Laminated glass shall be made with DuPont SentryGlas+ interlayer or an equivalent ionoplast interlayer. Glass light stresses may be evaluated using either the simplified methods shown herein or by finite element analysis models for the specific proposed installation.

For these conditions the railing meets applicable requirements of the 2006, 2009, 2012 and 2015 International Building Code and state codes adopted from the IBC codes, SEI/ASCE 8-02 and all requirements of ASTM E 2358-04. Refer to the M-Rail Test Report for MLevel Guard Systems dated Dec 2013 for physical testing performed.

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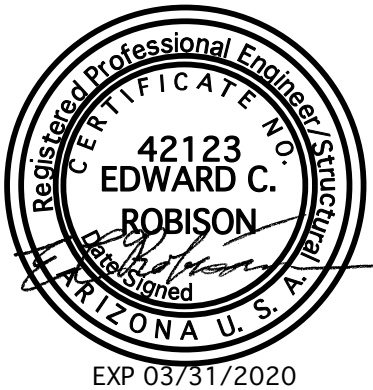

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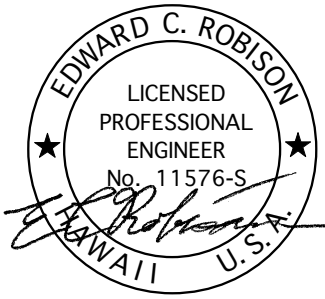

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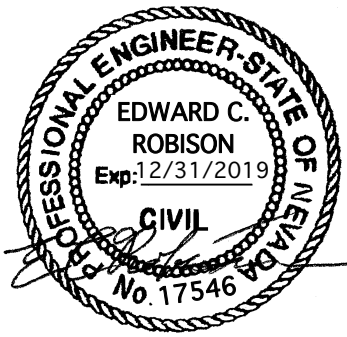

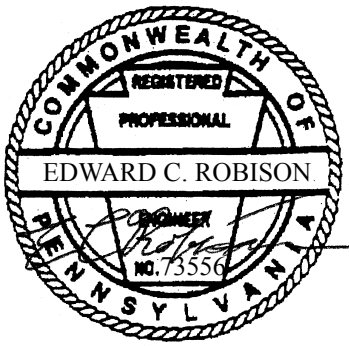

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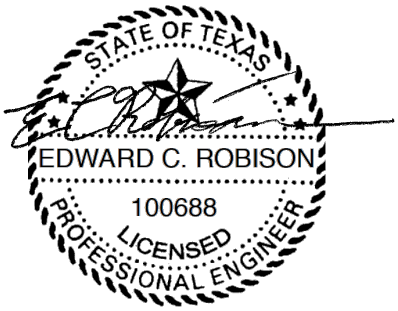

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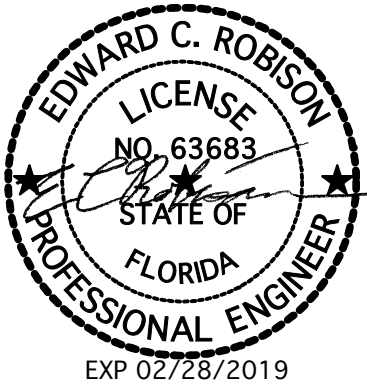

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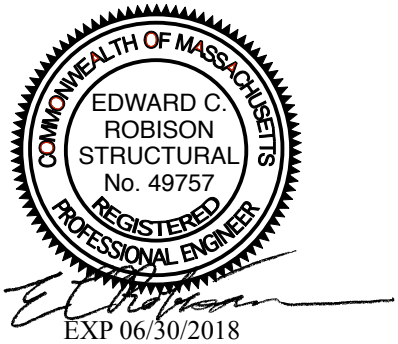

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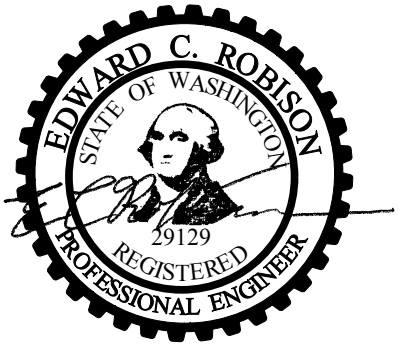

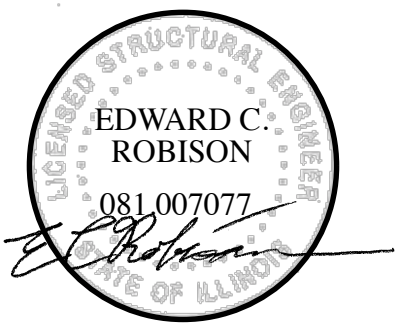

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Design Guide

Select glass thickness

Glass can be mounted to mini posts or directly to fascia. For glass mounted directly to fascia, the glass cantilevers further so a thicker glass will generally be required. Another important consideration is the presence of a top rail to tie adjacent lites together. Additional stand off pairs may be used to accommodate larger lite sizes but this causes a higher stress concentration factor so check allowable lite sizes for the selected glass thickness and mount condition. The glass thicknesses that pass live loading (200# concentrated load or 50plf distributed load) are listed below. For exterior guards, the allowable wind loading for the glass condition **and** the anchorage condition must be lower than those determined by a qualified professional for the specific site.

Glass Mounted to Mini Posts, No Top Rail

Allowable Glass Thicknesses	Allowable Lite Sizes
9/16” SGP Laminated with corners clamped	42” wide lite with 2 standoff pairs[1]
11/16” SGP Laminated	42” wide lite with 2 standoff pairs, or 72” wide lite with 3 standoff pairs
13/16” SGP Laminated	42” wide lite with 2 standoff pairs, or 72” wide lite with 3 standoff pairs

Glass Mounted to Mini Posts, With Top Rail

Allowable Glass Thicknesses	Allowable Lite Sizes
1/2” Monolithic	**42” wide lite with 2 standoff pairs[1]**
5/8” Monolithic	42” wide lite with 2 standoff pairs, or 72” wide lite with 3 standoff pairs
3/4” Monolithic	42” wide lite with 2 standoff pairs, or 72” wide lite with 3 standoff pairs
9/16” SGP Laminated	42” wide lite with 2 standoff pairs
11/16” SGP Laminated	42” wide lite with 2 standoff pairs, or 72” wide lite with 3 standoff pairs
13/16” SGP Laminated	42” wide lite with 2 standoff pairs, or 72” wide lite with 3 standoff pairs

Based on 42”guard height.
1: 2” stand off required for 1/2” or 9/16” glass mounted to mini posts.

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Glass Fascia Mounted, No Top Rail

Allowable Glass Thicknesses	Allowable Lite Sizes
13/16” SGP Laminated	36” wide lite with 2 standoff pairs, or 60” wide lite with 3 standoff pairs, or 84” wide lite with 4 standoff pairs

Glass Fascia Mounted, With Top Rail

Allowable Glass Thicknesses	Allowable Lite Sizes
1/2” Monolithic[2]	**Standard sizes can be used on residential projects only**
5/8” Monolithic	36” wide lite with 2 standoff pairs
3/4” Monolithic	36” wide lite with 2 standoff pairs, or 60” wide lite with 3 standoff pairs, or 84” wide lite with 4 standoff pairs
11/16” Laminated	36” wide lite with 2 standoff pairs
13/16” Laminated	36” wide lite with 2 standoff pairs, or 60” wide lite with 3 standoff pairs, or 84” wide lite with 4 standoff pairs

2: Residential projects only

Check Glass Allowable Wind Load

	Allowable Wind Loading 2” Stand Off (PSF)				
	2 post	3 post	2 fascia	3 fascia	4 fascia
1/2”	59.6	43.0	27.6	22.0	21.2
5/8”	95.9	69.2	44.5	35.5	34.1
3/4”	140.0	101.1	65.0	51.8	49.8
9/16”	62.1	44.9	28.8	23.0	22.1
11/16”	93.7	67.7	43.5	34.7	33.3
13/16”	130.3	94.1	60.5	48.2	46.4

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	Allowable Wind Loading 1-1/2" Stand Off (PSF)				
	2 post	3 post	2 fascia	3 fascia	4 fascia
1/2"	54.8	35.9	25.9	21.2	20.0
5/8"	88.2	57.8	41.6	34.1	32.3
3/4"	128.8	84.4	60.8	49.8	47.1
9/16"	57.2	37.5	27.0	22.1	20.9
11/16"	86.2	56.5	40.7	33.3	31.5
13/16"	119.9	78.6	56.6	46.4	43.9

Check Anchorage Allowable Wind Loading

	Allowable Wind Loading (PSF)		
	Wood	Concrete	Steel
Mini Post Surface Mount	32.0	32.0	32.0
Mini Post Fascia Mount	27.0	33.0	102.0
Fascia Mount	31.0	49.0	152.0

All standard anchorage details meet live loading criteria.

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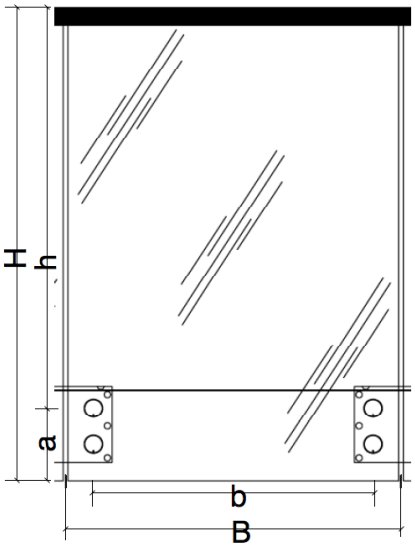
Glass Strength



All glass is fully tempered glass conforming to the specifications of ANSI Z97.1, ASTM C 1048-97b and CPSC 16 CFR 1201. For the 1/2" glass the typical Modulus of Rupture, F_r is 24,000 psi. The applicable safety factor against glass rupture is 4.0 in accordance with IBC 2407.1.1
Allowable glass bending stress: 24,000/4 = 6,000 psi. – Tension stress calculated for live loads.

Bending strength of glass for the given thickness:

$$S = \frac{12"*(t)^2}{6} = 2*(t)^2 \text{ in}^3/\text{ft}$$

Use the minimum glass thickness for stress calculations:
Figure 1
For 1/2" glass, $t_{min} = 0.469"$; Weight = 6.5 psf
$S = 2*(0.469)^2 = 0.44 \text{ in}^3/\text{ft}$
$M_{alive} = 6{,}000\text{psi}*0.44 \text{ in}^3/\text{ft} = 2{,}640"\#/\text{ft} = 220'\#$

For 5/8" glass, $t_{min} = 0.595"$; Weight = 9.8 psf
$S = 2*(0.595)^2 = 0.708 \text{ in}^3/\text{ft}$
$M_{alive} = 6{,}000\text{psi}*0.708 \text{ in}^3/\text{ft} = 4{,}248"\#/\text{ft} = 354'\#$

For 3/4" glass, $t_{min} = 0.719"$; Weight = 9.8 psf
$S = 2*(0.719)^2 = 1.034 \text{ in}^3/\text{ft}$
$M_{alive} = 6{,}000\text{psi}*1.034 \text{ in}^3/\text{ft} = 6{,}204"\#/\text{ft} = 517'\#$

The allowable moments are based on the minimum glass thickness allowed for the nominal thickness. The section properties and allowable moments may be calculated based on the actual glass thickness supplied.

Laminated glass shall be evaluated based on the effective thickness determined in accordance with ASTM E1300-12a or the DuPont online laminated glass calculator.

For wind loading the allowable glass stress may be increased in accordance with ASTM E1300-12a. It is recommended that a maximum allowable stress of 9,600 psi be used for wind loads. For wind loads the allowable moment may be taken as:

$$M_{awind} = M_{alive}*9{,}600/6000 = 1.6\ M_{alive}$$

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9/16” Laminated With SGP Interlayer

Laminated Glass Effective Thickness				
h1	h2	hv	E	g
0.219	0.219	0.06	10400000	1640
hs	hs;1	hs;2	Is	
0.279	0.1395	0.1395	0.00852359	
a	Γ	hef;w	h1;ef;σ	h2;ef;σ
36	0.76416501	0.462868129	0.47900772	0.47900772

Variable	Description
H1 & H2	Glass pane thicknesses
Hv	Interlayer thickness
E	Young's Modulus
g	Shear Modulus
Hs	.5(h1+h2)+hv
Hs;1	hsh1/(h1+h2)
Hs;1	hsh2/(h1+h2)
Is	$h1(hs;2)^2+h2(hs;1)^2$
a	Minimum Pane Width
Γ	$1/(1+9.6(Eishv/(G(ahs)^2))$
hef;w	$\sqrt[3]{((h1)^3+(h2)^3+12Γ Is)}$
h1;ef;σ	$\sqrt{((hef;w)^3/(h1+2Γhs;2))}$
h2;ef;σ	$\sqrt{((hef;w)^3/(h2+2Γhs;1))}$

I=0.4628”^{3}=0.09912in^4/ft
S=2*0.4790”^{2}=0.4588in^3/ft

11/16” Laminated With SGP Interlayer

Laminated Glass Effective Thickness				
h1	h2	hv	E	g
0.292	0.292	0.06	10400000	1640
hs	hs;1	hs;2	Is	
0.352	0.176	0.176	0.018089984	
a	Γ	hef;w	h1;ef;σ	h2;ef;σ
36	0.708470932	0.588280842	0.613232616	0.613232616

I=0.5883”^{3}=0.2036in^4/ft
S=2*0.6132”^{2}=0.7520in^3/ft

13/16” Laminated With SGP Interlayer

Laminated Glass Effective Thickness				
h1	h2	hv	E	g
0.355	0.355	0.06	10400000	1640
hs	hs;1	hs;2	Is	
0.415	0.2075	0.2075	0.030569938	
a	Γ	hef;w	h1;ef;σ	h2;ef;σ
36	0.666546243	0.693818411	0.727180009	0.727180009

I=0.6938”^{3}=0.3340in^4/ft
S=2*0.7272”^{2}=1.057in^3/ft

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Glass Stress Limitations

Allowable Glass Stress (psi)	
Live Loads	**Wind Loads**
6000	9600

Stress Concentration Factors, χ		
Support Type	**χ 2” Stand Off**	**χ 1-1/2” Stand Off**
Two Mini Posts At 30” Spacing	1.61	1.75
Three Mini Posts At 30” Spacing	2.23	2.67
Two Pair Fascia Mount At 24” Spacing	1.61	1.72
Three Pair Fascia Mount At 24” Spacing	2.02	2.10
Four Pair Fascia Mount At 24” Spacing	2.10	2.22

For monolithic panels

1/2” Monolithic Tempered:

Live load limitations
50 plf live load along top of guard. Applies to all commercial guards.
M_a=2,640”#

Mini post condition
M=50plf*31”*χ=1,550”#χ
χ_a=2,640”#/1,550”#=1.70
Ok for two mini post mounts at 30” spacing only.
May not be used for fascia mounts.

Allowable wind loads
5psf wind load applied to interior guards. For exterior guards wind loads must be determined by a qualified engineer.
M_a=1.6*2,640”#=4,224”#

M= $1.61*W*31^2/12*0.55 = 4{,}224$”#
W=59psf

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5/8” Monolithic Tempered:

Live load limitations
50 plf live load along top of guard. Applies to all commercial guards.
M_a=4,248”#

Mini post condition
M=50plf*31”*χ=1,550”#χ
χ_a=4,248”#/1,550”#=2.74
Ok for two or three mini post mounts at 30” spacing.

Fascia mount condition
M=50plf*45.5”*χ=2275χ
χ_a=4,248”#/2275”#=1.86
Ok for two pairs of fascia mounts at 24” spacing.

Allowable wind loads
5psf wind load applied to interior guards. For exterior guards wind loads must be determined by a qualified engineer.
M_a=1.6*4,248”#=6,796”#

Two post condition
M= 1.61*W*31^2/12*0.55 = 6,796”#
W=95psf

Three post condition
M= 2.23*W*31^2/12*0.55 = 6,796”#
W=69psf

Two fascia condition
M= 1.8*W*45.5^2/12*0.55 = 6,796”#
W=39psf

Rest of glass options are solved using the same equations. See table below for summary of solutions.

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	$M_{a,L}$	$M_{a,w}$	$\chi_{a,p}$	$\chi_{a,f}$
1/2" Mono	2640	4223	1.70	1.16
5/8" Mono	4248	6797	2.74	1.87
3/4" Mono	6204	9926	4.00	2.73
9/16" Lam	2753	4405	1.78	1.21
11/16" Lam	4153	6645	2.68	1.83
13/16" Lam	5776	9242	3.73	2.54

Determine allowable wind loads for other glass thicknesses.

3/4" Monolithic Glass

Can be used in any condition.

Allowable wind loads
5psf wind load applied to interior guards. For exterior guards wind loads must be determined by a qualified engineer.

Two post condition
$M= 1.61*W*31^2/12*0.55 = 9{,}925"\#$
W=140psf

Three post condition
$M= 2.23*W*31^2/12*0.55 = 9{,}925"\#$
W=101psf

Two fascia condition
$M= 1.8*W*45.5^2/12*0.55 = 9{,}925"\#$
W=58psf

Three fascia condition
$M= 2.02*W*45.5^2/12*0.55 = 9{,}925"\#$
W=51psf

Four fascia condition
$M= 2.10*W*45.5^2/12*0.55 = 9{,}925"\#$
W=49psf

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	Allowable Wind Loading 2” Stand Off (PSF)				
	2 post	3 post	2 fascia	3 fascia	4 fascia
1/2”	59.6	43.0	27.6	22.0	21.2
5/8”	95.9	69.2	44.5	35.5	34.1
3/4”	140.0	101.1	65.0	51.8	49.8
9/16”	62.1	44.9	28.8	23.0	22.1
11/16”	93.7	67.7	43.5	34.7	33.3
13/16”	130.3	94.1	60.5	48.2	46.4

Repeat for 1-1/2” stand offs

	Allowable Wind Loading 1-1/2” Stand Off (PSF)				
	2 post	3 post	2 fascia	3 fascia	4 fascia
1/2”	54.8	35.9	25.9	21.2	20.0
5/8”	88.2	57.8	41.6	34.1	32.3
3/4”	128.8	84.4	60.8	49.8	47.1
9/16”	57.2	37.5	27.0	22.1	20.9
11/16”	86.2	56.5	40.7	33.3	31.5
13/16”	119.9	78.6	56.6	46.4	43.9

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200 Pound Live Load

Worst case is fascia condition with two pairs and no cap rail. For t=0.719" f_b=5,288psi
$t_{min}=(5288/6000*.719^2)^{1/2}=0.675$"

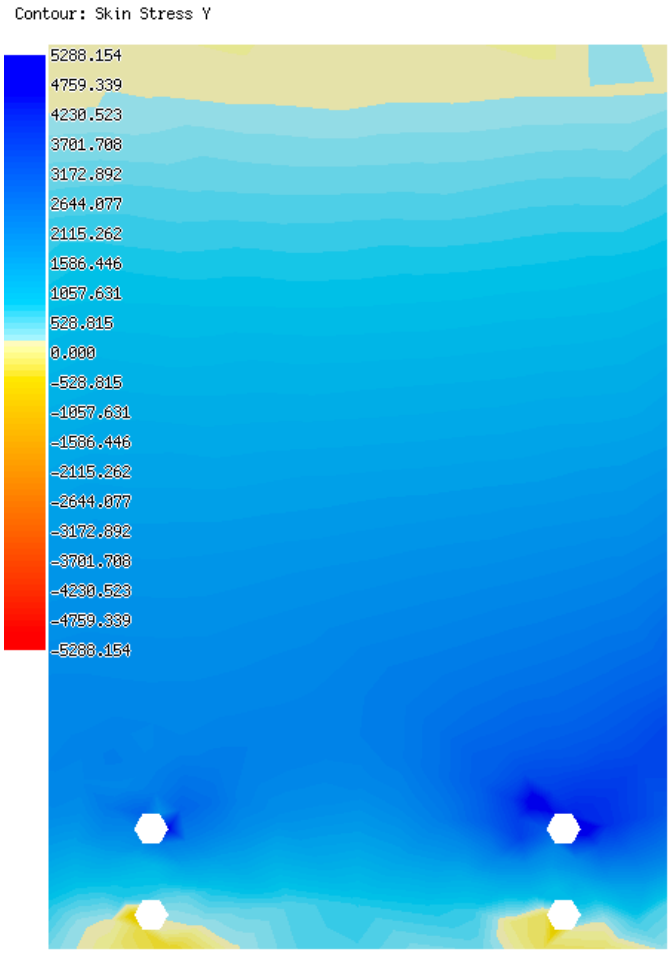
Where a cap rail is not used glass must be laminated.

Fascia mounts without a cap rail must be 13/16" laminated glass.

Also check deflections, for guards without a cap rail, deflection must be lower than glass thickness.

Δ=0.77"<0.8125" OK

For 1-1/2" stand off
f_b=5,461psi
$t_{min}=(5461/6000*.719^2)^{1/2}=0.686$"
Δ=0.754"<0.8125" OK



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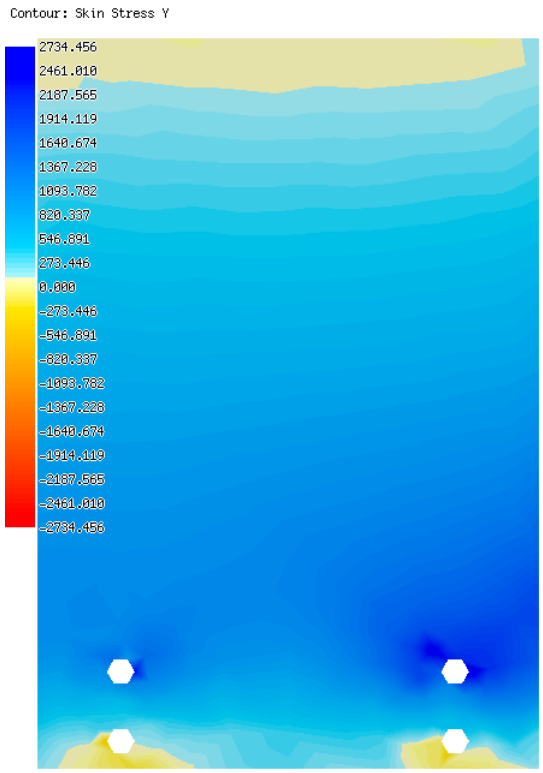
When a cap rail is used 200# load is shared by adjacent lites.
For t=0.719” f_b=2,735psi
$t_{min}=(2,735/6000*.719^2)^{1/2}=0.485$”
Excludes 9/16” and 1/2” glass only.

For 1 1/2” standoff
f_b=2,764psi
$t_{min}=(2,764/6000*.719^2)^{1/2}=0.488$”

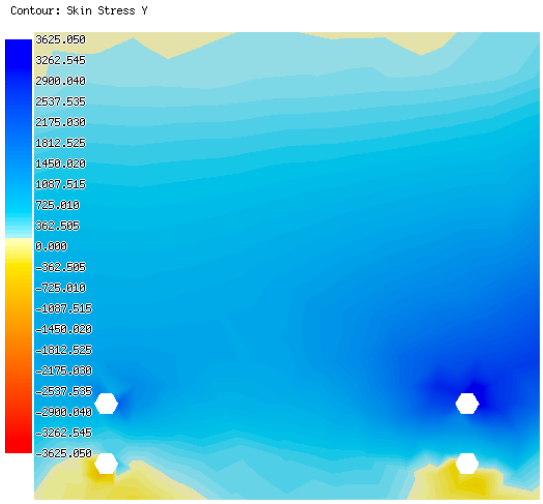


Check for post mounted glass without a cap rail.
For t=0.719” f_b=3,625psi
$t_{min}=(3,625/6000*.719^2)^{1/2}=0.559$”
Excludes 9/16” glass.

Deflection of 11/16” glass = 0.509” < 0.6875” OK

For 1-1/2” glass
f_b=4,231psi
$t_{min}=(4,231/6000*.719^2)^{1/2}=0.604$”
Excludes 9/16” glass.

Deflection of 11/16” glass = 0.511” < 0.6875” OK



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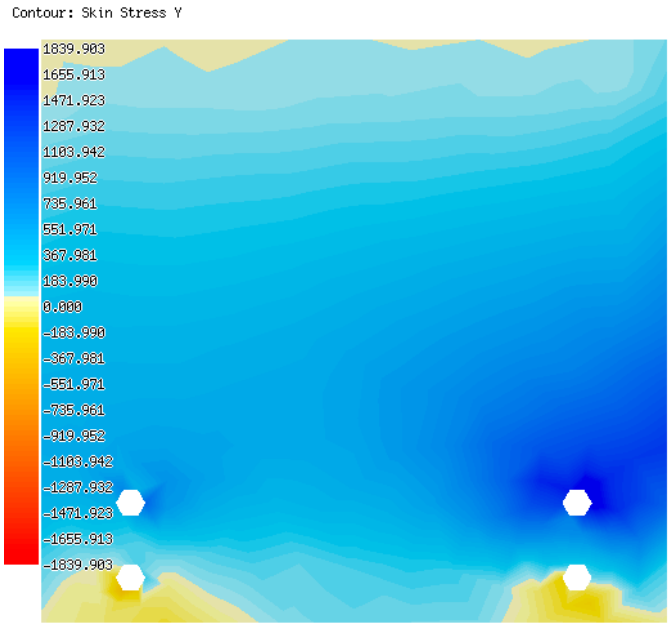
Check for post mounted glass with a cap rail
For t=0.719" f_b=1,840psi
$t_{min}=(1{,}840/6000*.719^2)^{1/2}=0.398$"
200# load does not control glass design when mini posts and a cap rail are used.



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Stand Off Assembly Strength

Cap to base is connected by the adjustable screw at the screws narrowest section.
Screw strength = $0.0775in^2*75ksi/2 = 2,906\#$
Minimum thread engagement = $2,906\#/(0.576in^2/in*75ksi*1000*0.6/2)$ => 1/4”
Minimum engagement on base side = $2,906\#/(0.799in^2/in*75ksi*1000*0.6/2)$ => 3/16”

Find anchor loading by anchorage top and loading type:

Mini post mounts:
50 plf Live Load, worst load condition on center post of three post condition.
744# to top support and 562# in the opposite direction on the bottom support.

Wind Loading:

Load to center post from 1psf wind load = 23# on top support and 13# on bottom support in opposite direction.
Load to top support = 23#W
Load to bottom support = -13#W
Moment at base, M = 23#W*11”-13#*6”=175”#*W
Shear at base = 23#W-13#W=10#*W

200# live load:
794# to top mount and -580# to bottom mount when cap rail is not used. Halve loads for cap rail condition.
Moment at base, M = 794#*11”-580#*6”=5,254”#
Shear at base = 794#-580#=214#

Fascia mount condition

50 plf Live Load, worst load condition on center post of three post condition.
838# to top support and 690# in the opposite direction on the bottom support.

Wind Loading:

Load to center post from 1psf wind load = 35# on top support and 25# on bottom support in opposite direction.
Load to top support = 35#W
Load to bottom support = -25#W

200# live load:
990# to top mount and -774# to bottom mount when cap rail is not used. Halve loads for cap rail condition.

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Mini Post Strength

Post strength:
For 1-1/2”X1” posts
$L_b d/t^2$=11.375”*1.5”/1^2=17.1
.08E/F_y=.08*28*10^3/30=74.7
Lateral torsional buckling does not apply.
S=0.375in^3
Z=0.5625in^3
M_a=30ksi*1.6*0.375in^3/1.67=10,778”#
or M_a=30ksi*0.5625in^3/1.67=10,104”# (controls)

Post to plate connection:
3/8”x1-1/4” SS screws
e=1.25”-.75”=0.75” (pullout will not control)
T_a=0.0775in^2*75ksi/2=2,906#

Screw edge distance = 0.375”
0.0775*y=1”*d^2/2
y=(1.5”-.375”)-d
d^2/2+.0775d-0.08719=0
d=0.3472”
M_a=2,906#*(1.5”-.375”-1/3*.3472”) = 2,933”#
Steel compression stress = 2,906#/(.3472”/2*1”)=16.7ksi<30ksi OK

For 2-1/2”X3/4” posts
$L_b d/t^2$=11.375”*2.5”/$.75^2$=50.6
.08E/F_y=.08*28*10^3/30=74.7
Lateral torsional buckling does not apply.
S=0.7812in^3
Z=1.171in^3
M_a=30ksi*1.6*0.7812in^3/1.67=22,453”#
or M_a=30ksi*1.171in^3/1.67=21,036”# (controls)

Post to plate connection:
3/8”x1-1/4” SS screws
Screw edge distance = 0.375”
0.0775*y=0.75”*d^2/2
y=(2.5”-.375”)-d
.375d^2+.0775d-0.1647=0
d=0.5674”
M_a=2,906#*(2.5”-.375”-1/3*.5674”) = 5,626”#
Steel compression stress = 2,906#/(.5674”/2*.75”)=13.7ksi<30ksi OK

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Recall max loading, M=5,254”# and V=214#
1-1/2” post does not meet code.

V_a=0.6*2,906#=1,743#
V/V_a=(214#/2)/1743=0.06<0.3 (Shear does not reduce tension capacity)
M_a= 5,626”#>5,254”# OK

Find allowable wind load:
M=175W=5,626”#
W=32psf
V=10*32psf=320# (will not reduce tension capacity)
W_a=32psf

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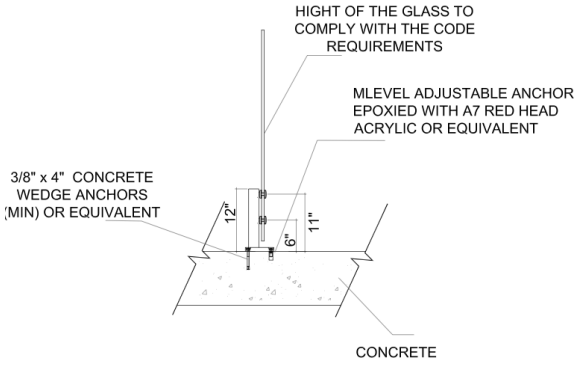
Mini Post to Concrete Mount



Assume (3) 3/8" SS Hilti kwikbolt TZ anchors for standard system. Assume nominal embedment >3-1/16".
h_{ef}=2.75"
f'_c=3,000psi

Assume back anchors of 3" edge distance.

Tension strength of single anchor far from edge:

Area Calcs:

Segment:	Anc W	B
1	4.125	4.125
2	4.125	4.125
Total:	8.25	8.25

Concrete Breakout Strength:

Anc	Anco
68.0625	68.0625

Ψed,N	Ψc,N	Ψcp,N	Kc
1	1	1	17

Nb	Ncbg
4246.27962	4246.27962

To find allowable tension load multiply by φ=0.65 and divide by 1.6 to convert to ASD level loading

All tens

1725.0511

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Tension strength of two anchors 3” from edge:
S_{min}=2.25” per ESR 1917.
Distance from center of hole to edge of plate = (3”-2.25”)/2=0.375”
l_e=0.375”-(3/8”+1/8”)/2=0.125”
Tear out strength = 0.125”*0.75”*75ksi*0.6/2 = 2,109# OK

Area Calcs:

Segment:	Anc W	B
1	3	4.125
2	4.125	2.25
3		4.125
Total:	**7.125**	**10.5**

Concrete Breakout Strength:

Anc	Anco
74.8125	68.0625

Ψed,N	Ψc,N	Ψcp,N	Kc	Ψec,N
0.91818182	1	1	17	1

Nb	Ncbg
4246.27962	4285.52022

To find allowable tension load multiply by φ=0.65 and divide by 1.6 to convert to ASD level loading

All tens

1740.99259

Weak direction is load on single anchor:
T_a=1,725#
Compression block depth = 1725#/(.85*3000psi*3”)=0.225”
M_a=1,725#*(5”-0.225”/2)=8,431”#>5,626”# (Exceeds post strength)

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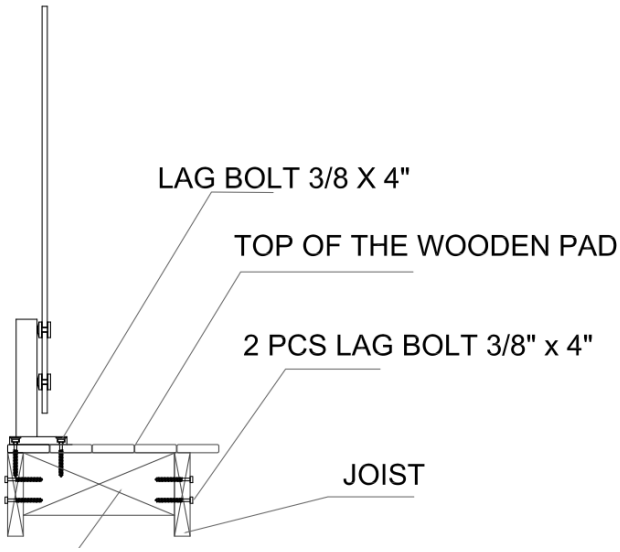
Mini Post to Wood Mount

Controlling loading will put single lag screw in tension.



3/8”X5” Lag screw strength:
Assume G=0.42 and protected from moisture
p=5”-1.5”-7/32”=3.281”
W’=243pli*1.6=388.8pli
W’p=1,275#

Wood compression area:
F'_c=405psi
a=1,275#/(405psi*3”)=1.05”
M_a=1,275#*(5”-1.05”/2)=5,705”#>5,626”#
(Exceeds post strength)

Changing condition of wood can change strength of connection.

For moisture exposed wood:
W’p=1,275#*0.7=893#
F'_c=405psi*0.67=271psi
a=893#/(271psi*3”)=1.1”
M_a=893#*(5”-1.1”/2)=3,974”# (will not hold live load)

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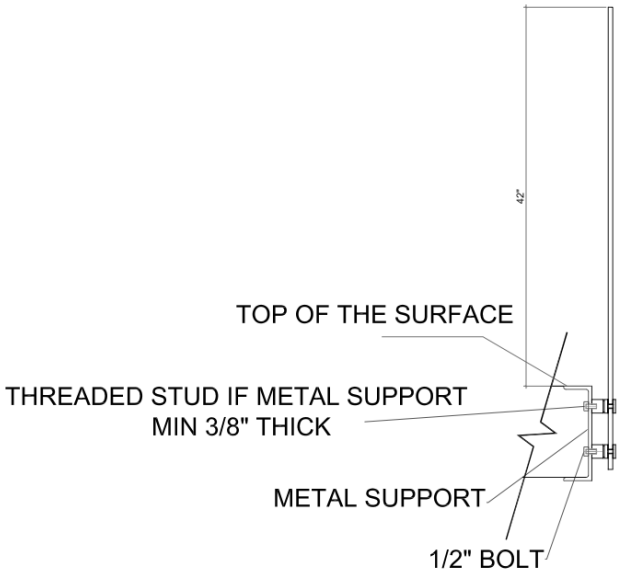
Fascia Mount To Steel

Max tension load on anchor = 990#
Anchor strength = 0.142in^2*75ksi/2
=5,325#>990# OK
Pullout strength = 0.6*58ksi/2*1.08in^2/in*3/8”
=7,047#
Thread stripping=0.6*75ksi/2*0.799in^2/in*3/8”
=6,741#

Allowable wind load:
5,325#/35=152psf



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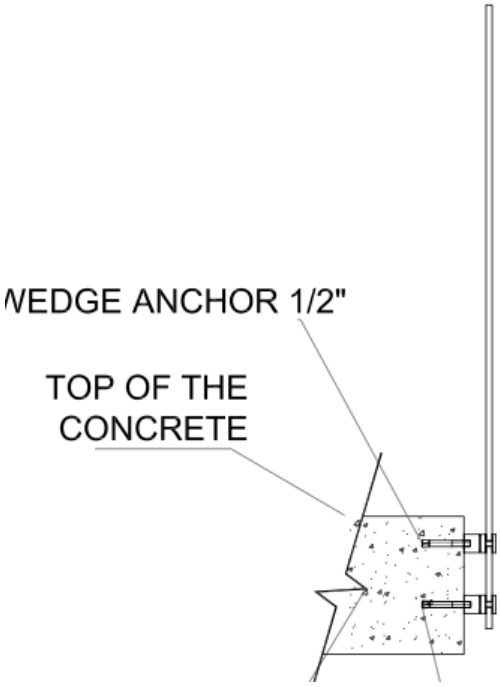
Fascia Mount to Concrete

Edge distance = 3-1/2”
Tension load on single anchor = 990#
Assume anchor with 3-1/4” effective embedment. (3-5/8” nominal embedment for 1/2” Hilti Kwikbolt)



Area Calcs:

Segment:	Anc W	B
1	3.5	4.875
2	4.875	4.875
Total:	8.375	9.75

Concrete Breakout Strength:

Anc	Anco
81.65625	95.0625

Ψed,N	Ψc,N	Ψcp,N	Kc
0.91538462	1	1	17

Nb	Ncbg
5455.50038	4289.61583

To find allowable tension load multiply by φ=0.65 and divide by 1.6 to convert to ASD level loading

All tens

1742.65643

Ok for all live loads

W_a=1,742#/35=49psf

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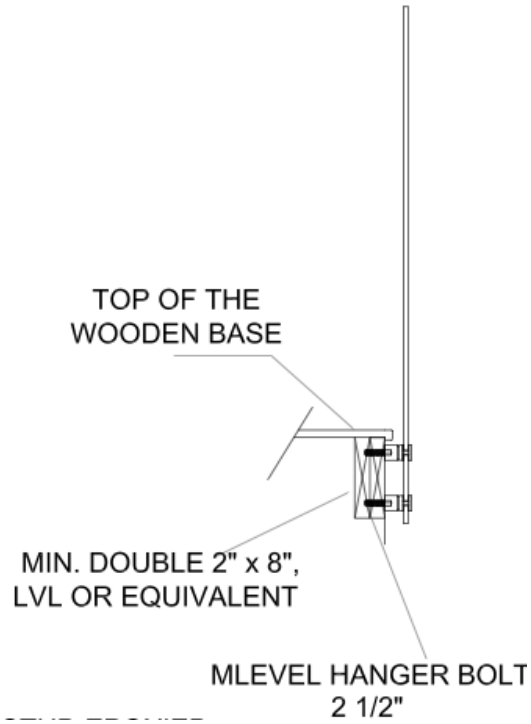
Fascia Anchorage to Wood

Assume at least 2.25” of penetration into solid wood. W’p=302pli*1.6*2.25=1,087#>990# OK for all live loads.

Allowable wind load = 1,087#/35=31psf

Again moisture effected wood could bring strength down to unacceptable levels.



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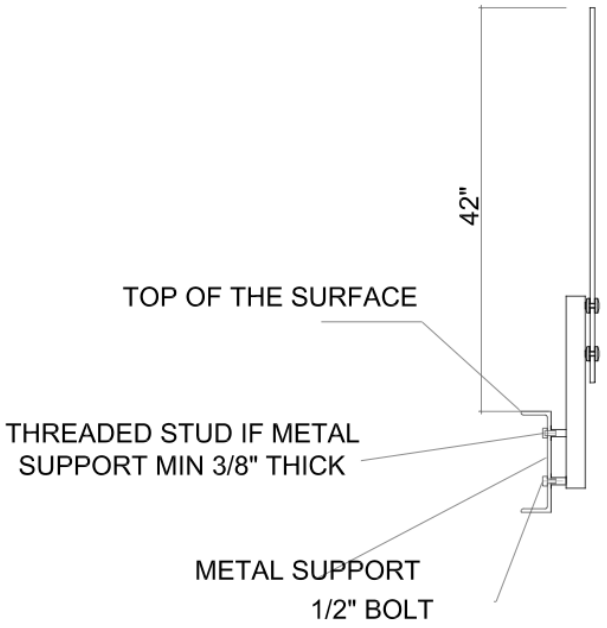
Mini Post Fascia Mount to Steel

Max live load tension load =
(794#*19.5”-580#*14.5”)/5”=1,415#

Wind load tension load =
(23#W*19.5”-13#W*14.5”)/5”
=52W#

Anchor strength = 0.142in^2*75ksi/2
=5,325#>990# OK
Pullout strength = 0.6*58ksi/2*1.08in^2/in*3/8”
=7,047#
Thread stripping=0.6*75ksi/2*0.799in^2/in*3/8”
=6,741#

Allowable wind load:
5,325#/52=102psf



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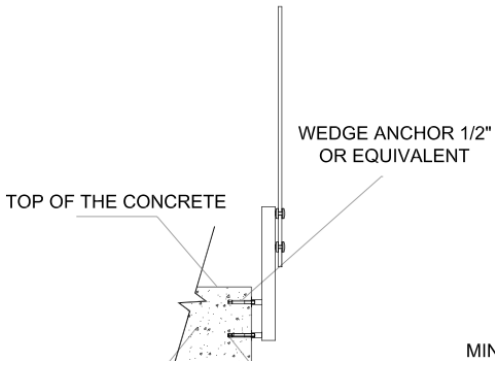
Mini Post Fascia Mount to Concrete



Edge distance = 3-1/2”
Tension load on single anchor = 1,415#
Assume anchor with 3-1/4” effective embedment. (3-5/8” nominal embedment for 1/2” Hilti Kwikbolt)

Area Calcs:

Segment:	Anc W	B
1	3.5	4.875
2	4.875	4.875
Total:	**8.375**	**9.75**

Concrete Breakout Strength:

Anc	Anco
81.65625	95.0625

Ψed,N	Ψc,N	Ψcp,N	Kc
0.91538462	1	1	17

Nb	Ncbg
5455.50038	4289.61583

To find allowable tension load multiply by φ=0.65 and divide by 1.6 to convert to ASD level loading

All tens

1742.65643

Ok for all live loads

W_a=1,742#/52=33psf

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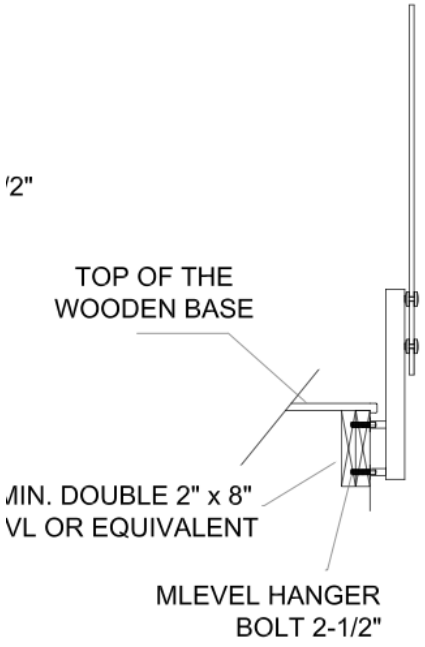
Fascia Anchorage to Wood

Assume at least 2.25” of penetration into solid wood.
W’p=302pli*1.6*2.25=1,087#<1,415#
Min penetration = 1415/1087*2.25=2.92”
Use 3-1/2” hanger screws for mini post fascia mounts.
W’p=302pli*1.6*3=1,449#>1,415#

Allowable wind load = 1,449#/52=27psf

Again moisture effected wood could bring strength down to unacceptable levels.



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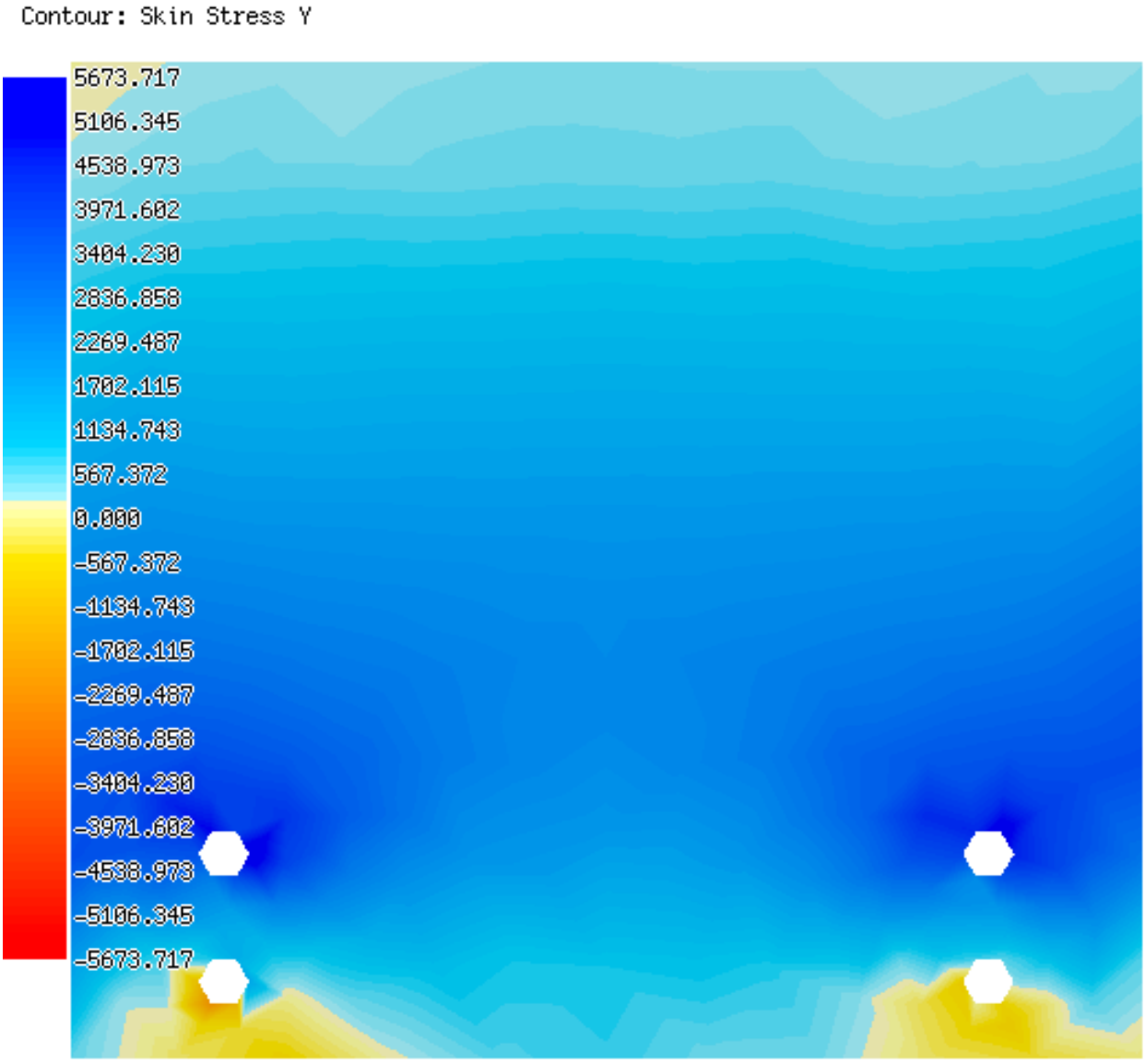
Stress Concentration Factor Calculations

Two mini posts, 30" post spacing and 42" glass height.

Distance from top of glass to top support = 31"
Glass stress with continuous clamping at bottom = 50plf*31"/S = 1,550"#/S (live load)
= W/12*31²*0.55/S = W44.05/S

From model
2" standoffs, f_b=5,674psi for 1/2" glass
Stress concentration factor = 5674/(1550/.44) = 1.61



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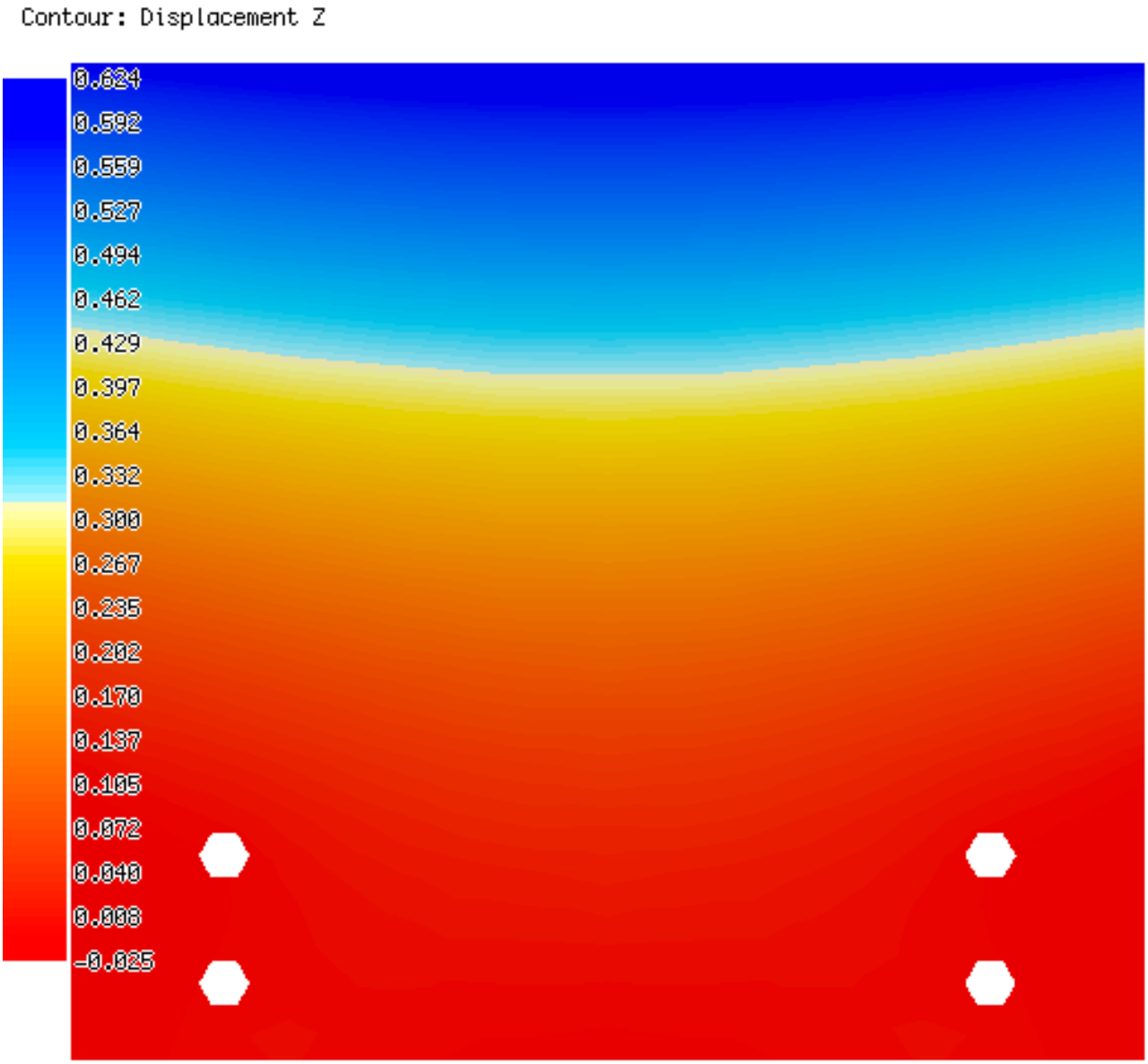
Δ= 0.624”



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Check concentration factor applicability to other thicknesses:
For 3/4" glass predicted stress from 50plf load = $1550/(2*.719^2)*1.61$ = 2,414psi
From model f_b=2,414psi (model and concentration factor method agree to 4 digits)

Concentration factors are applicable to all glass thicknesses.

Check concentration factor applicability to wind loading:
Predicted 3/4" glass stress from 25psf wind load = $1.61*25*44.05/(2*.719^2)$ = 1,715psi
From model f_b=1,661psi
% error = (1715-1661)/1661*100%=3.3% overestimate (Wind load stress concentration factor actually slightly lower but the single concentration factor can be used conservatively)

Check for 1-1/2" stand offs-
f_b=6,150psi
Stress concentration factor = 6150/(1550/.44) = 1.75

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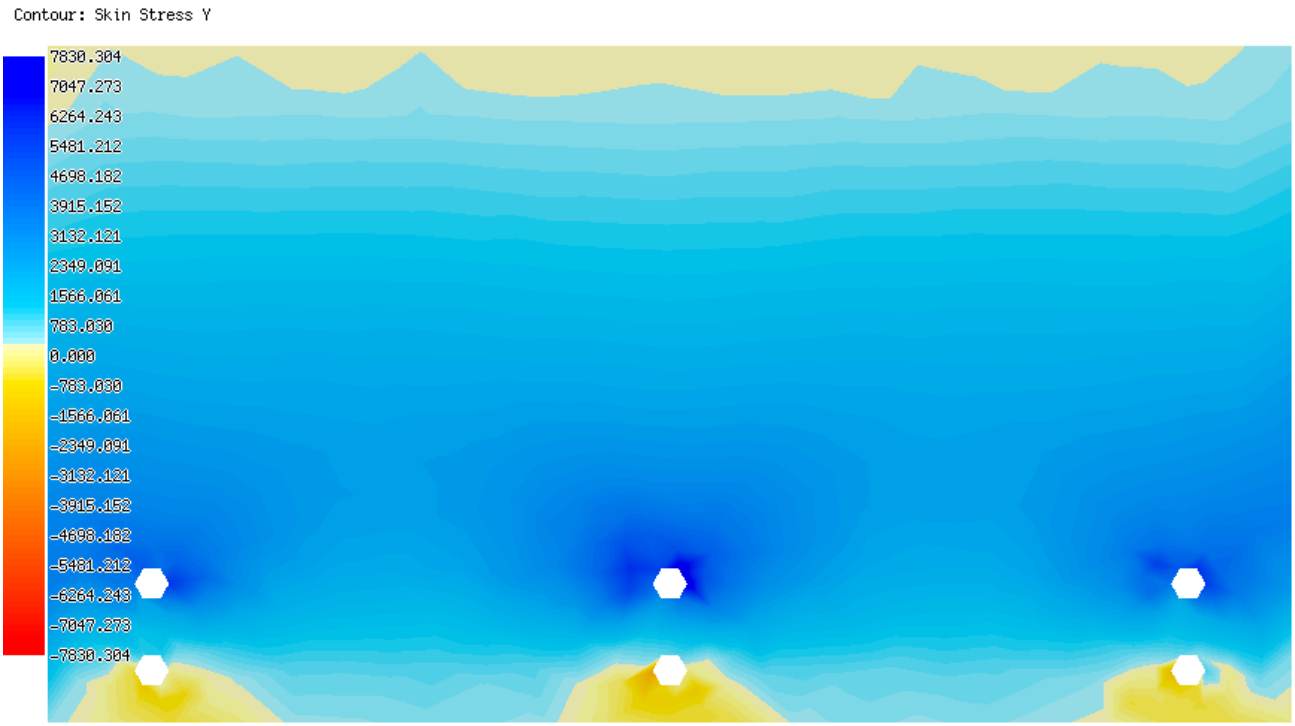
Three mini posts, 30" post spacing and 42" glass height.

Distance from top of glass to top support = 31"
Glass stress with continuous clamping at bottom = 50plf*31"/S = 1,550"#/S (live load)
= W/12*31^2*0.55/S = W44.05/S

From model
2" standoffs, f_b=7,830psi for 1/2" glass
Stress concentration factor = 7,830/(1550/.44) = 2.23



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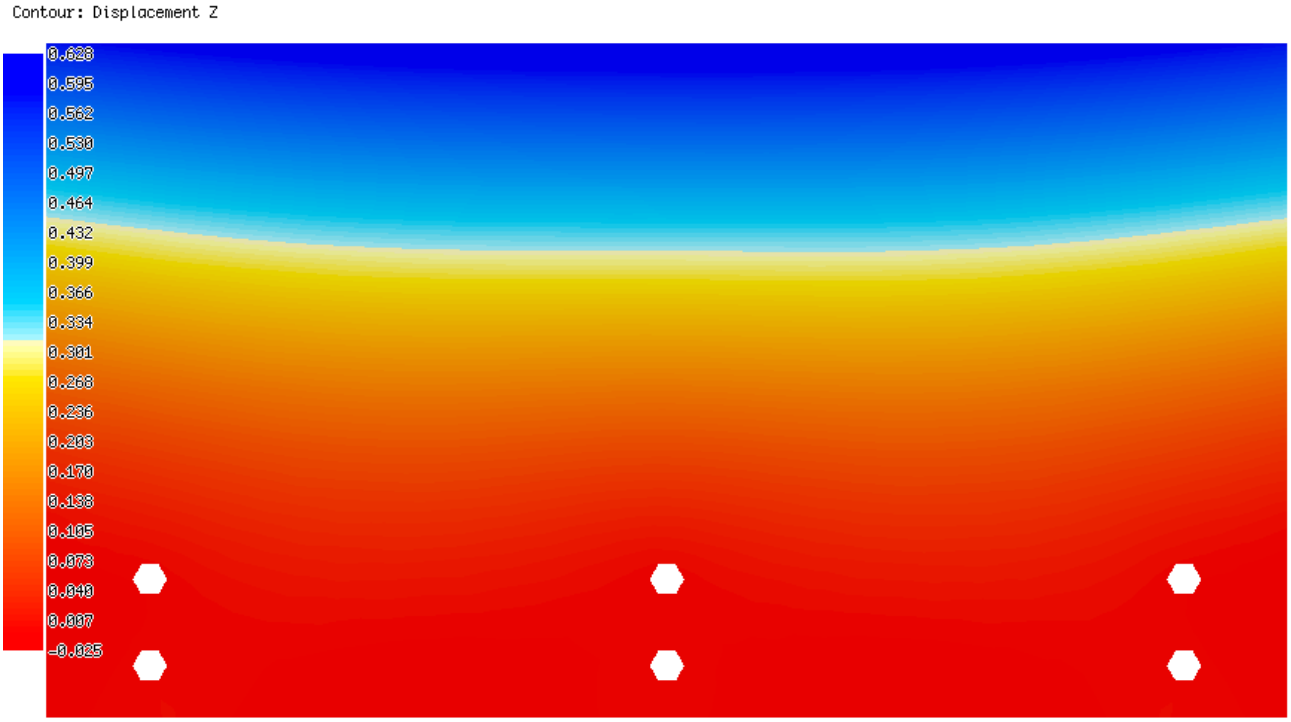
Δ= 0.628”



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Check concentration factor applicability to other thicknesses:
For 3/4" glass predicted stress from 50plf load = $1550/(2*.719^2)*2.23$ = 3,343psi
From model f_b=3,332psi (concentration factor slightly conservative but applicable)

Concentration factors are applicable to all glass thicknesses.

Check concentration factor applicability to wind loading:
Predicted 3/4" glass stress from 25psf wind load = $2.23*25*44.05/(2*.719^2)$ = 2,375psi
From model f_b=2,321psi
% error = (2,375-2,321)/2,321*100%=2.3% overestimate (Wind load stress concentration factor actually slightly lower but the single concentration factor can be used conservatively)

Check for 1-1/2" stand offs-
f_b=9,419psi
Stress concentration factor = 9419/(1550/.44) = 2.67

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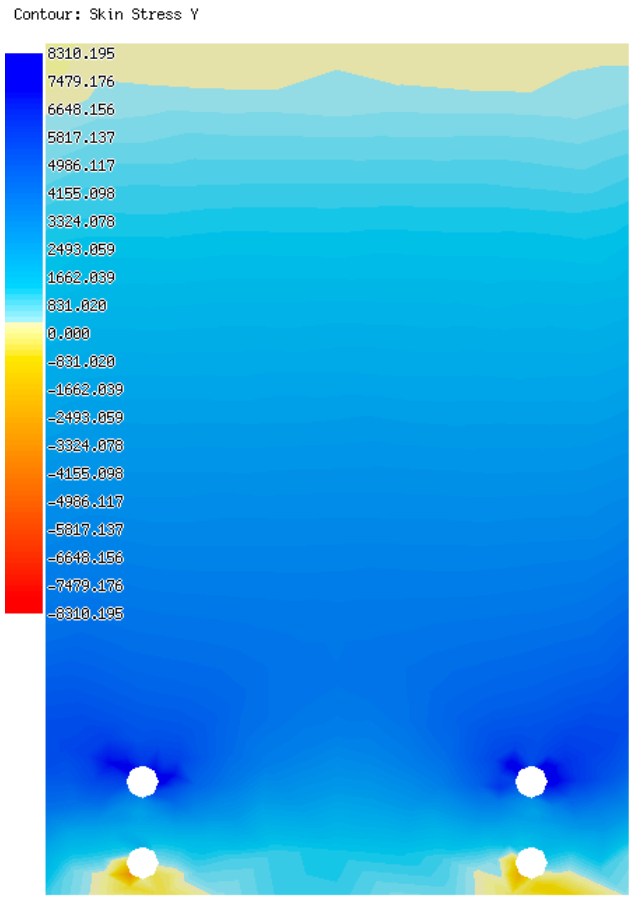
Two fascia pairs, 24" post spacing and 42" glass height.

Distance from top of glass to top support = 45.5"
Glass stress with continuous clamping at bottom = 50plf*45.5"/S = 2,275"#/S (live load)
= W/12*45.5²*0.55/S = W94.89/S

From model
2" standoffs, f_b=9,287psi for 1/2" glass
Stress concentration factor = 8310/(2,275/.44) = 1.61



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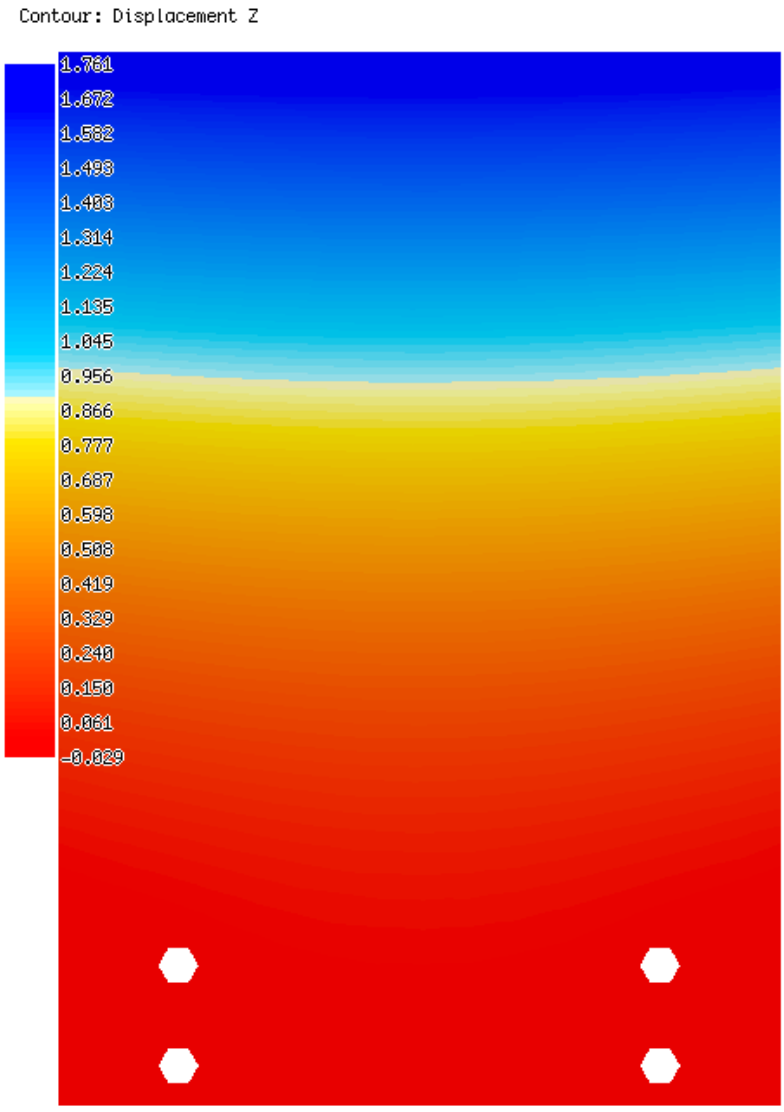
Δ= 1.761”



Check for 1-1/2” stand offs-
f_b=8878psi
Stress concentration factor = 8878/(2,275/.44) = 1.72

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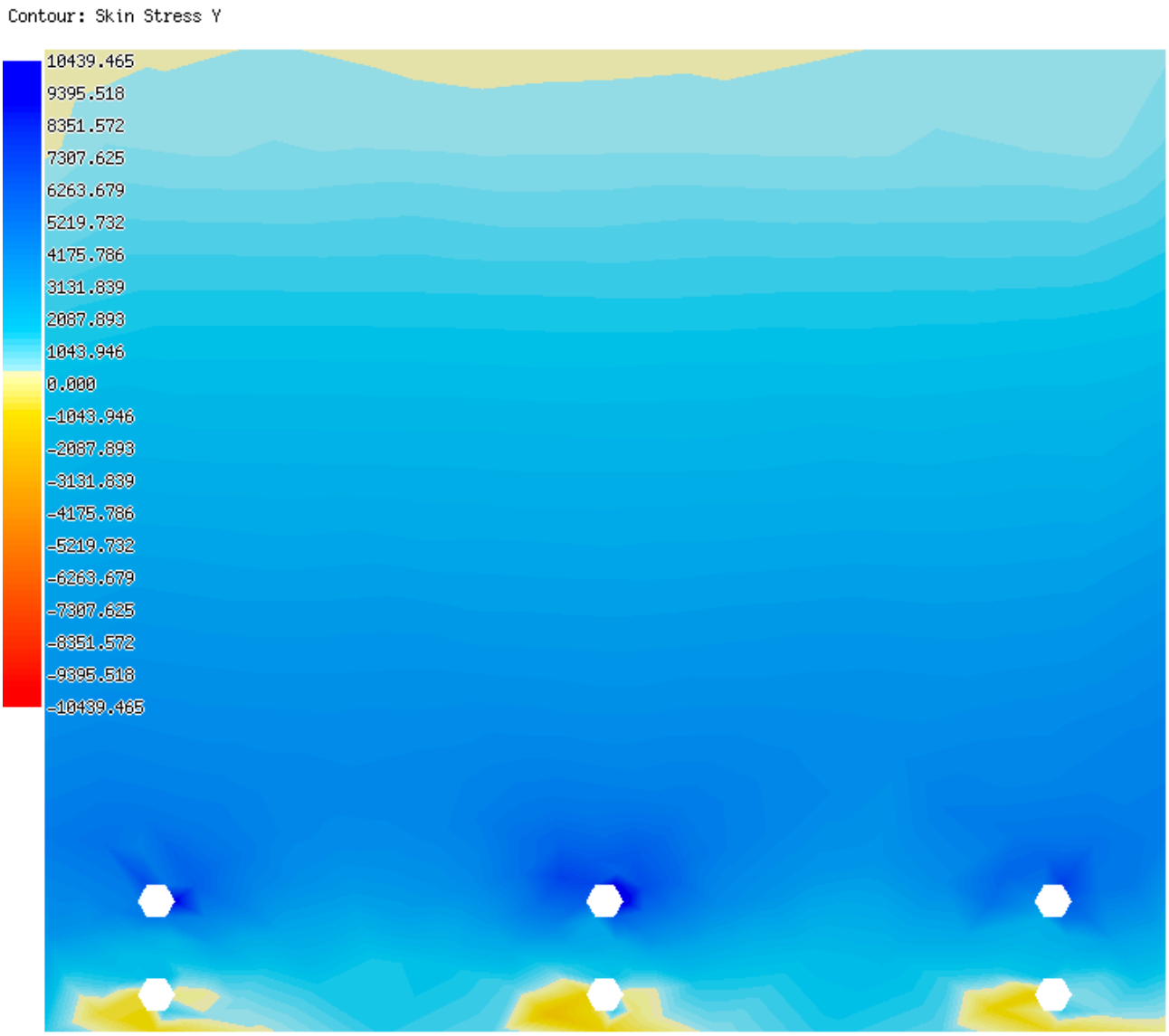
Three fascia pairs, 24" post spacing and 42" glass height.

Distance from top of glass to top support = 45.5"
Glass stress with continuous clamping at bottom = 50plf*45.5"/S = 2,275"#/S (live load)
= W/12*45.5²*0.55/S = W94.89/S

From model
2" standoffs, f_b=10,440psi for 1/2" glass
Stress concentration factor = 10,440/(2,275/.44) = 2.02



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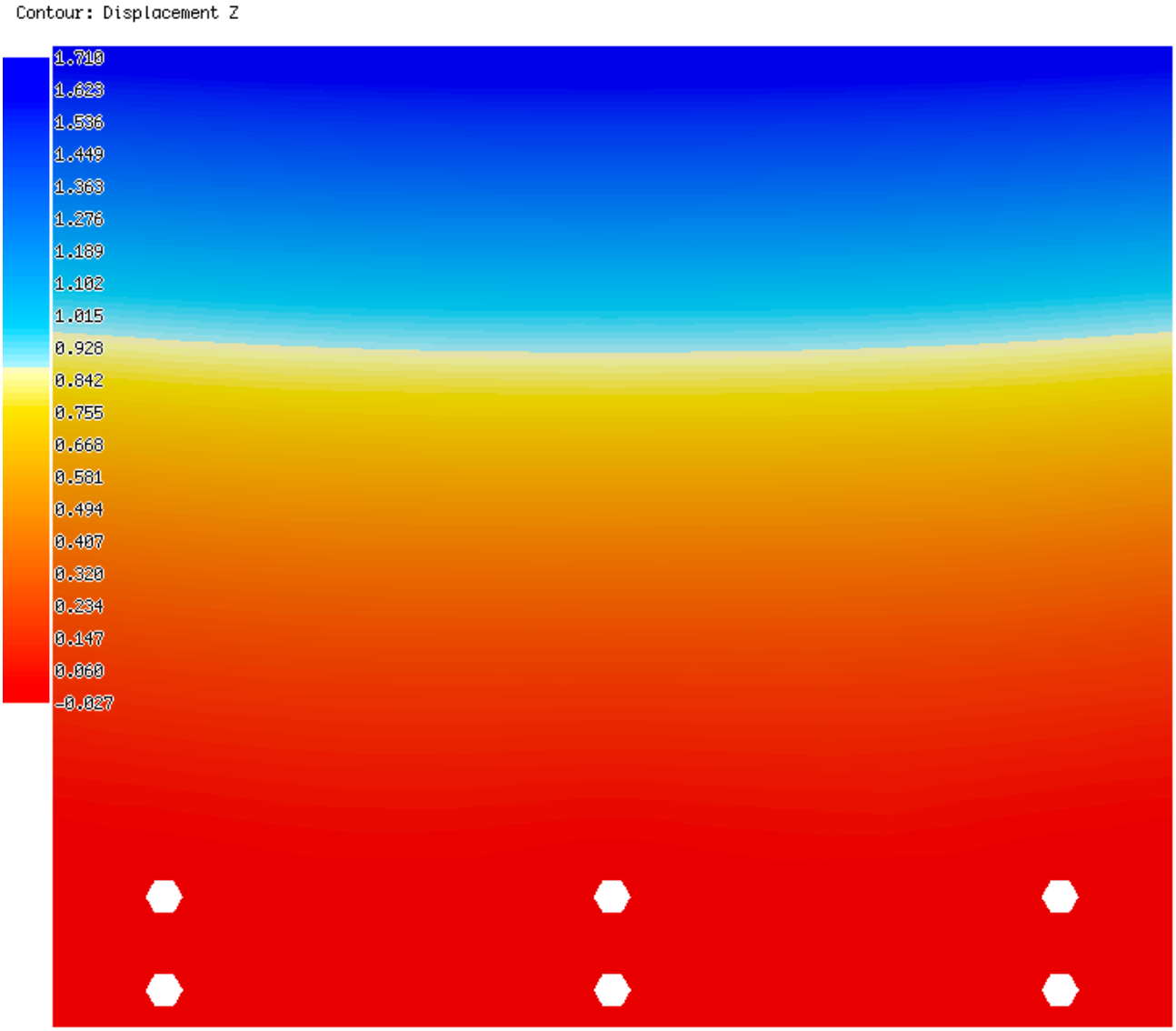
Δ= 1.71”



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Check concentration factor applicability to other thicknesses:
For 3/4" glass predicted stress from 50plf load = $2275/(2*.719^2)*2.02$ = 4,445psi
From model f_b=4,442psi (concentration factor slightly conservative but applicable)

Concentration factors are applicable to all glass thicknesses.

Check concentration factor applicability to wind loading:
Predicted 3/4" glass stress from 25psf wind load = $2.02*25*94.89/(2*.719^2)$ = 4,635psi
From model f_b=4,271psi
% error = (4,635-4,271)/4,271*100%=8.5% overestimate (Wind load stress concentration factor actually slightly lower but the single concentration factor can be used conservatively)

Check for 1-1/2" stand offs-
f_b=10867psi
Stress concentration factor = 10867/(2,275/.44) = 2.10

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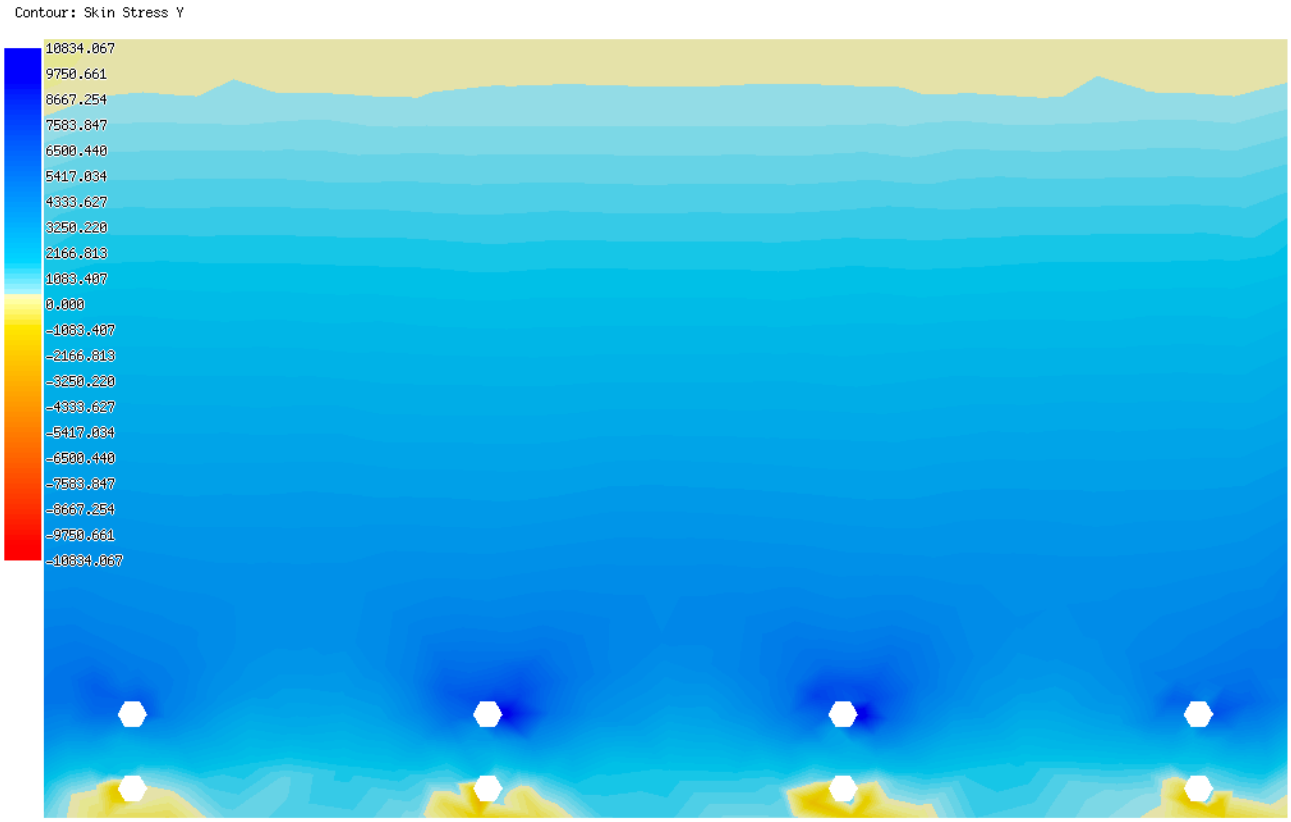
Four fascia pairs, 24" post spacing and 42" glass height.

Distance from top of glass to top support = 45.5"
Glass stress with continuous clamping at bottom = 50plf*45.5"/S = 2,275"#/S (live load)
= W/12*45.5²*0.55/S = W94.89/S

From model
2" standoffs, f_b=10834psi for 1/2" glass
Stress concentration factor = 10834/(2,275/.44) = 2.10



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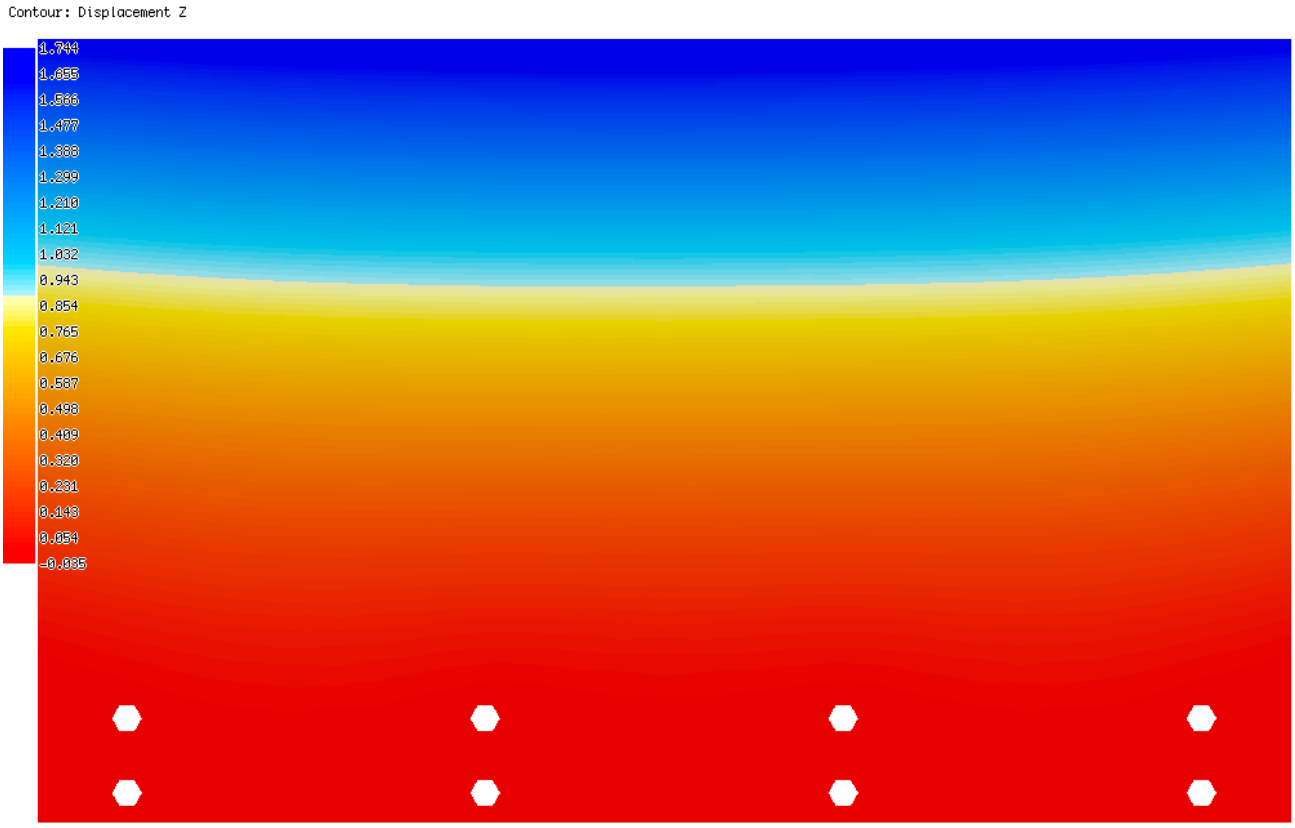
Δ= 1.744”



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Check concentration factor applicability to other thicknesses:
For 3/4" glass predicted stress from 50plf load = $2275/(2*.719^2)*2.10$ = 4,621psi
From model f_b=4,610psi (concentration factor slightly conservative but applicable)

Concentration factors are applicable to all glass thicknesses.

Check concentration factor applicability to wind loading:
Predicted 3/4" glass stress from 25psf wind load = $2.10*25*94.89/(2*.719^2)$ = 4,818psi
From model f_b=4,506psi
% error = (4,818-4,506)/4,506*100%=6.9% overestimate (Wind load stress concentration factor actually slightly lower but the single concentration factor can be used conservatively)

Check for 1-1/2" stand offs-
f_b=8878psi
Stress concentration factor = 11474/(2,275/.44) = 2.22

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Standoff and glass panel assembly

Assembly Fig.1 consists of one tempered glass panel, thickness as required (1) (made by others) and four standoffs (2).
Glass panel has four or six 3/4" diameter holes, two per standoff pair.
A standoff Fig.2 consists of an hanger bolt anchoring screw (3)(sold separately), standoff body (4), adjustable screw (5), glass retainer (6), two plastic washers (7), and a 3/8" cap nut (8).
Anchoring screw (3) has a first section (9) threaded with knife wood thread 5/8" x 2" and a second section (10) threaded 1/2"x5/8".
Standoff body (4) is cylindrical shape having 1/2" threaded receivers (11) extending from two distant ends.
Adjustable screw (5) has a 3/4" diameter middle section (12), first end threaded 1/2" (13) and second, distant end, threaded 3/8" (14).
Glass retainer (6) has the shape of a 1-1/2" diameter washer having a 3/8" diameter hole (15).
3/8" nut (8) has shape of a cap 1-1/2" diameter.

Recommended procedure for installation in wood support
1.2" dia. holes are drilled in support as per glass holes layout.
Mlevel hanger bolts (3) are driven in predrilled holes
standoff bodies (4)are threaded on hanger bolts
adjustable screws (5) are threaded in standoff bodies.
glass retainers (6) with plastic washers (7) are sleeved over adjustable screws
glass panel (1) is sleeved over adjustable screws
Cap nuts (8) with washers (7) are threaded on adjustable screws to secure glass panel

Recommended procedure for installation in concrete support
5/8" dia holes are drilled in support as per glass holes layout
Template is made with 1/2" dia holes drilled as per glass holes layout.
Standoffs (including hanger bolts) are mounted on template.
Template is dry fit in holes and holes are corrected if needed.
Holes are thoroughly cleaned and vacuumed
Epoxy is deposited in holes (it is recommended to brush it on hole walls and on hanger bolts for better adherence).
Template is set in place and secured until epoxy cures.
Template is replaced with glass panel.

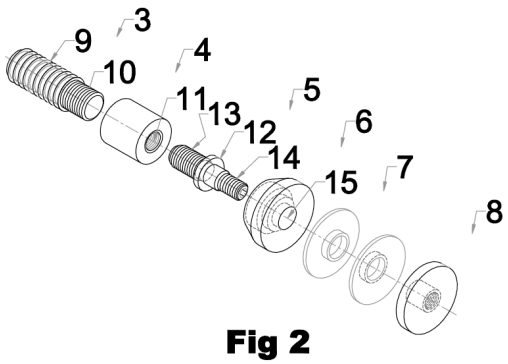

Fig 2

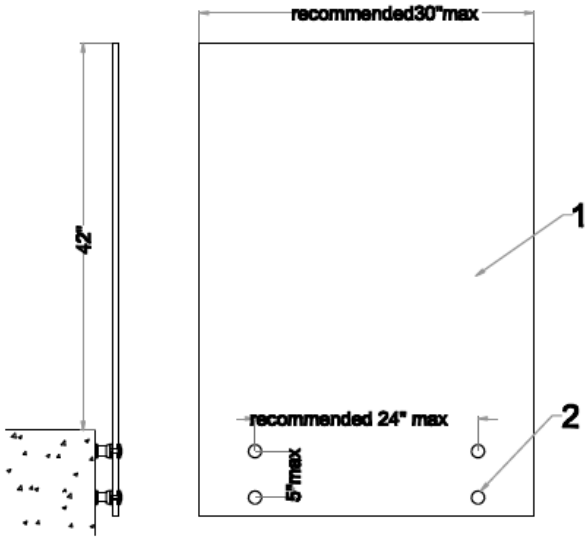

Fig 1

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Top mount mini posts and glass panel installation

Assembly Fig. 3 consists of one tempered glass panel thickness as specified (16) (by others), two mini posts (17) and six Mlevel anchors (18) (shown on Fig 4).
Mlevel anchors are sold separately.
Glass panel has four holes 3/4" diameter.
Mini post Fig 4 consists of post body (19), plate (20), two screws 3/8"x1-1/4"(21), and two glass standoffs (22).
Post body (19) is made of solid aluminum or stainless steel 3/4"x2"x11-1/4". Post body has two 3/8" threaded receivers (23) and two 1/2" threaded receivers (24).
Plate (20) has two assembly holes (25) and three anchoring holes (26).
Glass standoff (22) consists of an adjustable screw (27) a glass retainer (28) two plastic washers (29) and a cap nut (30).
Adjustable standoff screw (27) has first threaded section 1/2" diameter (31), middle section diameter 5/8" (32)and second threaded section 3/8" diameter (33).
Glass retainer (28) has the shape of a 1-1/2" diameter washer with a 3/8" diameter hole (34).
3/8" cap nut (30) has the shape of a cap 1-1/2" diameter.
Mlevel anchor (35) consists of a anchoring socket(36), an adjustable screw(37) and a 3/8"nut (38).
Anchoring socket (36) has a cylindrical shape with outer knife thread 3/4" diameter (39) and threaded receiver 1/2" diameter (40).
Adjustable anchoring screw (37) has first threaded section 1/2" diameter (41) middle section. 3/4" diameter (42) and second threaded section 3/8" diameter (43)

Mini posts and glass assembling

Post body (19) and plate (20) are connected with 2 screws (21).
Adjustable screw (27) is threaded into receiver (24).
Glass retainer (28) with washer (29) is sleeved over adjustable screw second threaded section (33).
Glass panel is sleeved over adjustable screw second threaded section (33) to rest on glass receiver (28).
Cap nuts (30) are threaded onto adjustable screw second threaded section to secure glass to mini posts.
Recommended installation procedure for wood support
Three holes 5/8" dia are drilled in support for each post plate as per plate holes layouts.
Anchoring sockets (36) are driven into holes.
Anchoring adjustable screws (37) are threaded into anchoring sockets.
Glass and mini post assembly is placed over anchoring assembly. Using an Allan key adjustable anchoring screws may be rotated up or down to adjust plumb post position.
Posts are secured with secured with 3/8" nuts (38)

Recommended installation procedure for concrete support

Three holes 3/4" dia are drilled in support for each post plate as per plate holes layouts.
Mini posts and glass panel are assembled.
Anchors are secured to Mini posts plates.
Assembly is dry fit in holes.
If needed correct hole alignment.
Holes are thoroughly cleaned and vacuumed.
Epoxy is deposited in holes (recommended to brush it on holes walls and on anchoring sockets for better adherence).
Assembly is set in holes and secured until epoxy cures.

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Posts plumb position may be adjusted turning adjustable anchoring screws up or down.

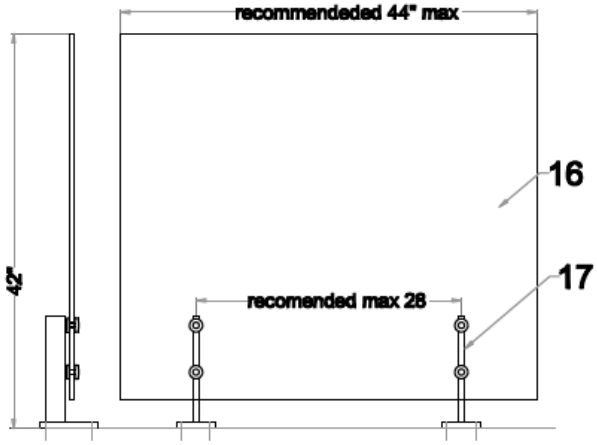

Fig 3

This system may be modified by the use of three mini posts.

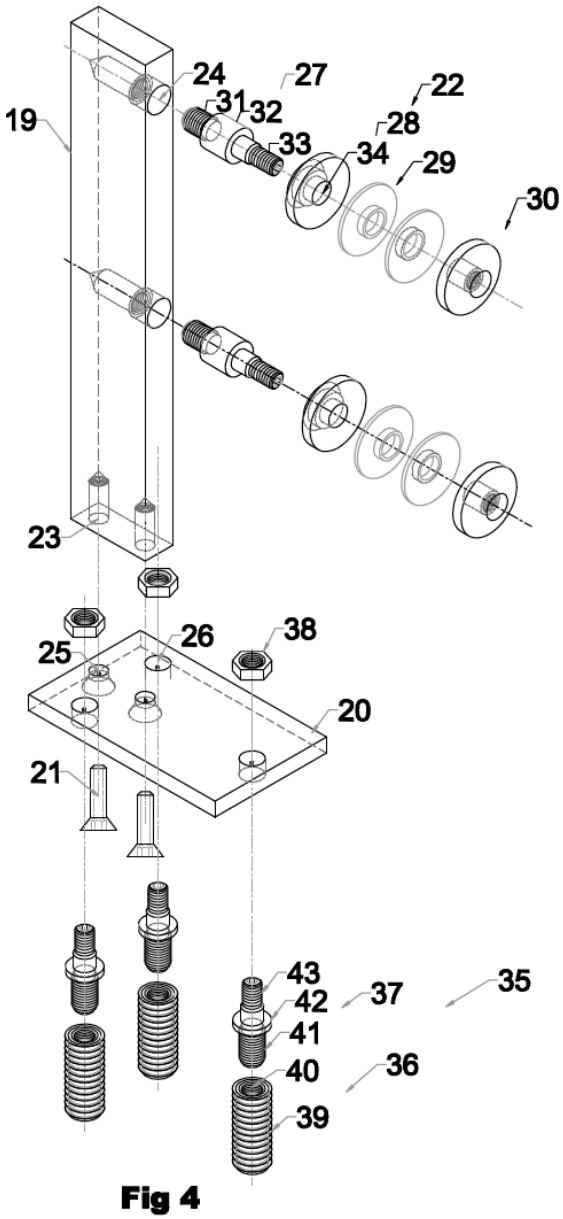

Fig 4

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Side mount mini posts and glass panel installation

Assembly Fig. 5 Consists of a glass panel 1/2" thickness (44) (by others), two mini posts (45) and four Mlevel anchors (65) (shown on Fig. 6).
Glass panel has four holes 3/4" diameter.
Mini post Fig. 6 consists of a post body (46) and two glass standoffs (47).
Post body (46) is made of solid aluminum or stainless steel 3/4"x 2"x20". Post body has two 1/2" threaded receivers (48) and two mounting holes (49).
Glass standoff (47) consists of an adjustable screw (50) a glass retainer (51) two plastic washers (52) and a cap nut (53).
Adjustable screw (50) has first threaded section 1/2" diameter (54) middle section 5/8" diameter (55) and second threaded section 3/8" diameter (56).
Glass retainer (51) has the shape of a 1-1/2" diameter washer with a 3/8" diameter hole (57).
3/8" cap nut (53) has the shape of a cap, 1-1/2" diameter.
Mlevel anchor (65) consists of a anchoring screw (58), coupling nut (59) and a 3/8"x2" screw (60)
Anchoring screw (58) has a first section (61) threaded with knife wood thread 5/8"x2" and a second section (62) threaded 1/2"x5/8".
Coupling nut (59) has a cylindrical shape with a ó" threaded receiver (63) extending from first end and a 3/8"threaded receiver (64) extending from second, distant, end.

Recommended installation procedure for wood support

Holes 1/2" with layout corresponding to mini posts holes layout are drilled in support.
Anchoring hanger bolts (58) are driven into predrilled holes.
Coupling nut (59) are threaded on anchoring hanger bolts.
Screws (60) are inserted through post holes (49) and threaded into coupling nut (59) securing the post to the support.
Adjustable screws (50) are threaded into receiver (48).
Glass retainers (51) with washers (52) are sleeved over adjustable screw second threaded section (56).
Glass panel is sleeved over adjustable screw second threaded section (56) to rest on glass retainer (57).
Cap nuts (53) are threaded onto adjustable screw second threaded section to secure glass to mini posts.

Recommended installation procedure for concrete support

Holes 3/4" with layout corresponding to mini posts holes layout are drilled in support.
Template with holes as per glass holes layout is made.
Template and mini posts are assembled.
Anchoring assemblies are secured to mini posts.
Assembly is dry fitted in holes.
If needed holes are corrected.
Holes are thoroughly cleaned and vacuumed.
Epoxy is deposited in holes (recommended to brush it on hole walls and on anchoring sockets for better adherence).
Assembly is set in holes and secured until epoxy cures
Template is replaced with glass panel.

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Glass panels position adjustment

When all glass panels are installed, their relative position may be adjusted.
One cap nut at a time may be removed to access adjustable standoff screw. Using an Allan key adjustable screw may be turned in or out to adjust glass position.

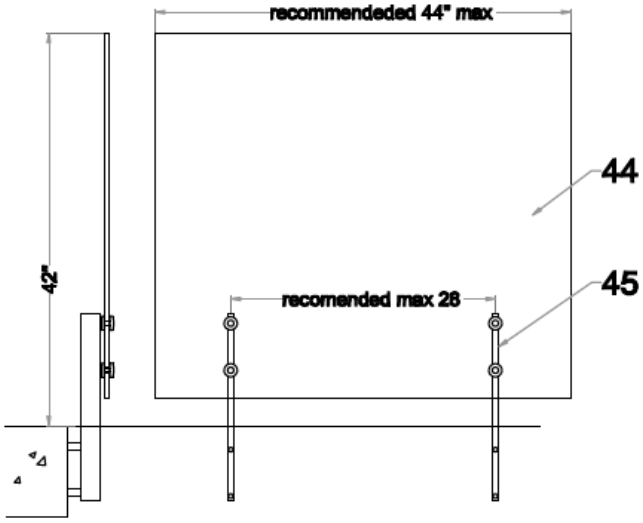

Fig 5

This system may be modified by using three posts.

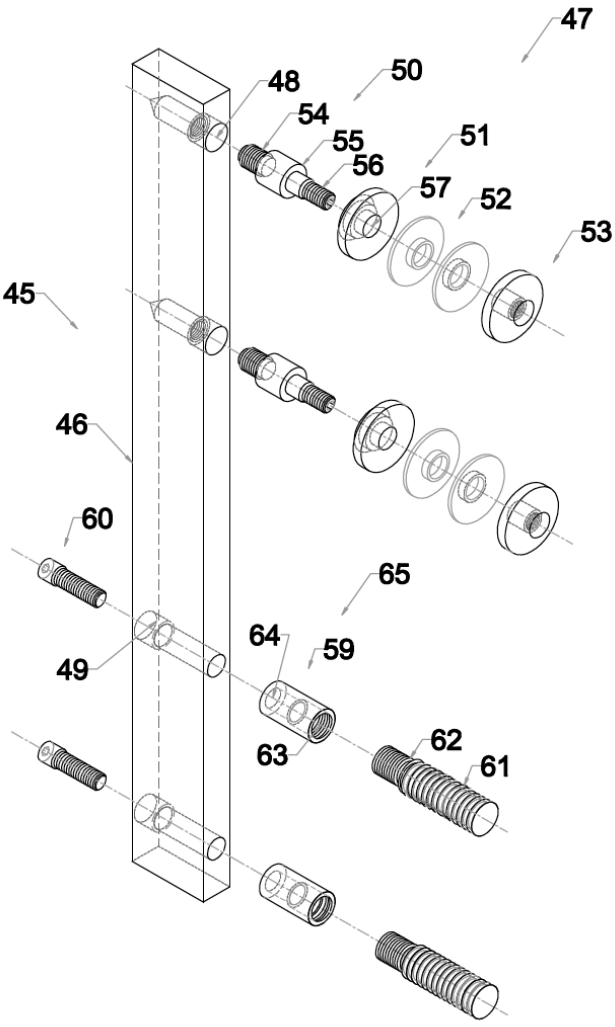

Fig 6

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