The Z-Series Glass Clamps are used to support fully tempered glass lights in guards, partitions, displays and similar applications. This report is an analysis of the structural characteristics of the clamps and supported glass lights to assist the specifier in determining the proper application and use of the Z-series clamps.

When used in installations complying with the recommendations herein the Z-series clamps and supported lights will be in accordance with the requirements of the 1997 Uniform Building Code, 2000, 2003, 2006 and 2009 International Building Codes, Florida Building Code (non-hurricane zones), 2007 and 2010 California Building Code and 2005 Aluminum Design Manual. Wood components and anchorage to wood are designed in accordance with the National Design Specification for Wood Construction.

Edward Robison, P.E.
Component Description
The CR Laurence Z-Series Glass Clamp is a two-piece through glass or edge bearing clamp used to point support tempered glass or similar panels in a frame to construct guard infills, partitions, wind screens, display cases or similar assemblies.

(Width varies)

The width and channel size of the clamps are made in three sizes to accommodate glass thicknesses of 1/4”, 3/8” and 1/2”. Other glass thicknesses within this range may be accommodated by using nylon shims. The clamps may be used with laminated glass using appropriate shims. Annealed glass may be used only where there is no potential for human impacts.

The clamps are produced from either cast 316 stainless steel or cast Zamak 3 zinc-aluminum alloy produced by Nyrstar with a variety of finishes. The clamps may be powder coated or otherwise finished.

The clamp is bolted to the supporting structure using a 5/16” maximum diameter fastener of a length and type appropriate to the substrate material.

The clamp is attached to the glass by a through glass pin (requires a 1/2” hole in glass, 9/16” hole for 1/2” glass). Or may be installed without the glass hole where the glass is supported in a configuration that confines the glass without need of the through glass shear pin.

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Z-CLAMPS
Clamps to the glass on the side of the glass using a hole through the glass light at the clamp.

The Z-clamp provides a simple connection point (shear transferred only with no moment resistance.)

Load to the Z- clamp:
Vertical load $V = D/4$ (lite weight/ four clamps per lite)
$D = L' \times B' \times D_G$
$L = $ light length, $B = $ light height and $D_G = $ light weight in psf
Glass dead load:
$D_{1/4''} = 2.9$ psf
$D_{3/8''} = 4.8$ psf
$D_{1/2''} = 6.5$ psf

Horizontal load (H), live or wind:
$W$ or $L$ in psf
$H = L' \times B' \times W$ or $L$
Load per clamp = $H/4$

Glass bearing on clamp pin:
allowable = $t \times d \times 3,000$ psi

TYPICAL USE:
Glass infill panel with 25 psf wind load, 42” total rail height and posts at 5’ on center.
Clamp Strength:
Screws holding clamp back to front: two #10 SS screws into tapped holes.

\[ \phi T_n = 0.75 \times 67.5 \text{ksi} \times 0.0175 \text{ in}^2 = 886 \text{# each} \]

\[ T_s = \phi T_n / 1.6 = 886 / 1.6 = 554 \text{#} \]

Total allowable service tension load on bracket = 2*554# = 1,108#

Check screw shear strength
Screw strength, \( A_v = 0.0175 \text{ in}^2, F_{nt} = 33.7 \text{ ksi} \)

\[ V_s = \phi A_v F_{nv} / 1.6 = 0.65 \times 0.0175 \times 33.7 / 1.6 = 240 \text{#} \]

Total allowable service shear load on bracket = 2*240# = 480#

Shear carried by through glass pin in clamp:
Pin strength, \( A_v = 0.0767 \text{ in}^2, F_{nt} = 33.7 \text{ ksi} \)

\[ T_s = \phi A_v F_{nv} / 1.6 = 0.65 \times 0.0767 \times 33.7 / 1.6 = 1,050 \text{#} \]

Pin strength will not control clamp loading

FOR LARGE SERIES CLAMPS (2-1/8” TALL)
Moment on screw from vertical load

\[ M_V = V \times 1.469” \]

Screw tension from \( \sum M \) and solving for \( T \)

\[ T_V = M_V / (2.125” / 2) = 1.469V / 1.0625” = 1.382V \]

setting \( T_V = T_s \) and solving for \( V \)

\[ V = 1,375#/1.382 = 995\# \] (for all large clamps)

Vertical load will not be limiting for any of the clamp styles or attachments.

Clamp connections to posts:

Moment on anchor screw from horizontal load

\[ M_H = H \times 1.48” \]

Screw tension from \( \sum M \) and solving for \( T \)

\[ T_H = M_H / (B_c / 2) = 1.469H / (B_c / 2) = 2.938H / B_c \]

\( B_c = \) clamp width

\( B_c = 15/16” \) for 1/4” glass
\( B_c = 1-3/32” \) for 3/8” glass (1.09/0.935) = 1.166
\( B_c = 1-7/32” \) for 1/2” glass (1.21/0.935) = 1.294

Determine allowable horizontal loads based on the allowable screw tension load
Solving for \( H \):

\[ H = T_H \times B_c / 2.938 \]

Substituting for \( T_H = T_s = 1,375# \)

\[ M_H = 1,375 \times B_c / 2.938 = 468.0 \times B_c \]

Clamp base secured to post with 5/16” fastener
Screw secured with rivet nut for thin wall post or tapped hole for sch 40 pipe.

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Screw strength:
Tension strength, $A_t = 0.0524 \text{ in}^2$, $F_{nt} = 56 \text{ ksi}$
\[ T_s = \phi A_t F_{nt} / 1.6 = 0.75 \times 0.0524 \times 56 / 1.6 = 1,375\# \]
Shear strength, $A_v = 0.0613 \text{ in}^2$, $F_{nv} = 33.7 \text{ ksi}$
\[ V_s = \phi A_v F_{nv} / 1.6 = 0.65 \times 0.0613 \times 33.7 / 1.6 = 840\# \]

Moment strength of attachment:
\[ M_{sh} = 1,375\# \times (0.935'' / 2) = 643''\# \]
\[ H_s = 643''\# / 1.48'' = 434\# \]

Shear load on screw
\[ Z = (H^2 + V^2)^{1/2} \]

Glass dead load based on tributary area: $6.5 \text{ psf} \times 3' \times 5' / 4 = 24.4\#$
\[ Z = (434^2 + 24.4^2)^{1/2} = 435\# \]

combined shear and tension:
\[ 1375 / 1375 + 435 / 840 = 1.51 > 1.2 \]
Must reduce tension load: $1.2 / 1.51 \times 1,375 = 1,093\#$
\[ M_{sh} = 1,093\# \times (0.935'' / 2) = 511''\# \]
\[ H_s = 511''\# / 1.48'' = 345\# \]

combined shear and tension:
\[ 1,093 / 1375 + 345 / 840 = 1.20 \leq 1.20 \]

Allowable horizontal load on Z-clamp bolted to steel post:
1/4” glass clamp -
\[ H = 345\#: \quad w = 345 \times 4 / (3 \times 5) = 92 \text{ psf} \]
\[ D = 24.4\# \quad (3' \times 5' \times 1/2'' \text{ glass light}) \]
3/8” glass clamp -
\[ H = 1.166 \times 345\# = 385: \quad w = 385 \times 4 / (3 \times 5) = 102.7 \text{ psf} \]
1/2” glass clamp -
\[ H = 1.294 \times 345\# = 446: \quad w = 446 \times 4 / (3 \times 5) = 119 \text{ psf} \]

WOOD ATTACHMENT
Pullout strength of lag screw into wood post:
5/16” x 2” lag screw
Withdrawal strength of lag screw based on NDS Table 11.2A
Typical embed depth = 2” - 5/8” - 3/16” = 1.1875”
$W_1 = 220\# / \text{in} \quad (5/16” \text{ diameter with } G = 0.44 \text{ and } C_d = 1.33 \text{ for guard application})$
$W_1 = 220\# / \text{in} \times 1.1875'' \times 1.33 = 347\#$

Moment strength of attachment:
\[ M_{sh} = 347\# \times (0.935'' / 2) = 162.2''\# \]
\[ H_s = 162.2''\# / 1.48'' = 110\# \]

Lag screw withdrawal strength is not reduced for shear load on lag.
Allowable shear on lag screw from NDS Table 11K, 1/4” side plate with $G \geq 0.43$
\[ Z_T = 170\# \quad (\text{horizontal load}) \]
Z_{ll} = 250\# (vertical load)
For 3’x5’ glass light maximum wind load:
\[ w = \frac{110\# \times 4}{(3 \times 5)} = 29.3 \text{ psf} \]

**Allowable horizontal load on Z-clamp bolted to wood post:**

1/4” glass clamp -
\[ H = 110\#: \quad w = \frac{110\# \times 4}{(3 \times 5)} = 29.3 \text{ psf} \]
\[ D = 24.4\# \quad (3’x5’x1/2” glass light) \]

3/8” glass clamp -
\[ H = 1.166 \times 110\# = 122.8\#: \quad w = \frac{122.8\# \times 4}{(3 \times 5)} = 32.7 \text{ psf} \]

1/2” glass clamp -
\[ H = 1.294 \times 110\# = 142.3\#: \quad w = \frac{142.3\# \times 4}{(3 \times 5)} = 38 \text{ psf} \]

**CONCRETE ATTACHMENT**

1/4” Hilti KWIK HUS-EZ (KH-EZ) screw-in anchor.
Strength from ESR-3027

\[ T_a \geq 475\# \]
\[ V_a \geq 580\# \]

Moment strength of attachment:
\[ M_{sh} = 475\# \times (0.935”/2) = 222”\# \]
\[ H_s = 222”/1.48” = 150\# \]
\[ Z = (150^2 + 24.4^2)^{1/2} = 152\# \]

Combined case:
\[ 152/580 = 0.26 \geq 0.2 \text{ therefore reduction in allowable tension load applies:} \]
\[ (1.2/(1+0.26)) \times 150 = 143\# \]
\[ Z = (143^2 + 24.4^2)^{1/2} = 145\# \]
\[ 143/150 + 145/580 = 1.20 \leq 1.20 \text{ okay} \]

**Allowable horizontal load on Z-clamp bolted to concrete:**

1/4” glass clamp -
\[ H = 143\#: \quad w = \frac{143\# \times 4}{(3 \times 5)} = 38.1 \text{ psf} \]
\[ D = 24.4\# \quad (3’x5’x1/2” glass light) \]

3/8” glass clamp -
\[ H = 1.166 \times 143\# = 166.7\#: \quad w = \frac{166.7\# \times 4}{(3 \times 5)} = 44.5 \text{ psf} \]

1/2” glass clamp -
\[ H = 1.294 \times 143\# = 185.0\#: \quad w = \frac{185.0\# \times 4}{(3 \times 5)} = 49.3 \text{ psf} \]
CLAMP BODY STRENGTH:

**Stainless Steel casting (part casting number Z906-1):**

Typical yield strength = 45 ksi, 
F<sub>ymin</sub> = 30 ksi

Controlling failure mode is from bending failure at point where the body arm meets the base.

Controlling section properties:
I<sub>xx</sub> = 0.0009 in<sup>4</sup>
S<sub>xx</sub> = 0.0043 in<sup>3</sup>
Z<sub>xx</sub> = 0.009 in<sup>3</sup>

\[ \varnothing M_n = \varnothing F_y Z = 0.9 \times 30 \text{ksi} \times 0.009 \text{in}^3 = 243'' \# \]

Determine maximum horizontal service load
\[ H_s = \frac{\varnothing M_n}{1.6 	imes 0.55''} = \frac{243''}{1.6 	imes 0.55''} = 276'' \# \]

**For loading in opposite direction:**

Load is supported by cast leg piece attached to main clamp body using (two) #10 screws. The load is resisted by a couple formed between the screw tension, compression at the bottom of the casting and shear across the pegs that fit into receiver holes on the main body.

Screw strength:
\[ \varnothing T_n = 0.75 \times 67.5 \text{ksi} \times 0.0175 \text{in}^2 = 886'' \# \text{ each} \]
\[ T_s = \frac{\varnothing T_n}{1.6} = \frac{886}{1.6} = 554'' \# \]

Shear strength of the pegs:
\[ \varnothing V_n = 0.75 \times 17 \text{ksi} \times (0.17^2) = 368'' \# \text{ each} \]
\[ V_s = \frac{\varnothing V_n}{1.6} = \frac{368}{1.6} = 230'' \# \text{ each} \]

From \( \sum \text{forces} \):
\[ H = -T \]
\[ V = -C \]

From \( \sum \text{M} \) about bottom at location where C acts

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M = H*1.32” + 0.37T + 0.18V = 0
Assuming shear strength controls moment:
substituting -H for T and V, for V and solving for H
(1.32-0.37)H = 0.18*230#*2
H = 87#

Mode II failure:
Horizontal load is resisted by couple formed by compression between bottom corner and tension in screw:
ΣM = 0 = H*1.32” + T*0.37”
setting T = T_s and solving for H
H = (0.37”*554#*2)/1.32” = 311#  Controls strength of force transfer between clamp sections.

Bending strength of piece is same as for leg on main body, will control horizontal load to:
H_a = 276#

STAINLESS STEEL Z-CLAMP

For connection to steel strength controlled by clamp body strength:
H_a = 276# = maximum allowable horizontal load on clamp.

For connection to wood strength is controlled by lag screw withdrawal:
Refer to page 7 for allowable load.

For connection to concrete strength controlled by anchor strength:
Refer to page 7 for allowable load.
For Zinc alloy cast parts (Casting number Z806-1 and Z806-2)
Zamak 3, ASTM B240-07 Alloy 3 – AG 40A UNS Z33521
Strength properties: \( F_u = 30.2 \text{ksi} \)
Allowable bending strength, \( F_{ba} = 12,000 \text{ psi} \) (based on preventing fatigue fracture)
All zinc alloy die cast parts are made with the same die cast only the finish varies.
Failure modes are the same as for the Z906 stainless steel casting.

Controlling failure mode is from bending failure at point where the body arm meets the base.

Controlling section properties:
\( I_{xx} = 0.00073 \text{ in}^4 \)
\( S_{xx} = 0.00357 \text{ in}^3 \)
\( M_a = F_i S = 12 \text{ksi} \times 0.00357 \text{ in}^3 = 42.8''# \)

Determine maximum horizontal service load
\( H_s = M_a/(0.58'') = 42.8''#/\(0.58''\) = 73.9#
Maximum wind load = 73.9#

Determine yield moment:
\( M_y = F_y S = 30.2 \text{ksi} \times 0.00357 \text{ in}^3 = 107.8''# \)
Yield load:
\( H_y = M_y/(0.58'') = 107.8''#/\(0.58''\) = 185.9#
Maximum live load = 185.9/1.67 = 111#

For failure:
\( Z = 0.0087 \text{ in}^3 \)
\( M_u = 0.0087 \times 30.2 \text{ksi} = 263''# \)
Failure load \( M_u/(0.58'') = 263''#/\(0.58''\) = 453# \)
Ultimate strength and failure mode verified by destructive testing.
For loading in opposite direction:
Load is supported by cast leg piece attached to main clamp body using (two) #10 screws. The load is resisted by a couple formed between the screw tension, compression at the bottom of the casting and shear across the pegs that fit into receiver holes on the main body.

Screw strength:
\[ \sigma_{T_n} = 0.75 \times 67.5 \text{ksi} \times 0.0175 \text{ in}^2 = 886\# \text{ each} \]
\[ T_s = \frac{\sigma_{T_n}}{1.6} = \frac{886}{1.6} = 554\# \]

Shear strength of the pegs:
\[ \sigma_{V_n} = 0.75 \times 14 \text{ksi} \times (0.17^2) = 303\# \text{ each} \]
\[ V_s = \frac{\sigma_{V_n}}{1.6} = \frac{303}{1.6} = 190\# \text{ each} \]

From \( \sum \) forces:
\[ H = -T \]
\[ V = -C \]
From \( \sum M \) about bottom at location where C acts
\[ M = H \times 1.32" + 0.37T + 0.18V = 0 \]
Assuming shear strength controls moment:
substituting \(-H\) for \(T\) and \(V_s\) for \(V\) and solving for \(H\)
\[ (1.32-0.37)H = 0.18 \times 230\# \times 2 \]
\[ H = 87\# \]

Mode II failure:
Horizontal load is resisted by couple formed by compression between bottom corner and tension in screw:
\[ \sum M = 0 = H \times 1.32" + T \times 0.37" \]
setting \( T = T_s \) and solving for \(H\)
\[ H = (0.37" \times 554\# \times 2) / 1.32" = 311\# \]

Bending strength of piece is same as for leg on main body, will control horizontal load.

Maximum glass size for 25psf uniform infill load:
\[ A = 4 \times 87\# / 25\text{psf} = 13.92 \text{ sf} \text{ (full area from floor to top rail and from post to post)} \]

**Zinc-Alloy castings** – For all installations loading is limited by clamp body strength to maximum horizontal load of 87#.
GLASS STRENGTH FULLY TEMPERED INFILL PANELS

All glass is fully tempered glass conforming to the specifications of ANSI Z97.1, ASTM C 1048-97b and CPSC 16 CFR 1201. The average Modulus of Rupture for the glass $F_r$ is 24 ksi. In accordance with IBC 2407.1.1 glass used in guards shall be designed for a safety factor of 4. For wind loads and loads other than human impact the glass used in guardrails may be designed in accordance with ASTM E1300-09a. Recommend using a maximum allowable bending stress of 8,000 psi for the wind loads because the glass is point supported. Higher glass stress may cause excessive glass deflection and failure at a stress less than the modulus of rupture.

Values for the modulus of rupture, $F_r$, modulus of Elasticity, E and shear modulus, G for glass are typically taken as:

$F_r = 24,000$ psi based on numerous published data from various glass manufacturers. This value is recognized in ASTM E 1300-09a, ANSI Z97.1, ASTM C 1048-97b and CPSC 16 CFR 1201 (derivation of the value may be required using the provided formulae and properties). This value is referenced in numerous publications, design manuals and manufacturers’ literature.

$E = 10,400$ ksi is used as the standard value for common glass. While the value of E for glass varies with the stress and load duration this value is typically used as an average value for the stress range of interest. It can be found in ASTM E 1300 and numerous other sources.

$G = 3,800$ ksi: This is available from various published sources but is rarely used when checking the deflection in glass. The shear component of the deflection tends to be very small, about 1% of the bending component and is therefore ignored.

$µ = 0.22$ Typical value of Poisson’s ratio for common glasses.

The shear strength of glass tracks closely to the modulus of rupture because failure under shear load will be a tensile failure with strength limited by the modulus of rupture. Thus shear loads are transformed using Mohr’s circle to determine the critical tension stress to evaluate the failure load. The safety factor of 4 is applicable to this case same as the bending case. Thus the shear stress is limited based on principal stresses of 0 and 6,000 psi to 6,000/2 = 3,000 psi.

Bearing stress can be derived in a similar fashion with the principal stresses being –6,000 psi and 6,000 psi so the bearing stress = 6,000 psi.

Bending strength of glass for the given thickness:

$I = 12''* (t)^3 /12 = (t)^3 \text{ in}^3/\text{ft}$

$S = 12''* (t)^2 /6 = 2*(t)^2 \text{ in}^3/\text{ft}$
From IBC 2407 the minimum nominal glass thickness for infill panels in guards is 1/4”
For point supported glass with pinned supports near each corner:
Controlling moments are at panel edge (longest side) mid way between Z-clamps.

\[ M = C^*w*b^2 \]

Graph A  
Graph B

Where \( a = \) shortest side, \( b = \) longest side  
\( C = C_e \) or \( C_c \) from graphs above derived from flat plate theory 
Moment at Z-clamps is nearly zero.  
For concentrated load at center of edge:  
\( C_0 = (1+a/b)^{1/3} \)  
\( M_e = 2*C_0*C_e*P*x \)  
where \( x = \) distance between Z-clamps along loaded edge  
Resisting glass width = lesser of glass width or \( x/2 \)

Example: glass size is 3’ x 5’  
\( a/b = 3/5 = 0.6 \)  
\( C_0 = (1+3/5)^{1/3} = 1.17 \)  
\( C_e = 0.138 \) from graph A  and \( C_c = 0.1175 \) from Graph B  
\( M_e = C_e*w*b^2 = 0.138*25\text{psf}^5*5^2 = 86.25'\# \) at center edge of long side  
\( M_c = C_c*w*b^2 = 0.1175*25\text{psf}^5*5^2 = 73.44'\# \) at center of glass light  
\( M_{ep} = 2C_0C_e*P*b = 2*1.17*0.138*50^*5 = 80.73'\# \) at center of glass light
Check glass deflections:
\[ \Delta_t = \eta_o wb^4 / \{E t^3 / [12(1-\mu^2)]\} \]
where:
a = short side, b = long side
w = greater of wind load, differential air pressure or live load (25 psf minimum)
E = 10.4x10^6 psi for glass
\( \mu = 0.22 \)
Maximum deflection occurs at the center of the plate.

Graph C

Allowable deflection:
Based on maximum rotation of glass within Z clamp:
\[ \kappa = 0.03125" \quad [1/2 \text{ hole clearance between glass and (steel rod + bushing diameter)}] \]
\[ \rho = \kappa / t = \pi \Delta / (L/2) \quad \text{substituting and solving for } D \]
\[ \Delta_a = L \kappa / (2\pi t) = 0.03125" * L / (2\pi t) \]
\[ \Delta_a = 0.03125" * L / (2*\pi t) = 0.005L/t \]

For 1/4" glass
\[ \Delta_a = 0.005L / 0.25 = 0.02L \]

For 3/8" glass
\[ \Delta_a = 0.005L / 0.375 = 0.0133L \]
1/4” FULLY TEMPERED GLASS
Weight = 2.89 psf
\( t_{ave} = 0.223'' \)
For 1/4” glass \( S = 2*(0.223)^2 = 0.0995 \text{ in}^3/\text{ft} \)
For live loads:
\( M_{fl} = 6,000\text{psi}*0.0995 \text{ in}^3/\text{ft} = 597''/\text{ft} = 49.75'' \)
For wind load on infill glass apply 33% stress increase for SF = 3.0
\( M_{aw} = 1.333*6,000\text{psi}*0.0995 \text{ in}^3/\text{ft} = 796''/\text{ft} = 66.33'' \)

Moment for 36” wide lite (infill for 42” rail height) 25 psf or 50 lb live load
Determine maximum span:
\( L = \sqrt{66.33''/25\text{psf}} = 1.629 \)
Assuming \( C_e = 0.145:\)
\( L = 1.629/(\sqrt{0.145}) = 4.28' \) (a/b = 3/4.28 = 0.70, \( C_e = 0.145 \) okay)

Check for concentrated load:
\( M_{cp} = 2C_eC_o*P*b \) check based on uniform load dimensions
\( M_{cp} = 2(1+0.7)^{1/3}*0.145*50*4.28' = 74.07'' \)
Resisting width = 4.28/2 = 2.14’ < 3’, 74.07/2.14 = 34.6 < 49.75’ okay

Verify Deflection:
36” wide lite (infill for 42” rail height) 25 psf
\( \Delta_a = \eta_o.wb/\{910,746.8 \text{ psi} * t^3\}\}
For a/b = 0.70; \( \eta_o = 0.0158 \)
\( \Delta_a = 0.0158*25/144*51^4/\{910,746.8 \text{ psi} * 0.223^3\} = 1.84'' > 0.02*43.84'' = 0.88'' \)

Deflection will exceed the limits of the Z-clamps to behave as designed so bending in clamps will increase accordingly.

Revised bending in Z-clamps at 25 psf:
\( H = 25\text{psf}*4.28''*3'/4 = 80.25' \)
\( M = 80.25'*1.12'' = 89.88'' > 42.8'' \)
Okay for the stainless steel Z-clamp only

Maximum span for Zamak Z-clamp:
Assume \( \eta_o=0.0263 \) (square light)
\( b = [90.02*910,746.8t^3]/(0.0263*25/144)]^{1/3} = 39.65'' \)

FOR 1/4” GLASS
Maximum glass length = 39 5/8” except;
For stainless steel clamps maximum glass length = 51”

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3/8” FULLY TEMPERED GLASS
Weight = 4.75 psi
t\text{ave} = 0.366”

For 3/8” glass S = 2*(0.366)² = 0.268 in³/ft
M\text{allowable} = 6,000psi*0.268 in³/ft = 1,607”#/ft = 133.92’#/ft

For wind load on infill glass apply 33% stress increase for SF = 3.0
M\text{all} = 1,607”#*4/3 = 2,143”#/ft = 178.58’#/ft

Moment for 36” wide lite (infill for 42” rail height) 25 psf wind load or 50 lb live load
Determine maximum span:
L\sqrt{C_e} = \sqrt{(178.58’#/25psf)} = 2.673
Assuming C_e = 0.13:
L = 2.673/(\sqrt{0.13}) = 7.41’ (a/b = 3/7.41 = 0.40, C_e = 0.129 okay)

Check for concentrated load:
M_{ep} = 2C_o C_e *P* b check based on uniform load dimensions
M_{ep} = 2(1+0.4)^{1/3}*0.129*50*7.41’ = 106.9’#
Resisting width = 7.41/2 = 3.7’ > 3’ limit to 3’ width
106.9/3 = 35.63 < 133.92’# okay

Z-clamp strength limits glass light size to 5’ for zinc clamps

Verify Deflection:
36” wide by 60” long light for 25 psf load.
\Delta_a = \eta_o wb^4/\{910,746.8 psi * t^3}\}
For a/b = 3/5 = 0.6; \eta_o = 0.0145
\Delta_a = 0.0145*25/144*60^4/\{910,746.8 psi * 0.366^3}\} = 0.73” < 0.0167*60” = 1.0”

Maximum wind load on 3’x5’ light:
b/a = 3/5 = 0.6 C_e = 0.137
w_{max} = 178.58/(0.137*5^2) = 52.1 psf
May be limited by clamp or anchor strength
1/2” FULLY TEMPERED GLASS
Weight = 6.5 psi
\( t_{\text{min}} = 0.469” \)

For 1/2” glass \( S = 2*(0.469)^2 = 0.44 \text{ in}^3/\text{ft} \)
\( M_{\text{allowable}} = 6,000 \text{psi} * 0.44 \text{ in}^3/\text{ft} = 2,640’’/\text{ft} = 220’/\text{ft} \)

For wind load on infill glass apply 33% stress increase for SF = 3.0
\( M_{\text{all}} = 2,640”/’4/3 = 3,520’’/\text{ft} = 293.33’’/\text{ft} \)

Moment for 36” wide lite (infill for 42” rail height) 25 psf wind load or 50 lb live load
Determine maximum span:
\( L\sqrt{C_e} = \sqrt{(293.33’’/25\text{psf})} = 3.425 \)
Assuming \( C_e = 0.13: \)
\( L = 3.425/(\sqrt{0.13}) = 9.5’ (a/b = 3/9.5 = 0.315, C_e = 0.127 \text{ okay}) \)

Check for concentrated load:
\( M_{ep} = 2C_e C_e * P * b \) check based on uniform load dimensions
\( M_{ep} = 2(1+0.4)^{1/3} * 0.127 * 50 * 9.5’ = 135.0’’ \)
Resisting width = 9.5/2 = 4.75’ > 3’ limit to 3’ width
135.0/3 = 45.0 < 133.92’’ okay

Z-clamp strength limits glass light size to 5’ for zinc clamps

Verify Deflection:
36” wide by 60” long light for 25 psf load.
\( \Delta_a = \eta_o wb^4/\{910,746.8 \text{ psi} * t^3\} \)
For a/b = 3/5 = 0.6; \( \eta_o = 0.0145 \)
\( \Delta_a = 0.0145 * 25/144 * 60^4/\{910,746.8 \text{ psi} * 0.469^3\} = 0.35” < 0.0167 * 60” = 1.0” \)

Maximum wind load on 3’x5’ light:
\( b/a = \frac{3}{5} = 0.6 \text{ C}_e = 0.137 \)
\( w_{\text{max}} = 293.33/0.137 * 5^2 = 85.6 \text{ psf} \)
May be limited by clamp or anchor strength

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Maximum allowable horizontal loads on clamp:
Stainless steel clamps

<table>
<thead>
<tr>
<th>Clamp Style</th>
<th>Horizontal Loads</th>
<th>Fastener to supports</th>
<th>5/16” lag to wood</th>
</tr>
</thead>
<tbody>
<tr>
<td>½” Glass</td>
<td>446#</td>
<td>185#</td>
<td>142#</td>
</tr>
<tr>
<td>3/8” Glass</td>
<td>385#</td>
<td>167#</td>
<td>123#</td>
</tr>
<tr>
<td>¼” Glass</td>
<td>345#</td>
<td>143#</td>
<td>110#</td>
</tr>
</tbody>
</table>

Maximum allowable wind load based on 3’x5’ glass light
Stainless steel clamps

<table>
<thead>
<tr>
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<th>Horizontal Loads</th>
<th>Fastener to supports</th>
<th>5/16” lag to wood</th>
</tr>
</thead>
<tbody>
<tr>
<td>½” Glass 3’x5’</td>
<td>85.6 psf</td>
<td>44.5 psf</td>
<td>32.8 psf</td>
</tr>
<tr>
<td>3/8” Glass 3’x5’</td>
<td>52.1 psf</td>
<td>44.5 psf</td>
<td>32.8 psf</td>
</tr>
<tr>
<td>¼” Glass 3’x4’-3”</td>
<td>25 psf</td>
<td>25 psf</td>
<td>25 psf</td>
</tr>
</tbody>
</table>

For Nystar (cast zinc alloy) clamps

<table>
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<tr>
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<th>Horizontal Loads</th>
<th>Fastener to supports</th>
<th>5/16” lag to wood</th>
</tr>
</thead>
<tbody>
<tr>
<td>½” Glass</td>
<td>87#</td>
<td>87#</td>
<td>87#</td>
</tr>
<tr>
<td>3/8” Glass</td>
<td>87#</td>
<td>87#</td>
<td>87#</td>
</tr>
<tr>
<td>¼” Glass</td>
<td>87#</td>
<td>87#</td>
<td>87#</td>
</tr>
</tbody>
</table>

Maximum wind load is 23.2 psf
HOLE CONDITIONS:
Hole size as specified for selected clamp.

Location of hole from edge of glass as shown in the glass fabrication template for the selected clamp.

Minimum distance from corner to periphery of hole is 6.5 times the glass thickness:
Distance from corner to centerline of the clamp is:
For 1/4” glass: \( e = 6.5 \times 0.25” + 0.5” / 2 = 1.875” = 1 \ 7/8” \)
for 5/16” glass: \( e = 6.5 \times (5/16) + 0.5/2 = 2.281” = 2 \ 9/32” \)
for 3/8” glass: \( e = 6.5 \times (3/8) + 0.5/2 = 2.6875” = 2 \ 11/16” \)
for 1/2” glass: \( e = 6.5 \times 0.5 + (9/16)/2 = 3.531 = 3 \ 17/32” \)

When compliance with ASTM C 1048 is required for the holes then the holes shall be fabricated as finger slots from the side or the clamps oriented so that the through glass pin is not required.

ALTERNATIVE CLAMP ARRANGEMENTS
The clamps may be alternatively attached to the top and bottom rail or a combination of attachment to posts and rails so that the glass is adequately supported.

The support configuration must be able to provide the support to the corner or glass edges. Examples of acceptable configurations are:

Top of glass set in top rail glazing pocket and Z-clamps to post near bottom corners with through glass pins.

Top of glass set in top rail glazing pocket and two Z-clamps to bottom rail without holes through glass.

Top of glass set in two Z-clamps to top rail and two Z-clamps to bottom rail, neither top nor bottom clamps require holes through glass.

Top of glass set in two Z-clamps to top rail without holes through glass and bottom edge set in glazing pocket in bottom rail.

Top of glass set in two Z-clamps to post without holes through glass and bottom edge set in glazing pocket in bottom rail.

Top of glass set in two Z-clamps to post without holes through glass and two Z-clamps to bottom rail without holes through glass.

Note: Top/grab rail at or above the top of the glass is required for guard applications.