August 6, 2021

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Vancouver, WA 98661

Analysis of Cable Guardrail Systems
One and Two Family Use
RailPro Profiles

Dear Mr. Krushner:

James G. Pierson, Inc. is pleased to submit this report which summarizes the results of the analysis of RailPro Cable Residential Guardrails.

Separate reports for the analysis and testing of the Railpro guardrail systems for the baluster and glass guardrail systems have been completed and are not part of the attached analysis.

CONCLUSIONS

1. The analysis demonstrates that the Railpro Cable System profiles used for residential guardrail systems meet the requirements of the 2015 International Residential Code.

2. The analysis utilizes allowable stress design (working stress design). The analysis provides a demonstration that the cable guardrail system meets the applicable code requirements.

3 . Verification that the deck or balcony framing supporting the guardrail system meets the minimum sizes specified is beyond the scope of this report (by others).

Consulting Structural Engineers

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PRODUCT DESCRIPTION

The Railpro Cable Residential Railing System consists of extruded aluminum alloy 6005A-T6 and T5 framing members (1 5/8” x 1 5/8” posts, 1 5/8”x 1 5/8” superposts, and 1”x3” termination posts) with aluminum top rails extruded from aluminum alloy 6063-T5 material. Cable in-fill are 1/8” diameter multi-strand 1x19 stainless steel cables spaced at 3 1/8” o/c and pre-stressed to 175 lbs tension. Aluminum members are connected together with cadmium-coated Torx Drive flat head steel screws and coated with a pigmented enamel finish for durability and aesthetics or Type 304 SH stainless steel flat head screws (#12).

The railing systems are typically sold for use as exterior guardrails on balconies, decks, porches, stairs and similar installations in residential use where railings are required or desired.

These systems are designed to be partially field-fabricated using stock components. The frames are designed to attach the systems to structures composed of wood and other components. The screw and lag connectors used to connect to the supporting structures should be either hot dipped galvanized steel or stainless steel.

The top railing for these systems is offered in a few different cross-sectional configurations (Series 1500S, 1500R, and 3000R). Railing sections are fabricated for the required spacing between vertical posts. The posts are attached to mounting brackets which are attached to the deck or balcony framing.

STANDARDS

Railpro products are based in Vancouver, WA and marketed in the western United States. Therefore, it was determined that standard used for analysis should be the minimum loads specified in the 2015 International Residential Code (IRC) which are the basis for state building codes in the Western United States.

It was determined that the loading provisions of Section R301.5 of the IRC applies to the Railpro cable residential railing systems. Railing Systems are required to withstand a specified loading of 200 pounds applied in any direction to the top rail of guardrails. The top rail load is not required to be concurrent with any other loads.

Components of a rail system (pickets, glass panels, cables, bottom rails) are required designed to resist a 50 lb force in any direction over a one foot square.

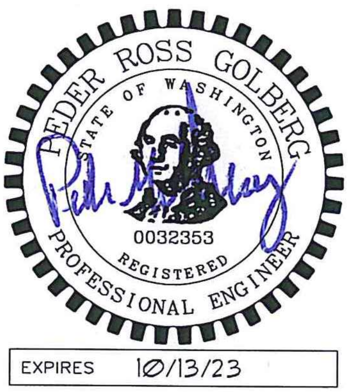
The terminology of the IRC "be designed to resist" was interpreted to mean that the railing system being analyzed would resist the forces applied without any material yielding (breaking or permanent bending). Because railing system members are not considered to be structural components of a building, the material deflection limit requirements do not apply; however, it is obvious that a railing system must resist minimum loads without plastic a deformation that would compromise safety. As a result, the analysis utilizes allowable stress design (working stress design). The analysis provides a suitably conservative demonstration that the residential guardrail system meets the applicable code requirements.

ANALYSIS RESULTS

The analysis is elaborated as follows:

· Calculations	Pages 1 - 30
. Section Properties	Pages P1 – P6
· Typical Connections	Pages C-1-

We are pleased to submit this report. Please call us if questions arise.



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Rail Pro Residential Cable Rail System

Check for conformance to:

International Residence Code Section R312 & Table R301.5

Loads: 200 lbs applied in any direction along top rail
50 lbs on an area of 1 ft^2 applied horizontally (non-concurrently with top rail load)

Framework is extruded Aluminum 6063-T5 (rails), 6005A-T6 (typ posts), or 6005-T5 (termination posts)

Cable in-fill is 1/8" diameter multi-strand 1x19 strainless steel cables spaced at 3 1/8" o/c and pre-stressed to 175 lbs max (see chart)

Fasteners are #12 18-8 stainless steel screws

Top rail is fastened to a flange on the top of the posts with (4) #12 18-8 screws. The vertical posts are attached to the baseplates with welds around all sides fully developing the material.

Working Stress Design Utilized

Aluminum Properties: Extruded 6005-T6

;Ft_u = 38 ksi
;Ft_y = 35 ksi
;F'_{cy} = 35 ksi
;F_{shear} = 20 ksi
;E = 10100 ksi

;$F_{b1} = F'_{cy} / 1.65 =$ **21212.121** psi ;(ASD) or ;$F_{b2} = Ft_u / (1 * 1.95) =$ **19487.179** psi ;(ASD)

; F_{b1} = **21212.121** psi ; F_{b2} = **19487.179** psi

;$F_{b6005T6} = \min(F_{b1}, F_{b2})$

;$F_{b6005T6}$ = **19487.179** psi

Aluminum Properties: Extruded 6063-T5

;Ft_{u6063} = 22 ksi
;Ft_{y6063} = 16 ksi
;F'_{cy6063} = 16 ksi
;$F_{shear6063}$ = 13 ksi
;E_{6063} = 10100 ksi

;$F_{b16063} = F'_{cy6063} / 1.65 =$ **9696.970** psi ;(ASD) or ;$F_{b26063} = Ft_{u6063} / (1 * 1.95) =$ **11282.051** psi ;(ASD)

; $F_{b16063} =$ **9696.970** psi ; $F_{b26063} =$ **11282.051** psi

;$F_{b6063} = \min(F_{b16063}, F_{b26063})$

;$F_{b6063} =$ **9696.970** psi

Aluminum Properties: Extruded 6005-T5

;$Ft_{u6005T5}$ = 38 ksi
;$Ft_{y6005T5}$ = 35 ksi
;$F'_{cy6005T5}$ = 35 ksi
;$F_{shear6005T5}$ = 24 ksi
;$E_{60005T5}$ = 10100 ksi

;$F_{b16005T5} = F'_{cy6005T5} / 1.65 =$ **21212.121** psi ;(ASD) or ;$F_{b26005T5} = Ft_{u6005T5} / (1 * 1.95) =$ **19487.179** psi ;(ASD)

; $F_{b16005T5} =$ **21212.121** psi ; $F_{b26005T5} =$ **19487.179** psi

;$F_{b6005T5} = \min(F_{b16005T5}, F_{b26005T5})$

;$F_{b6005T5} =$ **19487.179** psi

Guard Rail Cable Calculations

TASK:

Determine tension required so guard rail cables met deflection requirements

CABLE PROPERTIES:

Cable Material:	316 Stainless Steel
Cable Construction Type:	1 x 19
Young's Modulus:	;$E =$ **15000000** psi
Cable Diameter:	;$d =$ **0.125** in
Cross-Sectional Area:	;$A = (\pi \times d^2) / 4 =$ **0.012** in^2
Cable Spacing:	;$S =$ **3.125** in
Full Cable Length:	;$L = 50$ ft $=$ **600.000** in
Unsupported Cable Span:	;$l =$ **48.00** in

FORCES ON CABLE:

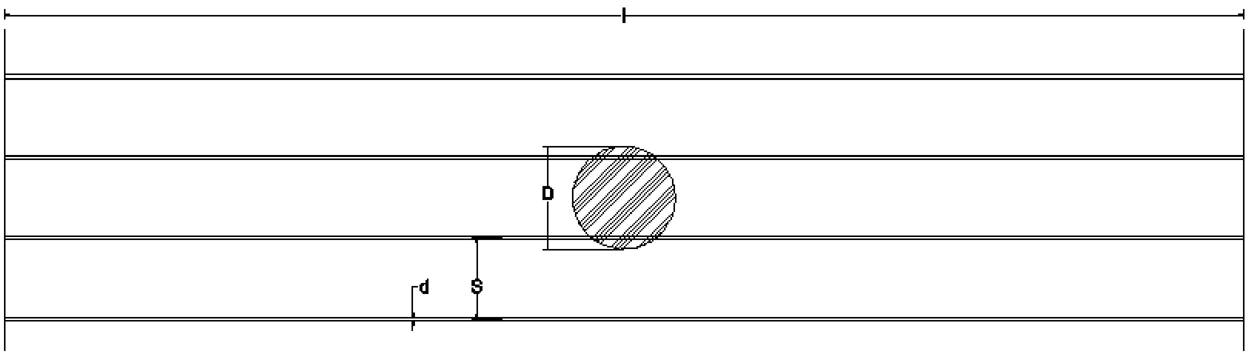
IBC 2015 1015.4:

"Required guards shall not have openings that allow passage of a sphere of 4 inches in diameter from the walking surface to the required guard height." No requirement or note in code about the force to be placed on the 4" sphere.

ASCE 7-10 4.5.1:

"Intermediate rails (all those excep the handrail or top rail) and panel fillers shall be designed to withstand a horiztonally applied normal load of 50 lb on an aea not to exceed 12in by 12in". Use this 50 psf force projected on the area of the 4" sphere since code isn't clear on the required force to maintain the 4" clear dimension.

Required Force:	;$F_{Req} =$ **50.00** psf
Sphere Diameter:	;$D =$ **4.00** in
Sphere Cirumference:	;$C = (\pi \times D^2) / 4 =$ **0.087** ft^2
Projected Load over Circumference:	;$F_{Proj} = F_{Req} \times C =$ **4.363** lb
Safety Factor (chosen to use)	;$FS =$ **2**;
Max Applied Force:	;$F_{Max} = F_{Proj} \times FS =$ **8.727** lb



ANGLED FORCES AND CABLE DEFLECTION:

When the 4” sphere is pushed through the cables, the cables are forced to move both vertically and horizontally, with the vertical displacement governing. The angle of the resultant force is approximately 45 degrees, which will be utilized in the angled force and deflection calculations.

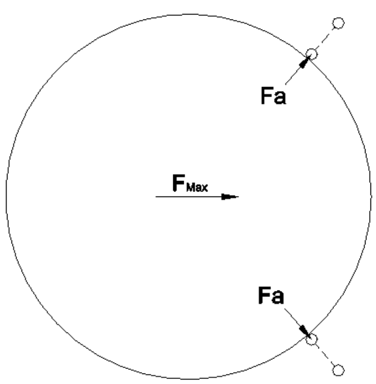
Angled Force on Cable: ;$F_A = \sqrt{((F_{Max})^2 + (F_{Max})^2)}$ = **12.341** lb

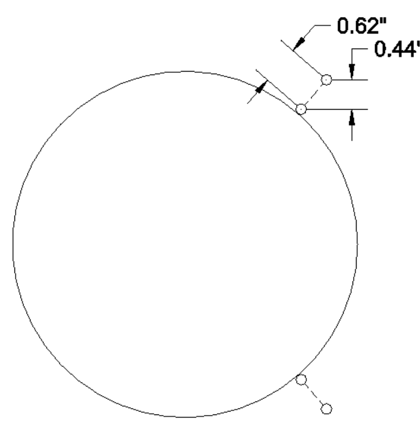
Allowable Vertical Deflection: ;$a_{Ver} = (D - S) / 2$ = **0.437** in;

(governs)

Allowable Cable Deflection: ;$a_{All} = \sqrt{(a_{Ver}^2 + a_{Ver}^2)}$ = **0.619** in ;per

cable





Deflection equation derivation:

$T = (F_A \times l) / (4 \times a)$;

$\delta = 2 \times a^2 / l$;

$\delta = (T \times L) / (E \times A) = (F_A \times l) / (4 \times a) \times L / (E \times A)$;

$2 \times a^2 / l = (F_A \times l) / (4 \times a) \times L / (E \times A)$;

$8 \times a^3 / l = (F_A \times l \times L) / (E \times A)$;

$8 \times a^3 = (F_A \times l\text{^}2 \times L) / (E \times A)$;

$a^3 = (F_A \times l^2 \times L) / (8 \times E \times A)$;
$a = ((F_A \times l^2 \times L) / (8 \times E \times A))^{1/3}$;

Deflection due to sphere load: ;$a_S = ((F_A \times l^2 \times L) / (8 \times E \times A))^{1/3}$= **2.263** in

CABLE TENSION FORCE:

Deflection due to load is higher than the allowable, so cable is to be pretensioned to be compliant.

Tension in cable due to sphere load: ;$T_S = (F_A \times l) / (4 \times a_S)$ = **65.450** lb
Tension in cable at max deflection: ;$T_a = T_S \times (a_S / a_{All})$ = **239.359** lb
Required pretension: ;$T_{p1} = T_a - T_S$ = **173.910** lb

- Cables are recommended by supplier to be tensioned at 300 lbs max / cable which is greater than the required pretension. Thus, cable is compliant with both codes IBC 2015 and IRC 2015.

CABLE TENSION FORCE FOR SHORTER SPANS:

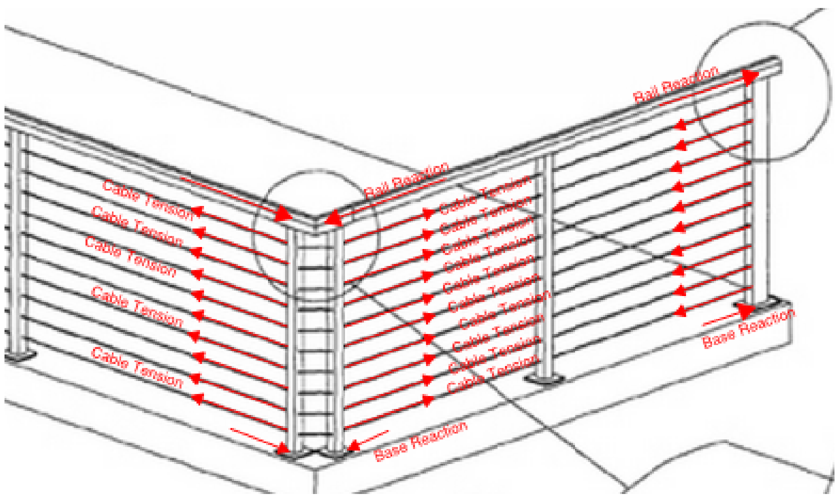
Unsupported Cable Span: ;l = 54.00 in
Deflection due to sphere load: ;$a_S = ((F_A \times l^2 \times L) / (8 \times E \times A))^{1/3}$=
2.448 in
Tension in cable due to sphere load: ;$T_S = (F_A \times l) / (4 \times a_S)$ = **68.071** lb
Tension in cable at max deflection: ;$T_a = T_S \times (a_S / a_{All})$ = **269.279** lb
Required pretension: ;$T_{p3} = T_a - T_S$ = **201.209** lb

Unsupported Cable Span: ;l = 42.00 in
Deflection due to sphere load: ;$a_S = ((F_A \times l^2 \times L) / (8 \times E \times A))^{1/3}$=
2.070 in
Tension in cable due to sphere load: ;$T_S = (F_A \times l) / (4 \times a_S)$ = **62.601** lb
Tension in cable at max deflection: ;$T_a = T_S \times (a_S / a_{All})$ = **209.440** lb
Required pretension: ;$T_{p4} = T_a - T_S$ = **146.839** lb

Unsupported Cable Span: ;l = 36.00 in
Deflection due to sphere load: ;$a_S = ((F_A \times l^2 \times L) / (8 \times E \times A))^{1/3}$=
1.868 in
Tension in cable due to sphere load: ;$T_S = (F_A \times l) / (4 \times a_S)$ = **59.465** lb
Tension in cable at max deflection: ;$T_a = T_S \times (a_S / a_{All})$ = **179.520** lb
Required pretension: ;$T_{p5} = T_a - T_S$ = **120.054** lb

Unsupported Cable Length:	Required Pretension:
;36 in ;	T_{p5} = **120.054** lb
;42 in ;	T_{p4} = **146.839** lb
;48 in ;	T_{p1} = **173.910** lb
;54 in ;	T_{p2} = **201.209** lb

Cable Forces on Posts:



Cable Tension is resisted by the termination posts and also corners or changes in direction.

Top rail acts as a compression member to resist cable tension forces. Bottom rail also acts as a compression member resisting cable tension when present. If there is no bottom rail, the base connection is required to resist the tension forces from cables. Top rail flat inserts (required for astestics) bear directly on face of post so tension forces are resisted by bearing and not just screws. For top rails when no infill is used, rail must be attached to posts with screws desgined to resist tension force.

Screw shear:

Per Aluminum Design Manual:

5.4.3 Screw Shear and Bearing

The shear force on a screw shall not exceed the least of:

1) $2 F_{tu1} D t_1/n_u$. (Eq. 5.4.3-1)

2) $2F_{tu2} Dt_2/n_u$ (Eq. 5.4.3-2)

3) $4.2(t_2^3D)^{1/2} F_{tu2}/n_r$, for $t_2 \leq t_1$ (Eq. 5.4.3-3)

4) $P_{ns}/(1.25\, n_s)$ (Eq. 5.4.3-4)

5.4.4 Minimum Spacing of Screws

The minimum distance between screw centers shall be 2.5 times the nominal screw diameter.

Minimum ; F_{tu1} = 38000 psi ;post and rails

;#12 screw ; d_{screw} = 0.218 in

Post and rail thickness; t_1 = 0.10 in

Screw; F_{tus} = 125000 psi

Pns = 2091 lbs ; #12-14 HWH Teks screw (ESR 3223)

1) ;$V_{allow10} = 2 * F_{tu1} * d_{screw} * t_1 / 3$ = **552.267** lbs

2) ;$V_{allow2} = 2 * F_{tu1} * d_{screw} * t_1 / 3$ = **552.267** lbs

3) ;$V_{allow3} = 4.2 * (t_1^3 * d_{screw})^{.5} * F_{tu1} / 3$ = **785.489** lbs

4) ;V_{allow4} = Pns / (1.25 * 3) = **557.600** lbs

;Vallow = Min($V_{allow10}$, V_{allow2}, V_{allow3}, V_{allow4}) = **552.267** lbs

;Resisting Force required at Top rail assuming no bottom rail (;225 lbs tension) = 1157 lbs for 36" guardrail post.

;Resisting Force required at Top rail assuming no bottom rail (225 lbs tension) = 1382 lbs for 42" guardrail post.

(See RISA model for results)

Load Check ; 1382 lbs / Vallow = **2.502** ;screws Use 4 screws at top rail to post connection.

Top Rails

Assume simply supported spans at ;L = 54 in ;maximum

Bending of Top Rail ;M = 200 lbs * L / 4 = **225.000** lb_ft ; or ; M = **2700.000** lb_in

1500 Series Top Rail (DIE AC6471 by Railcraft)

;$Svert_{1500}$ = 0.22693 in^3
;$Shorz_{1500}$ = 0.34740 in^3

;fb_{vert} = M / $Svert_{1500}$ = **11897.942** psi

;F_{b6063} = **9696.970** psi

No Good - Assume simply supported spans at ;L = 44 in ;maximum

Bending of Top Rail ;M = 200 lbs * L / 4 = **183.333** lb_ft ; or ; M = **2200.000** lb_in

;fb_{vert} = M / $Svert_{1500}$ = **9694.619** psi

1500R Series Top Rail (DIE AC6470 by Railcraft)

Assume simply supported spans at ;L = 42 in ;maximum

Bending of Top Rail ;M = 200 lbs * L / 4 = **175.000** lb_ft ; or ; M = **2100.000** lb_in

;$Svert_{1500r}$ = 0.20341 in^3
;$Shorz_{1500r}$ = 0.35765 in^3

;fb_{vert} = M / $Svert_{1500r}$ = **10323.976** psi

;F_{b6063} = **9696.970** psi

No Good - Assume simply supported spans at ;L = 39 in ;maximum

Bending of Top Rail ;M = 200 lbs * L / 4 = **162.500** lb_ft ; or ; M = **1950.000** lb_in

;fb_{vert} = M / $Svert_{1500r}$ = **9586.549** psi

3000R Series Top Rail (DIE AC62741 by Railcraft)

Assume simply supported spans at ;L = 54 in ;maximum

Bending of Top Rail ;M = 200 lbs * L / 4 = **225.000** lb_ft ; or ; M = **2700.000** lb_in

;$Svert_{3000r}$ = 0.29968 in^3
;$Shorz_{3000r}$ = 0.54228 in^3

;fb_{vert} = M / $Svert_{3000r}$ = **9009.610** psi

;F_{b6063} = **9696.970** psi

TOP RAIL COMPRESSION CHECK

Check allowable compression in top rails (tubular shapes per ADM 3.3.14)

;F'_{cy6063} = **16.000** ksi
;$B_c = F'_{cy6063} * (1 + (F'_{cy6063} /2250\ ksi)^{.5})$ = **17.349** ksi ; (Table 3.3-4 ADM)
;$D_e = B_c / 10\ ksi * (B_c / E_{6063})^{0.5}$ = **0.072**
;n_y = 1.65
;$S_1 = (B_c - F'_{cy6063} / (1.6 * D_c))^2$; S_1 = **307234091348490.**
;C_c = 1 in
;$S_2 = (C_c / 1.6)^2$ = **0.003**

;L = 42 in
; $Shorz_{1500}$ = **0.347** in^3
; $Ihorz_{1500}$ = 0.3474 in^4

L = **3.500** ft ;
;$L * Shorz_{1500} / (0.5 * Ihorz_{1500})^{.5}$ = **0.243**

;$F_c = Ft_{y6063} / n_y$ = **9.697** ksi

;f_c = 1382 lbs / .484 in^2 = **2.855** ksi ;okay (1500S top rail or larger at the 42" height and 225 lbs tension in cables)

Use 1500 or 1500R top rails for short spans only (39" for 1500, 44" for 1500R) and use 3000 series top rails for spans upto 54 inches.

Posts

System uses both Superpost Residential Posts (By Railcraft) or Termination posts at ends (Die # VH-61957) for 36" height

;H_{36} = 36 in ; H_{42} = 42 in

Intermediate posts (not used for cable termination)

Residentail Post (Superpost)

;S_{x1} = .43314 in^3

For 36" tall posts, 4.5 ft max spacing ;L_6 = 54 in

Per IRC ;M_1 = 200 lbs * H_{36} = **7200.000** lb_in

For 42" tall posts, 4.5 ft max spacing ;L_5 = 54 in

Per IRC ;M_3 = 200 lbs * H_{42} = **8400.000** lb_in

Residential – 36" height
;F_{b1} = M_1/ S_{x1} = **16622.801** psi ;

Commercial – 42" height
;F_{b3} = M_3/ S_{x1} = **19393.268** psi ;

Allowable; F_b = **19.487** ksi

Post good for either height and bending

Termination posts (used for cable termination)

1" x 3" CABLE POST 6005A-T6 Aluminum

;S_{y1} = 1.21016 in^3
;S_{XX1} = 0.87144 in^3

Out of plane loading
For 36" tall posts, 4.5 ft max spacing ;L_6 = 54 in

Per IRC ;M_1 = 200 lbs * H_{36} = **7200.000** lb_in ;at base connection
;M_5 = 200 lbs * H_{36}/2 = **3600.000** lb_in ;at mid-height

For 42" tall posts, 4.5 ft max spacing ;L_5 = 54 in

Per IRC ;M_3 = 200 lbs * H_{42} = **8400.000** lb_in ;at base connection

;M_6 = 200 lbs * H_{42}/2 = **4200.000** lb_in ;at mid-height

Residential – 36” height
;$F_{b1} = M_1/ S_{XX1}$ = **8262.187** psi ; at bottom connection
;$F_{b5} = M_5/ S_{XX1}$ = **4131.093** psi ; at midheight

Commercial – 42” height
;$F_{b3} = M_3/ S_{XX1}$ = **9639.218** psi ; at bottom connection
;$F_{b6} = M_6/ S_{XX1}$ = **4819.609** psi ; at midheight

Allowable; $F_{b6005T6}$ = **19.487** ksi

Check bending in other direction due to Cable tension bending (in-plane)

For 225 lbs tension

For 36” tall posts ; M_2 = 926 lb_ft

For 42” tall posts ; M_4 = 1287 lb_ft

Residential – 36” height
;$F_{b2} = M_2/ S_{y1}$ = **9.182** ksi ;

Commercial – 42” height
;$F_{b4} = M_4/ S_{y1}$ = **12.762** ksi ;

Allowable; $F_{b6005T6}$ = **19.487** ksi

36” Posts combined Loading (check at midheight):
;$F_{b5} / F_{b6005T6} + F_{b3} / F_{b6005T6}$ = **0.707**

36” tall Post good for tension created bending plus guardrail forces.

42” Posts combined Loading (checked at midheight):
;$F_{b6} / F_{b6005T6} + F_{b4} / F_{b6005T6}$ = **0.902**

42” tall Post okay for tension created bending plus guardrail forces.

TOP MOUNTED BASEPLATE

Posts attach to plate at interior holes and is attached to substrate (deck) at hole located near the edges.

IRC ;OTM_{36} = 200 lbs * (H_{36} + .375 in) ; OTM_{36} = **7275.000** lb_in

Tension in post base screw connections is ;T = OTM_{36} / (1.25 in * 2) ; T = **2910.000** lbs

SAE Grade 5 screws ; F_{tscrew} = 120 ksi * .75 = **90.000** ksi
;A_{screw}reg = T / F_{tscrew} ;A_{screw}reg = **0.032** in^2

Try ¼" diameter screws ;A_{screw} = 0.0318 in^2
;F_{vscrew} = 120 ksi * .60 / 3 * .7 ; F_{vscrew} = **16.800** ksi

Use (2) ¼" diameter x 2" long SAE Grade 5 (min.) self tapping Torx drive flate head screws (1 ½" min. Embedment into post)

Baseplate for 42" tall posts

Per IRC ;OTM_{42} = 200 lbs * (H_{42} + .375 in) ; OTM_{42} = **8475.000** lb_in

Tension in post base screw connections is ;T_{42} = OTM_{42} / (1.25 in * 3) ; T_{42} = **2260.000** lbs

SAE Grade 5 screws ; F_{tscrew} = 120 ksi * .75 = **90.000** ksi
;A_{screw}reg = T / F_{tscrew} ;A_{screw}reg = **0.032** in^2

Try ¼" diameter screws ;A_{screw} = 0.0318 in^2
;F_{vscrew} = 120 ksi * .60 / 3 * .7 ; F_{vscrew} = **16.800** ksi

Use (2) ¼" diameter x 2" long SAE Grade 5 (min.) self tapping Torx drive flate head screws (1 ½" min. Embedment into post)

Use 5/16" diameter screws (greater capacity than ¼")

CHECK TOP MOUNTED BASE PLATES FOR BENDING

3/8" x 4" x 4" plate (wood connections)

;T_{plate} = OTM_{42} / 3.375 in = **2511.111** lb

;Bending = OTM_{42} / (4 in * (4 in)^2 / 6); Bending = **794.531** psi
;d = 2 in
;T = Bending * d / 2 * 4 in; T = **3178.125** lb

Plate bending is maximum below edge of post or 1.18" from plate edge

;P_2 = (2 in – 1.18 in) / 2 in * Bending = **325.758** psi

;Mmax = ((P_2 * 1.18 in^2 / 2) + ((Bending – P_2)* 1.18 in^2 / (2) * (2/3))) * 4 in
;Mmax = **1506.325** lb_in

;F_b = Mmax *6 / (4 in * .375 in * .375 in) = **16067.470** psi

Okay

try **1/4” x 4” x 4” plate**

;T_{plate} = OTM_{42} / 3.375 in = **2511.111** lb

;Bending = OTM_{42} / (4 in * (4 in)^2 / 6); Bending = **794.531** psi
;d = 2 in
;T = Bending * d / 2 * 4 in; T = **3178.125** lb

Plate bending is maximum below edge of post or 1.18” from plate edge

;P_2 = (2 in – 1.18 in) / 2 in * Bending = **325.758** psi

;Mmax = ((P_2 * 1.18 in^2 / 2) + ((Bending – P_2)* 1.18 in^2 / (2) * (2/3))) * 4 in
;Mmax = **1506.325** lb_in

;F_b = Mmax *6 / (4 in * .25 in * .25 in) = **36151.807** psi

No Good – Need the 3/8” plate thickness

try 3**/8” x 5” x 5” baseplate (concrete connections)**

;T_{plate} = OTM_{42} / 4.375 in = **1937.143** lb

;Bending = OTM_{42} / (5 in * (5 in)^2 / 6); Bending = **406.800** psi
;d = 2.5 in
;T = Bending * d / 2 * 5 in; T = **2542.500** lb

Plate bending is maximum below edge of post or 1.68” from plate edge

;P_2 = (2.5 in – 1.68 in) / 2.5 in * Bending = **133.430** psi

;Mmax = ((P_2 * 1.68 in^2 / 2) + ((Bending – P_2)* 1.68 in^2 / (2) * (2/3))) * 5 in
;Mmax = **1325.843** lb_in

;F_b = Mmax *6 / (5 in * .375 in * .375 in) = **11313.857** psi

Okay

CHECK 6x5 BASE PLATE FOR BENDING

3/8” x 6” x 5” plate

;T_{plate2} = OTM_{42} / 4.38 in = **1934.932** lb

;Bending2 = OTM_{42} / (6 in * (5 in)^2 / 6); Bending2 = **339.000** psi
;d = 2.5 in
;T = Bending2 * d / 2 * 6 in; T = **2542.500** lb

Plate bending is maximum below edge of post or 1.75” from plate edge

;P_3 = (2.5 in – .75 in) / 2.5 in * Bending = **284.760** psi

;Mmax2 = ((P_3 * .375 in^2 / 2) + ((Bending – P_3)* .375 in^2 / (2) * (2/3))) * 5 in
;Mmax2 = **343.237** lb_in

;F_b = Mmax2 *6 / (5 in * .375 in * .375 in) = **2928.960** psi

Okay

BASE PLATE ATTACHMENT - TYP LINE POST

4x4x3/8" Plate

Anchor Tension ; AT = OTM_{36} / 3.375 in ; AT = **2155.556** lb
2 anchors per side ; Atbolt = AT / 2 = **1077.778** lb

Wood:

Try 3/8" diameter lag bolts and assume Douglas Fir

;T_{allow} = 305 lb/in * 1.6 * 2.78 in ;, 5" long lag, 2 25/32" embed 1.6 Cd wood factor ;T_{allow} = **1356.640** lb

Use 3/8" diameter x 5" embedment lag screws (4 corners)

Try 3/8" diameter lag bolts and assume Hem Fir PT

;T_{allow} = 269 lb/in * 1.6 * 3.28 in ;, 6" long lag, 3 9/32" embed 1.6 Cd wood factor ;T_{allow} = **1411.712** lb

Use 3/8" diameter x 6" embedment lag screws (4 corners)

Try 7/16" diameter lag bolts and assume Hem Fir PT

;T_{allow} = 302 lb/in * 1.6 * 2.22 in ;, 4" long lag, 2 7/32" embed 1.6 Cd wood factor ;T_{allow} = **1072.704** lb

Use 7/16" diameter x 4" embedment lag screws (4 corners)

Try #14 x 5" stainless steel wood screws and assume Hem Fir PT

;T_{allow} = 146 lb/in * 1.6 * 5 in ;, 5" long screws, 5" embed 1.6 Cd wood factor ;T_{allow} = **1168.000** lb

Just works #14-5" wood screws (4 corners)

Try #14 x 5" stainless steel wood screws and assume Douglas Fir

;T_{allow} = 172 lb/in * 1.6 * 5 in ;, 5" long screws, 5" embed 1.6 Cd wood factor ;T_{allow} = **1376.000** lb

Use #14-5" wood screws (4 corners)

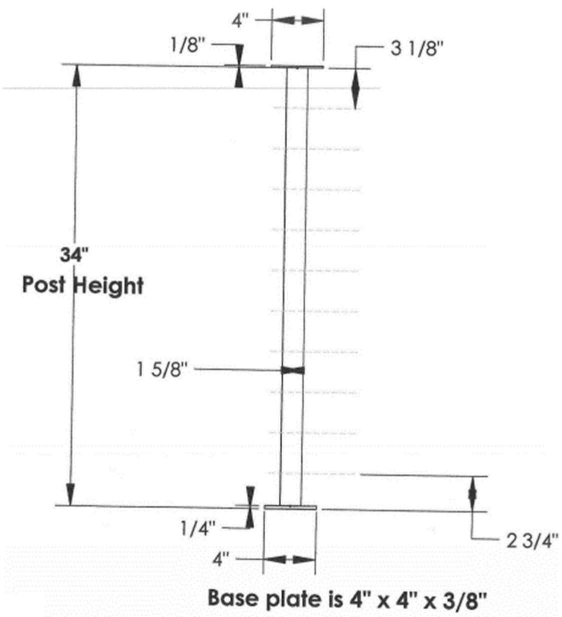
5x5x3/8" Plate

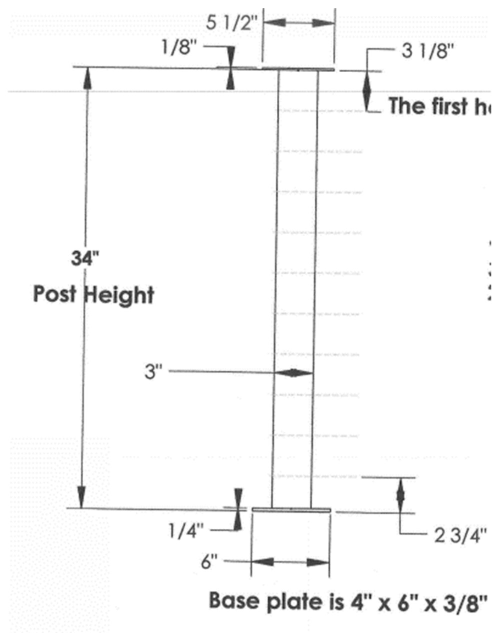
Anchor Tension ; AT = OTM_{42} / 4.375 in ; AT = **1937.143** lb
2 anchors per side ; Atbolt = AT / 2 = **968.571** lb

Try #14 x 5" stainless steel wod screws and assume Hem Fir PT

;T_{allow} = 146 lb/in * 1.6 * 5 in ;, 5" long lag, 5" embed 1.6 Cd wood factor ;T_{allow} = **1168.000** lb

Use #14 x 5" embedment ss wood screws (4 corners)


4"
1/8"
3 1/8"
34"
Post Height
1 5/8"
1/4"
2 3/4"
4"
Base plate is 4" x 4" x 3/8"


5 1/2"
1/8"
3 1/8"
34"
Post Height
3"
1/4"
2 3/4"
6"
Base plate is 4" x 6" x 3/8"

BASE PLATE ATTACHMENT - TERMINATION POST

6x4x3/8" Plate

Anchor Tension ; AT = OTM_{36} / 3.375 in ; AT = **2155.556** lb
2 anchors per side ; Atbolt = AT / 2 = **1077.778** lb
Shear due to 175 lbs in cables ;V_c = 5 * 175 lbs = **875.000** lbs
Shear due to fall protection ;V_f = 200 lbs

Try #14 x 5" stainless steel wood screws and assume Hem Fir PT

;T_{allow} = 146 lb/in * 1.6 * 5 in ;, 5" long lag, 5" embed 1.6 Cd wood factor ;T_{allow} = **1168.000** lb
;V_{allow} = 196 lbs * 4 * 1.6 ; 4 screws total, 1.6 Cd wood factor ; ;V_{allow} = **1254.400** lb

No Good

Try 3/8" diameter lag bolts and assume Hem Fir PT

;T_{allow} = 269 lb/in * 1.6 * 3.82 in ;, 6" long lag, 3 25/32" embed 1.6 Cd wood factor ;T_{allow} = **1644.128** lb
;V_{allow} = 270 lbs * 4 * 1.6 ; 4 lags total, 1.6 Cd wood factor ; ;V_{allow} = **1728.000** lb

Atbolt / T_{allow} = **0.656**
(V_c + V_f) / V_{allow} = **0.622**

Use 3/8" diameter x 7" embedment lag screws (4 corners)

Try 3/8" diameter lag bolts and assume Douglas Fir

;T_{allow} = 305 lb/in * 1.6 * 3.82 in ;, 6" long lag, 3 25/32" embed 1.6 Cd wood factor ;T_{allow} = **1864.160** lb
;V_{allow} = 280 lbs * 4 * 1.6 ; 4 lags total, 1.6 Cd wood factor ; ;V_{allow} = **1792.000** lb

Atbolt / T_{allow} = **0.578**
(V_c + V_f) / V_{allow} = **0.600**

Use 3/8" diameter x 7" embedment lag screws (4 corners)

FASCIA BRACKET CONNECTION - LINE POST

6x4x3/8” Plate

Anchor Tension ; AT = OTM_{42} / 4.2 in ; AT = **2017.857** lb
2 side by side anchors per bracket ; Atbolt = AT / 2 = **1008.929** lb

Wood:

Try 3/8” diameter lag bolts and assume Douglas Fir

;T_{allow} = 305 lb/in * 1.6 * 2.78 in ;, 5” long lag, 2 25/32” embed 1.6 Cd wood factor ;T_{allow} = **1356.640** lb

Use 3/8” diameter x 5” embedment lag screws (4 corners)

Try 3/8” diameter lag bolts and assume Hem Fir PT

;T_{allow} = 269 lb/in * 1.6 * 3.28 in ;, 6” long lag, 3 9/32” embed 1.6 Cd wood factor ;T_{allow} = **1411.712** lb
;V_{allow} = 270 lbs * 4 * 1.6 ; 4 lags total, 1.6 Cd wood factor ; ;V_{allow} = **1728.000** lb

Use 3/8” diameter x 6” embedment lag screws (4 corners)

Try 7/16” diameter lag bolts and assume Hem Fir PT

;T_{allow} = 302 lb/in * 1.6 * 2.22 in ;, 4” long lag, 2 7/32” embed 1.6 Cd wood factor ;T_{allow} = **1072.704** lb

Use 7/16” diameter x 4” embedment lag screws (4 corners)

Try #14 x 5” stainless steel wood screws and assume Hem Fir PT

;T_{allow} = 146 lb/in * 1.6 * 5 in ;, 5” long screws, 5” embed 1.6 Cd wood factor ;T_{allow} = **1168.000** lb

Just works #14-5” wood screws (4 corners)

Try #14 x 5” stainless steel wood screws and assume Douglas Fir

;T_{allow} = 172 lb/in * 1.6 * 5 in ;, 5” long screws, 5” embed 1.6 Cd wood factor ;T_{allow} = **1376.000** lb

Use #14-5” wood screws (4 corners)

FASCIA BRACKET - TERMINATION POST

6x4x3/8” Plate

Anchor Tension ; AT = OTM_{42} / 4.2 in ; AT = **2017.857** lb
2 side by side anchors per bracket ; Atbolt = AT / 2 = **1008.929** lb
Shear due to 175 lbs tension in cables ;V_c = 5 * 175 lbs = **875.000** lbs
Shear due to fall protection ;V_f = 200 lbs

Wood:

Try 3/8” diameter lag bolts and assume Douglas Fir

;T_{allow} = 305 lb/in * 1.6 * 2.78 in ;, 5” long lag, 2 25/32” embed 1.6 Cd wood factor ;T_{allow} = **1356.640** lb
;V_{allow} = 196 lbs * 4 * 1.6 ; 4 screws total, 1.6 Cd wood factor ; ;V_{allow} = **1254.400** lb

Use 3/8” diameter x 5” embedment lag screws (4 corners)

Try 3/8” diameter lag bolts and assume Hem Fir PT

;T_{allow} = 269 lb/in * 1.6 * 3.28 in ;, 6” long lag, 3 9/32” embed 1.6 Cd wood factor ;T_{allow} = **1411.712** lb
;V_{allow} = 270 lbs * 4 * 1.6 ; 4 lags total, 1.6 Cd wood factor ; ;V_{allow} = **1728.000** lb

Use 3/8” diameter x 6” embedment lag screws (4 corners)

Try 7/16” diameter lag bolts and assume Hem Fir PT

;T_{allow} = 302 lb/in * 1.6 * 2.22 in ;, 4” long lag, 2 7/32” embed 1.6 Cd wood factor ;T_{allow} = **1072.704** lb

Use 7/16” diameter x 4” embedment lag screws (4 corners)

Try #14 x 5” stainless steel wood screws and assume Hem Fir PT

;T_{allow} = 146 lb/in * 1.6 * 5 in ;, 5” long screws, 5” embed 1.6 Cd wood factor ;T_{allow} = **1168.000** lb

Just works #14-5” wood screws (4 corners)

Try #14 x 5” stainless steel wood screws and assume Douglas Fir

;T_{allow} = 172 lb/in * 1.6 * 5 in ;, 5” long screws, 5” embed 1.6 Cd wood factor ;T_{allow} = **1376.000** lb

Use #14-5” wood screws (4 corners)

BASE PLATE ATTACHMENTS - CONCRETE

Concrete:

Assume 6” minimum thick concrete – use Hilti HIT-HY 200 + HIT-Z-R Simpson 3/8” diameter strong bolts

See attached ACI 318 Appendix D calcs. and details.

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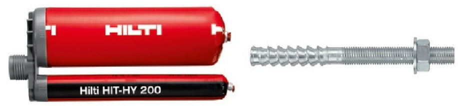
Specifier:	Golberg	Project:	Cable Railing
Address:	610 SW Alder #918	Sub-Project I Pos. No.:	Line Post Base
Phone I Fax:	503-226-1286 |	Date:	12/14/2017
E-Mail:			

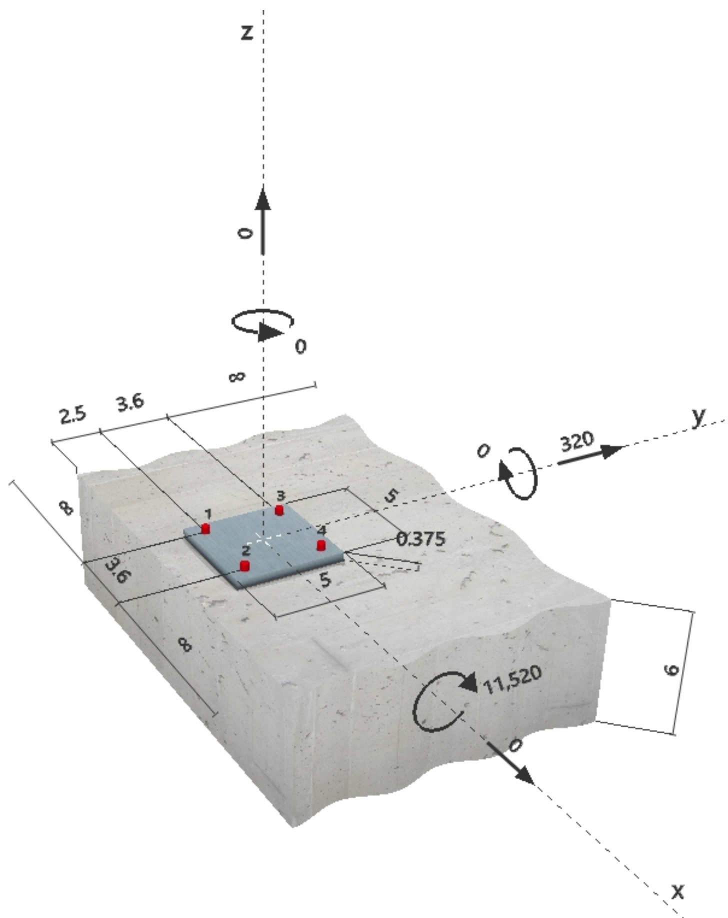
Specifier's comments: IRC Code, 36" tall

1 Input data

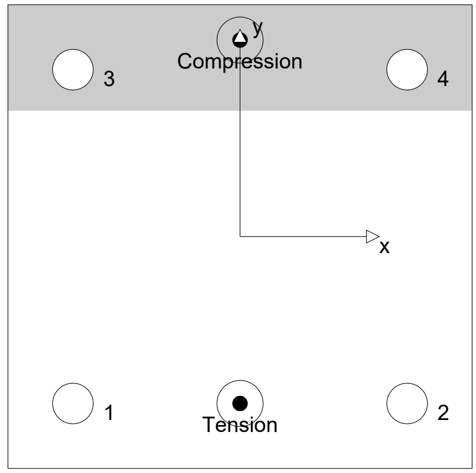


Anchor type and diameter:	**HIT-HY 200 + HIT-Z-R 3/8**
Effective embedment depth:	$h_{ef,opti}$ = 3.425 in. ($h_{ef,limit}$ = 3.750 in.)
Material:	A4
Evaluation Service Report:	ESR-3187
Issued I Valid:	11/1/2016 | 3/1/2018
Proof:	Design method ACI 318-08 / Chem
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.375 in.
Anchor plate:	l_x x l_y x t = 5.000 in. x 5.000 in. x 0.375 in.; (Recommended plate thickness: not calculated
Profile:	no profile
Base material:	cracked concrete, 2500, f_c' = 2500 psi; h = 6.000 in., Temp. short/long: 32/32 °F
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitting reinforcement present edge reinforcement: none or < No. 4 bar
Seismic loads (cat. C, D, E, or F)	no

Geometry [in.] & Loading [lb, in.lb]



2 Load case/Resulting anchor forces



Load case: Design loads

Anchor reactions [lb]
Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	1470	80	0	80
2	1470	80	0	80
3	0	80	0	80
4	0	80	0	80

max. concrete compressive strain: 0.24 [‰]
max. concrete compressive stress: 1029 [psi]
resulting tension force in (x/y)=(0.000/-1.800): 2939 [lb]
resulting compression force in (x/y)=(0.000/2.119): 2939 [lb]

3 Tension load

	Load N_{ua} [lb]	Capacity ϕN_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	1470	4749	31	OK
Pullout Strength*	1470	5169	29	OK
Sustained Tension Load Bond Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Strength**	2939	2957	100	OK

* anchor having the highest loading **anchor group (anchors in tension)

3.1 Steel Strength

N_{sa} = ESR value refer to ICC-ES ESR-3187
$\phi\ N_{sa} \geq N_{ua}$ ACI 318-08 Eq. (D-1)

Variables

$A_{se,N}$ [in.^{2}]	f_{uta} [psi]
0.08	94200

Calculations

N_{sa} [lb]
7306

Results

N_{sa} [lb]	ϕ_{steel}	$\phi\ N_{sa}$ [lb]	N_{ua} [lb]
7306	0.650	4749	1470

3.2 Pullout Strength

$N_{pn} = N_p$ refer to ICC-ES ESR-3187
$\phi\ N_{pn} \geq N_{ua}$ ACI 318-08 Eq. (D-1)

Variables

N_p [lb]
7952

Calculations

-
-

Results

N_{pn} [lb]	$\phi_{concrete}$	$\phi\ N_{pn}$ [lb]	N_{ua} [lb]
7952	0.650	5169	1470

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E-Mail:			

3.3 Concrete Breakout Strength

$N_{cbg} = \left(\frac{A_{Nc}}{A_{Nc0}}\right) \psi_{ec,N}\, \psi_{ed,N}\, \psi_{c,N}\, \psi_{cp,N}\, N_b$ ACI 318-08 Eq. (D-5)

$\phi\ N_{cbg} \geq N_{ua}$ ACI 318-08 Eq. (D-1)

A_{Nc} see ACI 318-08, Part D.5.2.1, Fig. RD.5.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-08 Eq. (D-6)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\ e'_N}{3\ h_{ef}}}\right) \leq 1.0$ ACI 318-08 Eq. (D-9)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5h_{ef}}\right) \leq 1.0$ ACI 318-08 Eq. (D-11)

$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-08 Eq. (D-13)

$N_b = k_c\ \lambda\ \sqrt{f'_c}\ h_{ef}^{1.5}$ ACI 318-08 Eq. (D-7)

Variables

h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]	$\psi_{c,N}$
3.425	0.000	0.000	2.500	1.000

c_{ac} [in.]	k_c	λ	f'_c [psi]
9.071	17	1	2500

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
104.82	103.96	1.000	1.000	0.847	1.000	5326

Results

N_{cbg} [lb]	$\phi_{concrete}$	$\phi\ N_{cbg}$ [lb]	N_{ua} [lb]
4549	0.650	2957	2939

4 Shear load

	Load V_{ua} [lb]	Capacity ϕ V_n [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	80	2630	4	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength (Concrete Breakout Strength controls)**	320	9386	4	OK
Concrete edge failure in direction **	N/A	N/A	N/A	N/A

* anchor having the highest loading **anchor group (relevant anchors)

4.1 Steel Strength

$V_{sa} = (0.6\ A_{se,V}\ f_{uta})$ refer to ICC-ES ESR-3187

$\phi\ V_{steel} \geq V_{ua}$ ACI 318-08 Eq. (D-2)

Variables

$A_{se,V}$ [in.^{2}]	f_{uta} [psi]	$(0.6\ A_{se,V}\ f_{uta})$ [lb]
0.08	94200	4384

Calculations

V_{sa} [lb]
4384

Results

V_{sa} [lb]	ϕ_{steel}	$\phi\ V_{sa}$ [lb]	V_{ua} [lb]
4384	0.600	2630	80

4.2 Pryout Strength (Concrete Breakout Strength controls)

$$V_{cpg} = k_{cp} \left[\left(\frac{A_{Nc}}{A_{Nc0}}\right) \psi_{ec,N}\ \psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b\right]$$ ACI 318-08 Eq. (D-31)

$\phi\ V_{cpg} \geq V_{ua}$ ACI 318-08 Eq. (D-2)

A_{Nc} see ACI 318-08, Part D.5.2.1, Fig. RD.5.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-08 Eq. (D-6)

$$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\ e_N'}{3\ h_{ef}}}\right) \leq 1.0$$ ACI 318-08 Eq. (D-9)

$$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5 h_{ef}}\right) \leq 1.0$$ ACI 318-08 Eq. (D-11)

$$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5 h_{ef}}{c_{ac}}\right) \leq 1.0$$ ACI 318-08 Eq. (D-13)

$N_b = k_c\ \lambda\ \sqrt{f_c'}\ h_{ef}^{1.5}$ ACI 318-08 Eq. (D-7)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	3.425	0.000	0.000	2.500

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ	f_c' [psi]
1.000	9.071	17	1	2500

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
154.49	103.96	1.000	1.000	0.847	1.000	5326

Results

V_{cpg} [lb]	$\phi_{concrete}$	$\phi\ V_{cpg}$ [lb]	V_{ua} [lb]
13409	0.700	9386	320

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E-Mail:			

5 Combined tension and shear loads

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.994	0.034	1.000	86	OK

$\beta_{NV} = (\beta_N + \beta_V) / 1.2 <= 1$

6 Warnings

- The anchor design methods in PROFIS Anchor require rigid anchor plates per current regulations (ETAG 001/Annex C, EOTA TR029, etc.). This means load re-distribution on the anchors due to elastic deformations of the anchor plate are not considered - the anchor plate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the design loading. PROFIS Anchor calculates the minimum required anchor plate thickness with FEM to limit the stress of the anchor plate based on the assumptions explained above. The proof if the rigid base plate assumption is valid is not carried out by PROFIS Anchor. Input data and results must be checked for agreement with the existing conditions and for plausibility!
- Condition A applies when supplementary reinforcement is used. The Φ factor is increased for non-steel Design Strengths except Pullout Strength and Pryout strength. Condition B applies when supplementary reinforcement is not used and for Pullout Strength and Pryout Strength. Refer to your local standard.
- Design Strengths of adhesive anchor systems are influenced by the cleaning method. Refer to the INSTRUCTIONS FOR USE given in the Evaluation Service Report for cleaning and installation instructions
- The ACI 318-08 version of the software does not account for adhesive anchor special design provisions corresponding to overhead applications.
- Checking the transfer of loads into the base material and the shear resistance are required in accordance with ACI 318 or the relevant standard!

Fastening meets the design criteria!

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E-Mail:			

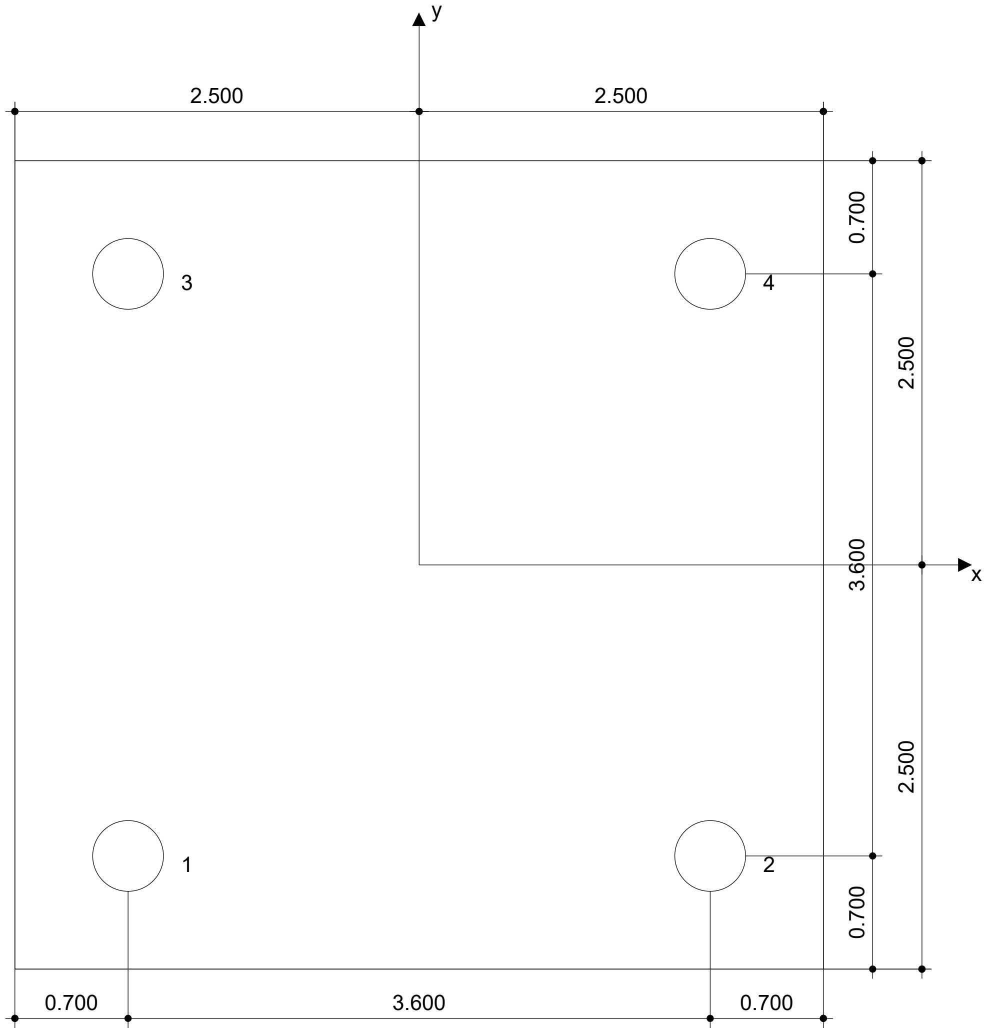
7 Installation data

Anchor plate, steel: -
Profile: no profile
Hole diameter in the fixture: d_f = 0.438 in.
Plate thickness (input): 0.375 in.
Recommended plate thickness: not calculated
Drilling method: Hammer drilled
Cleaning: No cleaning of the drilled hole is required

Anchor type and diameter: HIT-HY 200 + HIT-Z-R 3/8
Installation torque: 177.015 in.lb
Hole diameter in the base material: 0.438 in.
Hole depth in the base material: 4.425 in.
Minimum thickness of the base material: 5.675 in.

7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Properly sized drill bit	• No accessory required	• Dispenser including cassette and mixer • Torque wrench



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-1.800	-1.800	-	-	2.500	-
2	1.800	-1.800	-	-	2.500	-
3	-1.800	1.800	-	-	6.100	-
4	1.800	1.800	-	-	6.100	-

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E-Mail:			

8 Remarks; Your Cooperation Duties

- Any and all information and data contained in the Software concern solely the use of Hilti products and are based on the principles, formulas and security regulations in accordance with Hilti's technical directions and operating, mounting and assembly instructions, etc., that must be strictly complied with by the user. All figures contained therein are average figures, and therefore use-specific tests are to be conducted prior to using the relevant Hilti product. The results of the calculations carried out by means of the Software are based essentially on the data you put in. Therefore, you bear the sole responsibility for the absence of errors, the completeness and the relevance of the data to be put in by you. Moreover, you bear sole responsibility for having the results of the calculation checked and cleared by an expert, particularly with regard to compliance with applicable norms and permits, prior to using them for your specific facility. The Software serves only as an aid to interpret norms and permits without any guarantee as to the absence of errors, the correctness and the relevance of the results or suitability for a specific application.
- You must take all necessary and reasonable steps to prevent or limit damage caused by the Software. In particular, you must arrange for the regular backup of programs and data and, if applicable, carry out the updates of the Software offered by Hilti on a regular basis. If you do not use the AutoUpdate function of the Software, you must ensure that you are using the current and thus up-to-date version of the Software in each case by carrying out manual updates via the Hilti Website. Hilti will not be liable for consequences, such as the recovery of lost or damaged data or programs, arising from a culpable breach of duty by you.

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Specifier:		Project:	
Address:		Sub-Project I Pos. No.:	
Phone I Fax:	|	Date:	12/14/2017
E-Mail:			

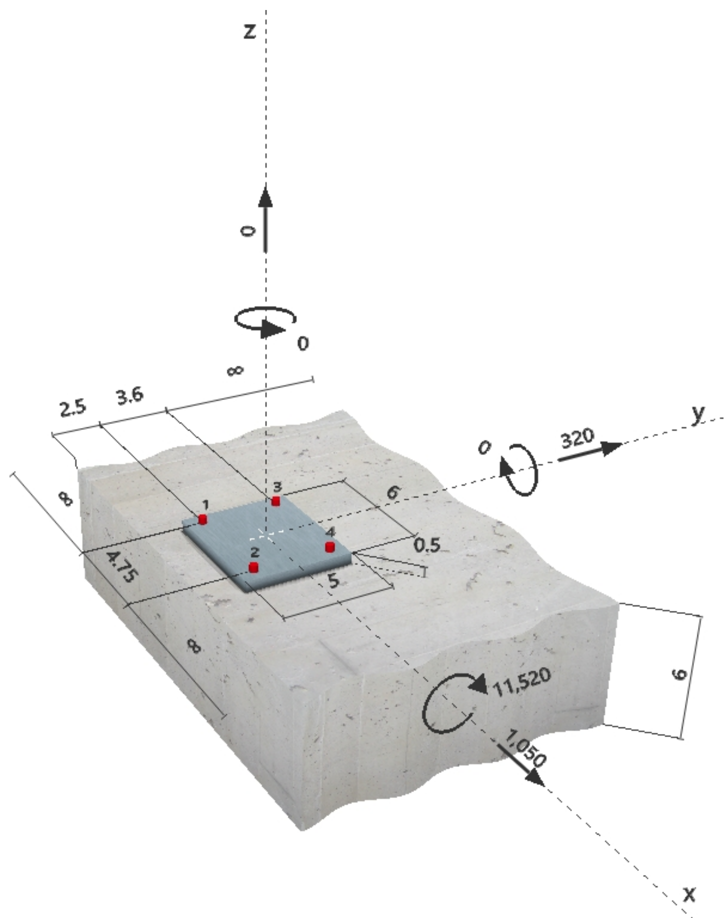
Specifier's comments:

1 Input data

SAFESET

Anchor type and diameter:	**HIT-HY 200 + HIT-Z-R 3/8**
Effective embedment depth:	$h_{ef,opti}$ = 3.583 in. ($h_{ef,limit}$ = 3.750 in.)
Material:	A4
Evaluation Service Report:	ESR-3187
Issued I Valid:	11/1/2016 | 3/1/2018
Proof:	Design method ACI 318-08 / Chem
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.500 in.
Anchor plate:	l_x x l_y x t = 6.000 in. x 5.000 in. x 0.500 in.; (Recommended plate thickness: not calculated
Profile:	no profile
Base material:	cracked concrete, 2500, f_c' = 2500 psi; h = 6.000 in., Temp. short/long: 32/32 °F
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitting reinforcement present edge reinforcement: none or < No. 4 bar
Seismic loads (cat. C, D, E, or F)	no

Geometry [in.] & Loading [lb, in.lb]



Company:		Page:	2
Specifier:		Project:	
Address:		Sub-Project I Pos. No.:	
Phone I Fax:	|	Date:	12/14/2017
E-Mail:			

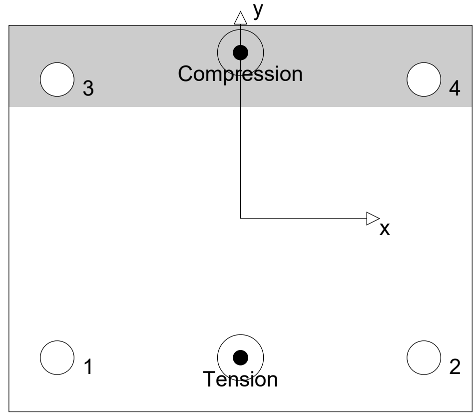
2 Load case/Resulting anchor forces

Load case: Design loads

Anchor reactions [lb]
Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	1459	274	262	80
2	1459	274	262	80
3	0	274	262	80
4	0	274	262	80

max. concrete compressive strain: 0.21 [‰]
max. concrete compressive stress: 920 [psi]
resulting tension force in (x/y)=(0.000/-1.800): 2918 [lb]
resulting compression force in (x/y)=(0.000/2.148): 2918 [lb]



3 Tension load

	Load N_{ua} [lb]	Capacity ϕN_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	1459	4749	31	OK
Pullout Strength*	1459	5169	29	OK
Sustained Tension Load Bond Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Strength**	2918	3305	89	OK

* anchor having the highest loading **anchor group (anchors in tension)

3.1 Steel Strength

N_{sa} = ESR value refer to ICC-ES ESR-3187
$\phi\ N_{sa} \geq N_{ua}$ ACI 318-08 Eq. (D-1)

Variables

$A_{se,N}$ [in.^{2}]	f_{uta} [psi]
0.08	94200

Calculations

N_{sa} [lb]
7306

Results

N_{sa} [lb]	ϕ_{steel}	$\phi\ N_{sa}$ [lb]	N_{ua} [lb]
7306	0.650	4749	1459

3.2 Pullout Strength

N_{pn} = N_p refer to ICC-ES ESR-3187
$\phi\ N_{pn} \geq N_{ua}$ ACI 318-08 Eq. (D-1)

Variables

N_p [lb]
7952

Calculations

-
-

Results

N_{pn} [lb]	$\phi_{concrete}$	$\phi\ N_{pn}$ [lb]	N_{ua} [lb]
7952	0.650	5169	1459

3.3 Concrete Breakout Strength

$N_{cbg} = \left(\frac{A_{Nc}}{A_{Nc0}}\right) \psi_{ec,N}\, \psi_{ed,N}\, \psi_{c,N}\, \psi_{cp,N}\, N_b$ ACI 318-08 Eq. (D-5)

$\phi\ N_{cbg} \geq N_{ua}$ ACI 318-08 Eq. (D-1)

A_{Nc} see ACI 318-08, Part D.5.2.1, Fig. RD.5.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-08 Eq. (D-6)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\ e'_N}{3\ h_{ef}}}\right) \leq 1.0$ ACI 318-08 Eq. (D-9)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5h_{ef}}\right) \leq 1.0$ ACI 318-08 Eq. (D-11)

$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-08 Eq. (D-13)

$N_b = k_c\ \lambda\ \sqrt{f'_c}\ h_{ef}^{1.5}$ ACI 318-08 Eq. (D-7)

Variables

h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]	$\psi_{c,N}$
3.583	0.000	0.000	2.500	1.000

c_{ac} [in.]	k_c	λ	f'_c [psi]
10.048	17	1	2500

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
120.79	113.81	1.000	1.000	0.841	1.000	5700

Results

N_{cbg} [lb]	$\phi_{concrete}$	$\phi\ N_{cbg}$ [lb]	N_{ua} [lb]
5085	0.650	3305	2918

4 Shear load

	Load V_{ua} [lb]	Capacity ϕV_n [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	274	2630	11	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength (Concrete Breakout Strength controls)**	1098	10391	11	OK
Concrete edge failure in direction y-**	1050	2936	36	OK

* anchor having the highest loading **anchor group (relevant anchors)

4.1 Steel Strength

$V_{sa} = (0.6 A_{se,V} f_{uta})$ refer to ICC-ES ESR-3187

$\phi V_{steel} \geq V_{ua}$ ACI 318-08 Eq. (D-2)

Variables

$A_{se,V}$ [in.^{2}]	f_{uta} [psi]	$(0.6 A_{se,V} f_{uta})$ [lb]
0.08	94200	4384

Calculations

V_{sa} [lb]
4384

Results

V_{sa} [lb]	ϕ_{steel}	ϕV_{sa} [lb]	V_{ua} [lb]
4384	0.600	2630	274

4.2 Pryout Strength (Concrete Breakout Strength controls)

$V_{cpg} = k_{cp} \left[\left(\frac{A_{Nc}}{A_{Nc0}} \right) \psi_{ec,N} \psi_{ed,N} \psi_{c,N} \psi_{cp,N} N_b \right]$ ACI 318-08 Eq. (D-31)

$\phi V_{cpg} \geq V_{ua}$ ACI 318-08 Eq. (D-2)

A_{Nc} see ACI 318-08, Part D.5.2.1, Fig. RD.5.2.1(b)

$A_{Nc0} = 9 h_{ef}^2$ ACI 318-08 Eq. (D-6)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2 e_N'}{3 h_{ef}}} \right) \leq 1.0$ ACI 318-08 Eq. (D-9)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5 h_{ef}} \right) \leq 1.0$ ACI 318-08 Eq. (D-11)

$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5 h_{ef}}{c_{ac}} \right) \leq 1.0$ ACI 318-08 Eq. (D-13)

$N_b = k_c \lambda \sqrt{f'_c} h_{ef}^{1.5}$ ACI 318-08 Eq. (D-7)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	3.583	0.000	0.000	2.500

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ	f'_c [psi]
1.000	10.048	17	1	2500

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
176.30	113.81	1.000	1.000	0.841	1.000	5700

Results

V_{cpg} [lb]	$\phi_{concrete}$	ϕV_{cpg} [lb]	V_{ua} [lb]
14844	0.700	10391	1098

Company:
Specifier:
Address:
Phone I Fax: |
E-Mail:

4.3 Concrete edge failure in direction y-

$V_{cbg} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ec,V}\ \psi_{ed,V}\ \psi_{c,V}\ \psi_{h,V}\ \psi_{parallel,V}\ V_b$ ACI 318-08 Eq. (D-22)

$\phi\ V_{cbg} \geq V_{ua}$ ACI 318-08 Eq. (D-2)

A_{Vc} see ACI 318-08, Part D.6.2.1, Fig. RD.6.2.1(b)

$A_{Vc0} = 4.5\ c_{a1}^2$ ACI 318-08 Eq. (D-23)

$\psi_{ec,V} = \left(\frac{1}{1 + \frac{2e_V'}{3c_{a1}}}\right) \leq 1.0$ ACI 318-08 Eq. (D-26)

$\psi_{ed,V} = 0.7 + 0.3\left(\frac{c_{a2}}{1.5c_{a1}}\right) \leq 1.0$ ACI 318-08 Eq. (D-28)

$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \geq 1.0$ ACI 318-08 Eq. (D-29)

$V_b = \left(7\left(\frac{l_e}{d_a}\right)^{0.2} \sqrt{d_a}\right) \lambda \sqrt{f_c'}\ c_{a1}^{1.5}$ ACI 318-08 Eq. (D-24)

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
2.500	-	0.000	1.000	6.000

l_e [in.]	λ	d_a [in.]	f_c' [psi]	$\psi_{parallel,V}$
3.000	1.000	0.375	2500	2.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
45.94	28.13	1.000	1.000	1.000	1284

Results

V_{cbg} [lb]	$\phi_{concrete}$	$\phi\ V_{cbg}$ [lb]	V_{ua} [lb]
4195	0.700	2936	1050

5 Combined tension and shear loads

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.883	0.358	5/3	100	OK

$\beta_{NV} = \beta_N^{\zeta} + \beta_V^{\zeta} <= 1$

6 Warnings

- The anchor design methods in PROFIS Anchor require rigid anchor plates per current regulations (ETAG 001/Annex C, EOTA TR029, etc.). This means load re-distribution on the anchors due to elastic deformations of the anchor plate are not considered - the anchor plate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the design loading. PROFIS Anchor calculates the minimum required anchor plate thickness with FEM to limit the stress of the anchor plate based on the assumptions explained above. The proof if the rigid base plate assumption is valid is not carried out by PROFIS Anchor. Input data and results must be checked for agreement with the existing conditions and for plausibility!
- Condition A applies when supplementary reinforcement is used. The Φ factor is increased for non-steel Design Strengths except Pullout Strength and Pryout strength. Condition B applies when supplementary reinforcement is not used and for Pullout Strength and Pryout Strength. Refer to your local standard.
- Design Strengths of adhesive anchor systems are influenced by the cleaning method. Refer to the INSTRUCTIONS FOR USE given in the Evaluation Service Report for cleaning and installation instructions
- The ACI 318-08 version of the software does not account for adhesive anchor special design provisions corresponding to overhead applications.
- Checking the transfer of loads into the base material and the shear resistance are required in accordance with ACI 318 or the relevant standard!

Fastening meets the design criteria!

Company:
Specifier:
Address:
Phone I Fax: |
E-Mail:

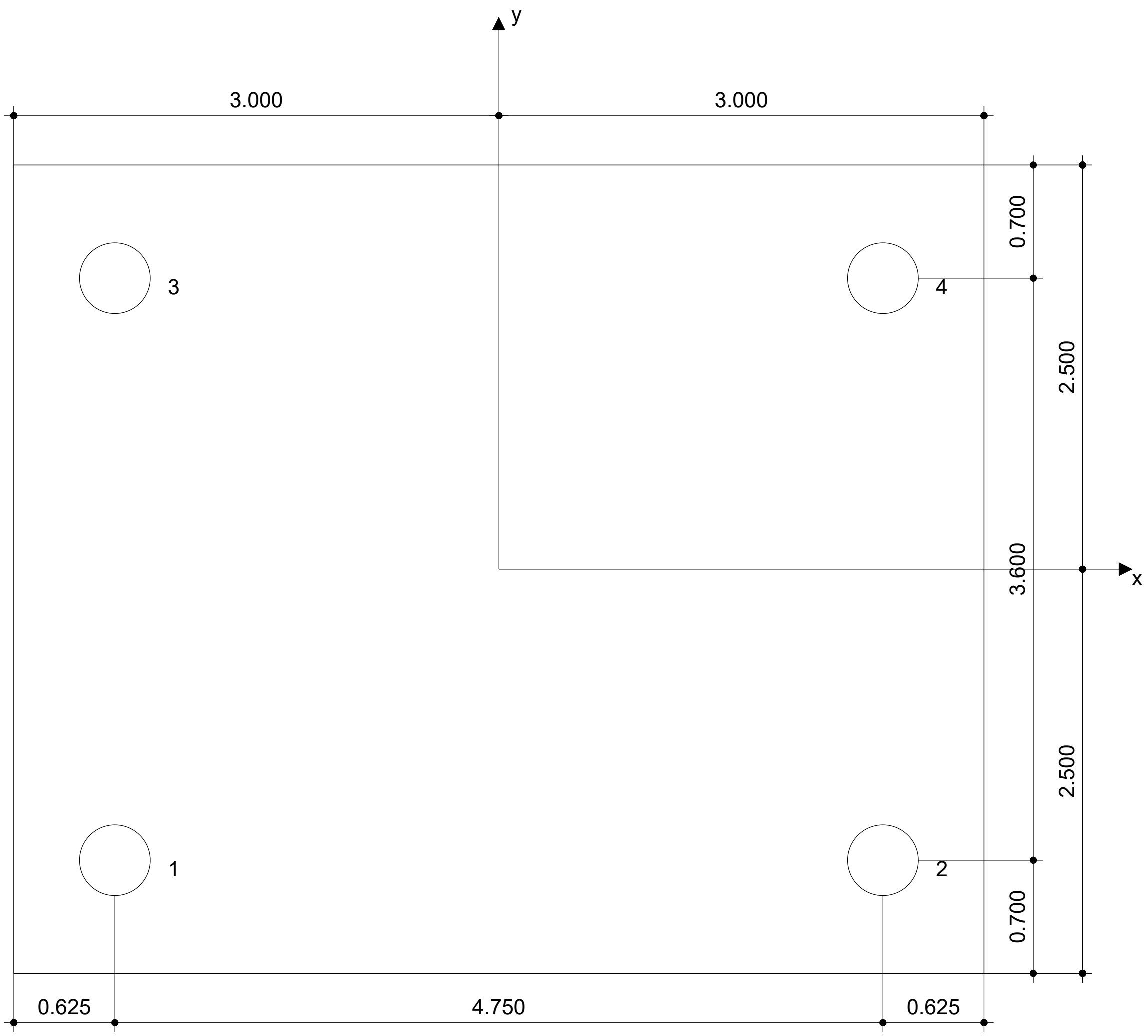
7 Installation data

Anchor plate, steel: -
Profile: no profile
Hole diameter in the fixture: d_f = 0.438 in.
Plate thickness (input): 0.500 in.
Recommended plate thickness: not calculated
Drilling method: Hammer drilled
Cleaning: No cleaning of the drilled hole is required

Anchor type and diameter: HIT-HY 200 + HIT-Z-R 3/8
Installation torque: 177.015 in.lb
Hole diameter in the base material: 0.438 in.
Hole depth in the base material: 4.583 in.
Minimum thickness of the base material: 5.833 in.

7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer	• No accessory required	• Dispenser including cassette and mixer
• Properly sized drill bit		• Torque wrench



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-2.375	-1.800	-	-	2.500	-
2	2.375	-1.800	-	-	2.500	-
3	-2.375	1.800	-	-	6.100	-
4	2.375	1.800	-	-	6.100	-

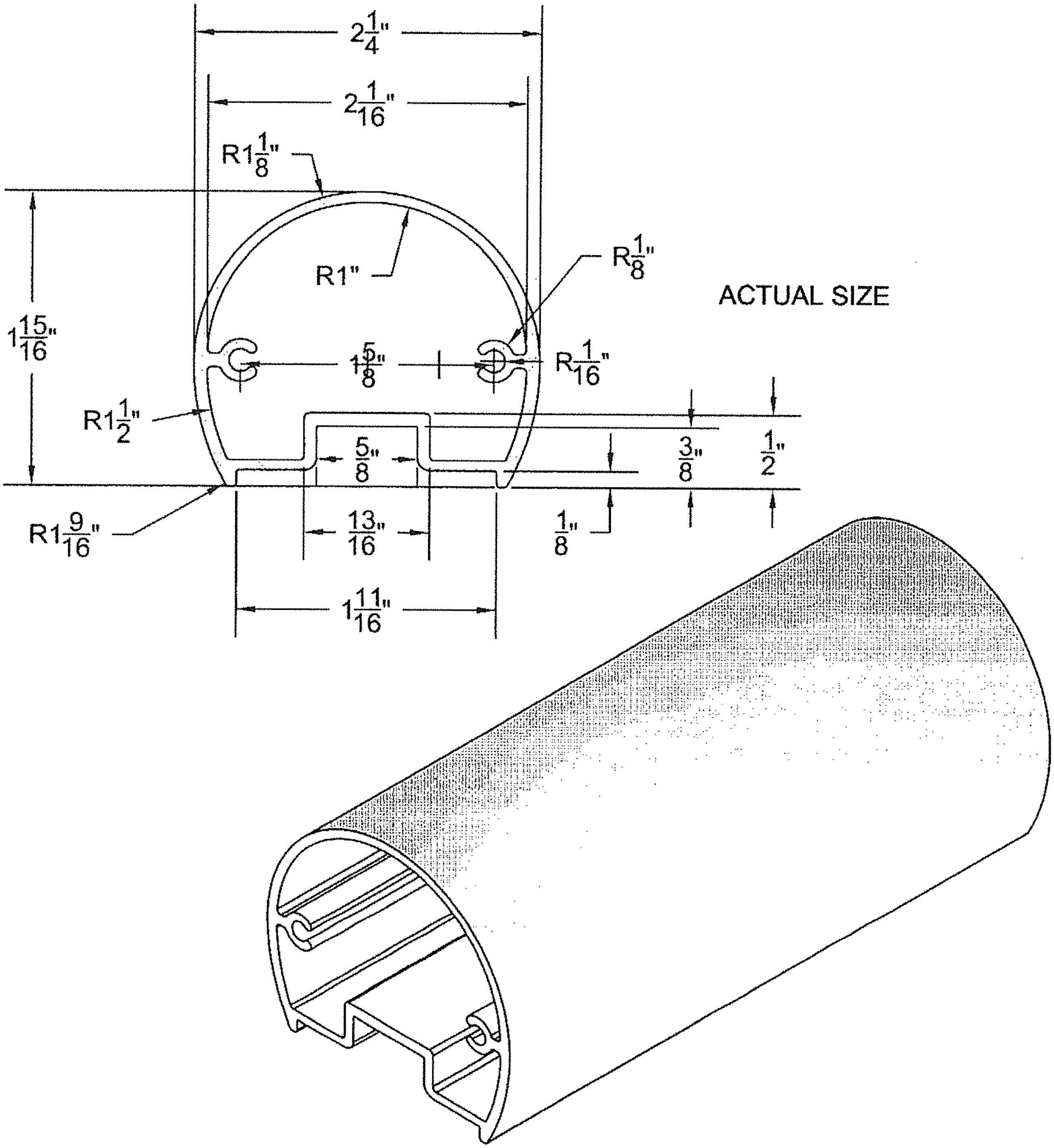
Company:		Page:	7
Specifier:		Project:	
Address:		Sub-Project I Pos. No.:	
Phone I Fax:	|	Date:	12/14/2017
E-Mail:			

8 Remarks; Your Cooperation Duties

- Any and all information and data contained in the Software concern solely the use of Hilti products and are based on the principles, formulas and security regulations in accordance with Hilti's technical directions and operating, mounting and assembly instructions, etc., that must be strictly complied with by the user. All figures contained therein are average figures, and therefore use-specific tests are to be conducted prior to using the relevant Hilti product. The results of the calculations carried out by means of the Software are based essentially on the data you put in. Therefore, you bear the sole responsibility for the absence of errors, the completeness and the relevance of the data to be put in by you. Moreover, you bear sole responsibility for having the results of the calculation checked and cleared by an expert, particularly with regard to compliance with applicable norms and permits, prior to using them for your specific facility. The Software serves only as an aid to interpret norms and permits without any guarantee as to the absence of errors, the correctness and the relevance of the results or suitability for a specific application.
- You must take all necessary and reasonable steps to prevent or limit damage caused by the Software. In particular, you must arrange for the regular backup of programs and data and, if applicable, carry out the updates of the Software offered by Hilti on a regular basis. If you do not use the AutoUpdate function of the Software, you must ensure that you are using the current and thus up-to-date version of the Software in each case by carrying out manual updates via the Hilti Website. Hilti will not be liable for consequences, such as the recovery of lost or damaged data or programs, arising from a culpable breach of duty by you.

PHYSICAL PROPERTIES

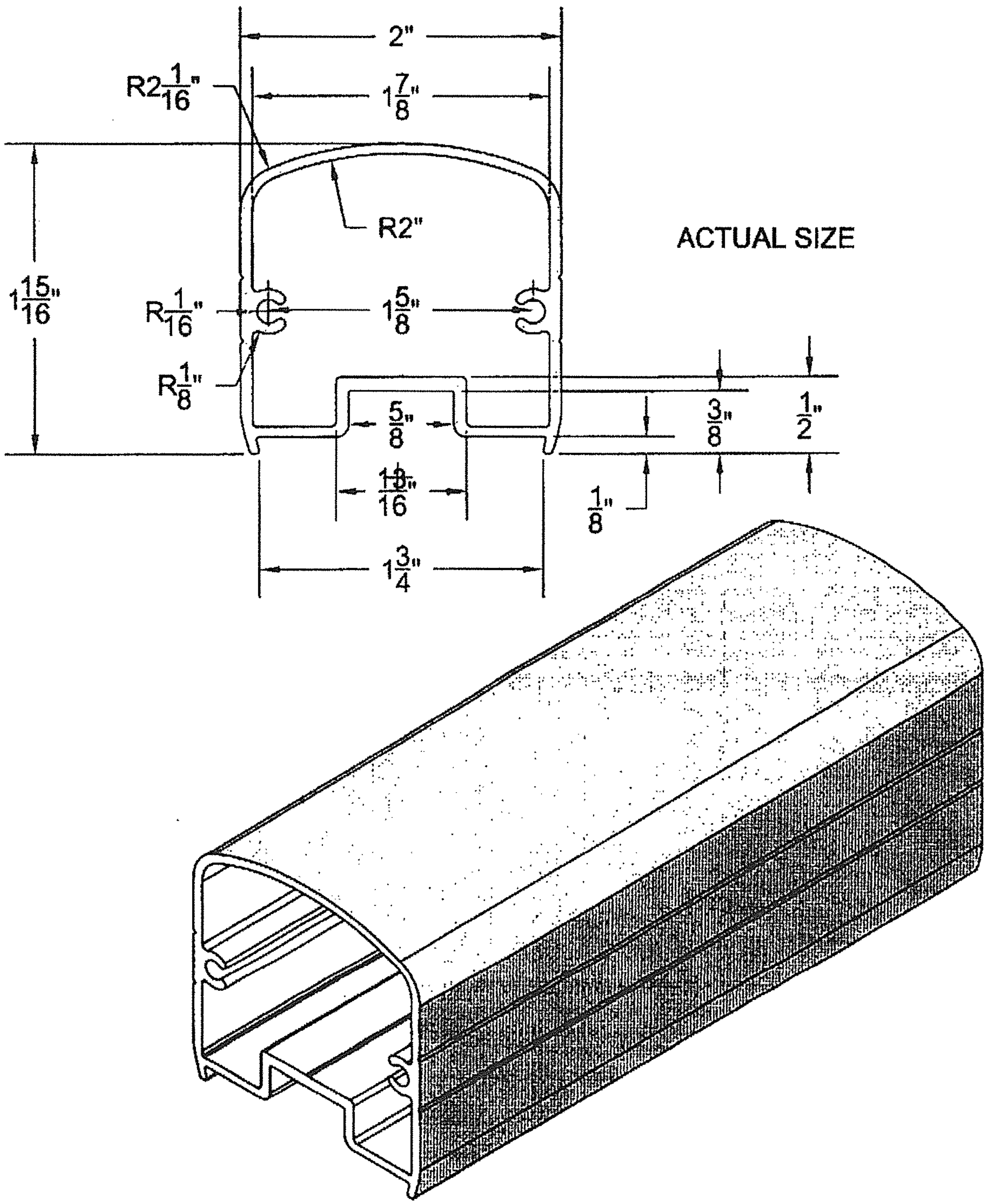
IMPERIAL						
	Ixx	0.22225 in^4	rxx	0.58354 in	Sxx	0.20341 in^3
	Iyy	0.40273 in^4	ryy	0.78552 in	Syy	0.35765 in^3
	ALLOY 6063-T5		ALLOWABLE STRESS = 9500 PSI		MINIMUM YIELD = 16000 PSI	



Bus.(604) 543-7245 Fax.(604) 543-4447 Toll Free: 1-800-211-4884 Web Site: www.railcraft.com Email: railinfo@railcraft.com	TITLE 1500R TOP RAIL		RAILCRAFT® ALUMINUM RAILING SYSTEMS
RAILCRAFT INTERNATIONAL INC. 13272 COMBER WAY SURREY,B.C. CANADA V3W 5V9	Physical Properties		23 OCT. 2006
	Engineering Standard		
	DIE # AC6470		
	SCALE 1"=1"	DATE 23 OCT. 2006	DRAWING NAME 1500R TOP RAIL-inch PHYSICAL PROPERTIES
	DRAFTPERSON JGUIANG	0	1/1

PHYSICAL PROPERTIES

IMPERIAL						
	Ixx	0.23745 in^4	rxx	0.62194 in	Sxx	0.22693 in^3
	Iyy	0.34741 in^4	ryy	0.75229 in	Syy	0.34740 in^3
	ALLOY 6063-T5		ALLOWABLE STRESS = 9500 PSI		MINIMUM YIELD = 16000 PSI	



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Web Site: www.railcraft.com
Email: railinfo@railcraft.com

RAILCRAFT INTERNATIONAL INC.
13272 COMBER WAY
SURREY, B.C.
CANADA V3W 5V9

TITLE	1500S TOP RAIL
	Physical Properties
	Engineering Standard
	DIE # AC6471
SCALE	1"=1"
DATE	23 OCT. 2006
DRAFTPERSON	JGUIANG
DRAWING NAME	1500S TOP RAIL-inch PHYSICAL PROPERTIES

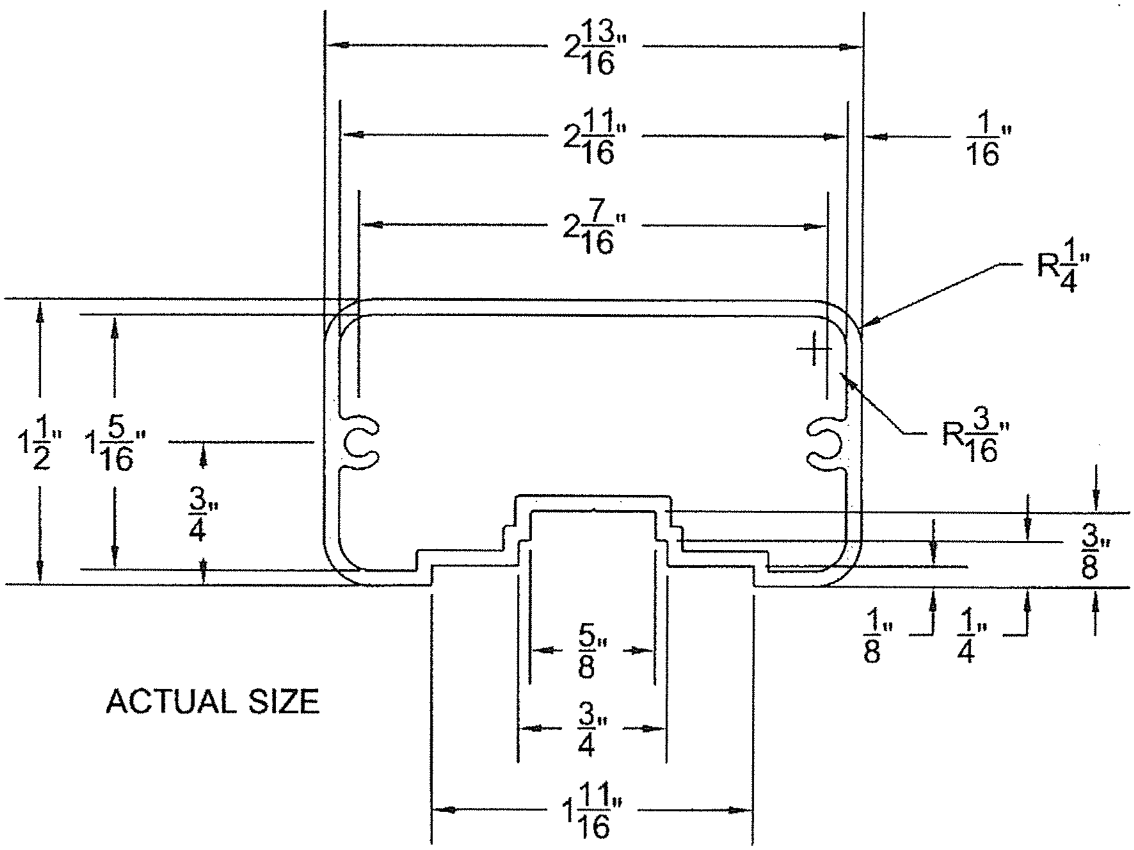
RAILCRAFT®
ALUMINUM RAILING SYSTEMS

23 OCT. 2006

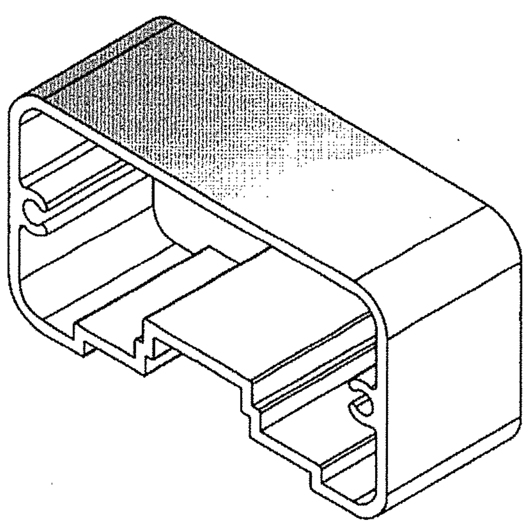
1/1

PHYSICAL PROPERTIES

IMPERIAL						
	Ixx	0.22530 in^4	rxx	0.54401 in	Sxx	0.29968 in^3
	Iyy	0.76681 in^4	ryy	0.99694 in	Syy	0.54228 in^3
	ALLOY 6063-T5		ALLOWABLE STRESS = 9500 PSI		MINIMUM YIELD = 16000 PSI	



ACTUAL SIZE



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Web Site: www.railcraft.com
Email: railinfo@railcraft.com

RAILCRAFT INTERNATIONAL INC.
13272 COMBER WAY
SURREY,B.C.
CANADA V3W 5V9

TITLE	3000R TOP RAIL
	Physical Properties
	Engineering Standard
	DIE # VH62741
SCALE 1"=1"	DATE 25 NOV. 2009
DRAFTPERSON BCALARA	$\triangle$ 0

RAILCRAFT®
ALUMINUM RAILING SYSTEMS

25 NOV. 2009

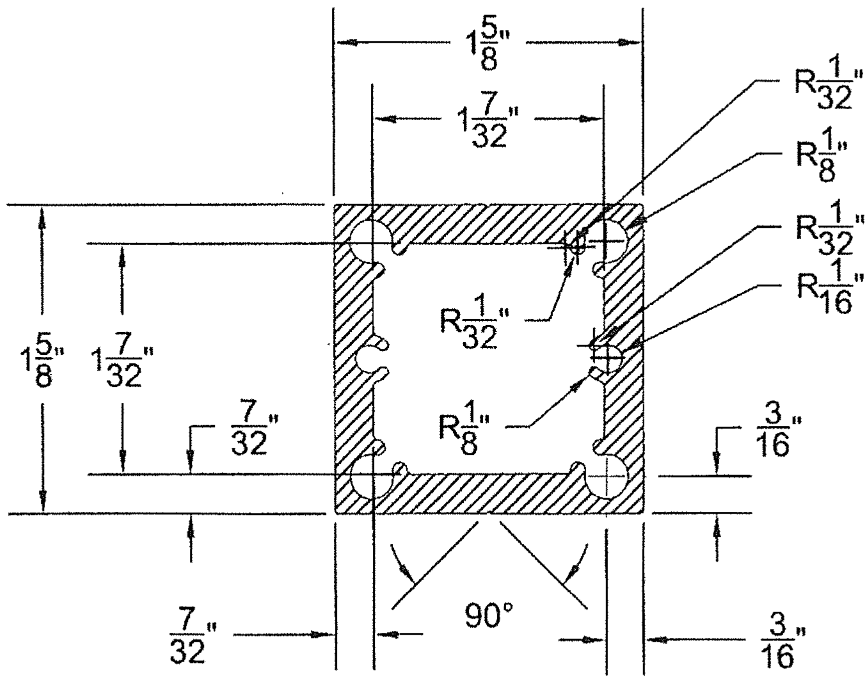
DRAWING NAME
3500S TOP RAIL-inch
PHYSICAL PROPERTIES

1 / 1

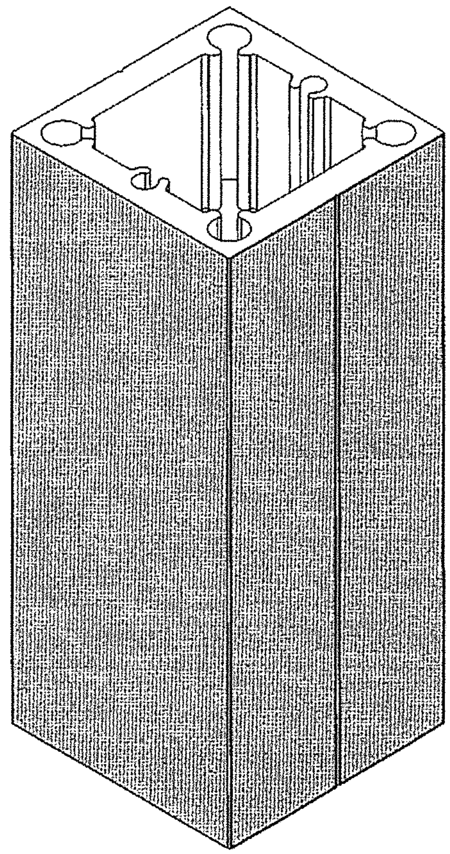
P4

PHYSICAL PROPERTIES

IMPERIAL						
	Ixx	0.35527 in^4	rxx	0.57899 in	Sxx	0.43726 in^3
	Iyy	0.35192 in^4	ryy	0.57625 in	Syy	0.43314 in^3
	ALLOY 6005A-T6		ALLOWABLE STRESS = 21000 PSI		MINIMUM YIELD = 35000 PSI	



TOP VIEW



ISOMETRIC VIEW

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Email: railinfo@railcraft.com

RAILCRAFT INTERNATIONAL INC.
13272 COMBER WAY
SURREY, B.C.
CANADA V3W 5V9

TITLE 1-5/8" SUPER POST3 MATERIAL

Physical Properties

Engineering Standard

SCALE 1"=1" DATE 23 JULY 2009

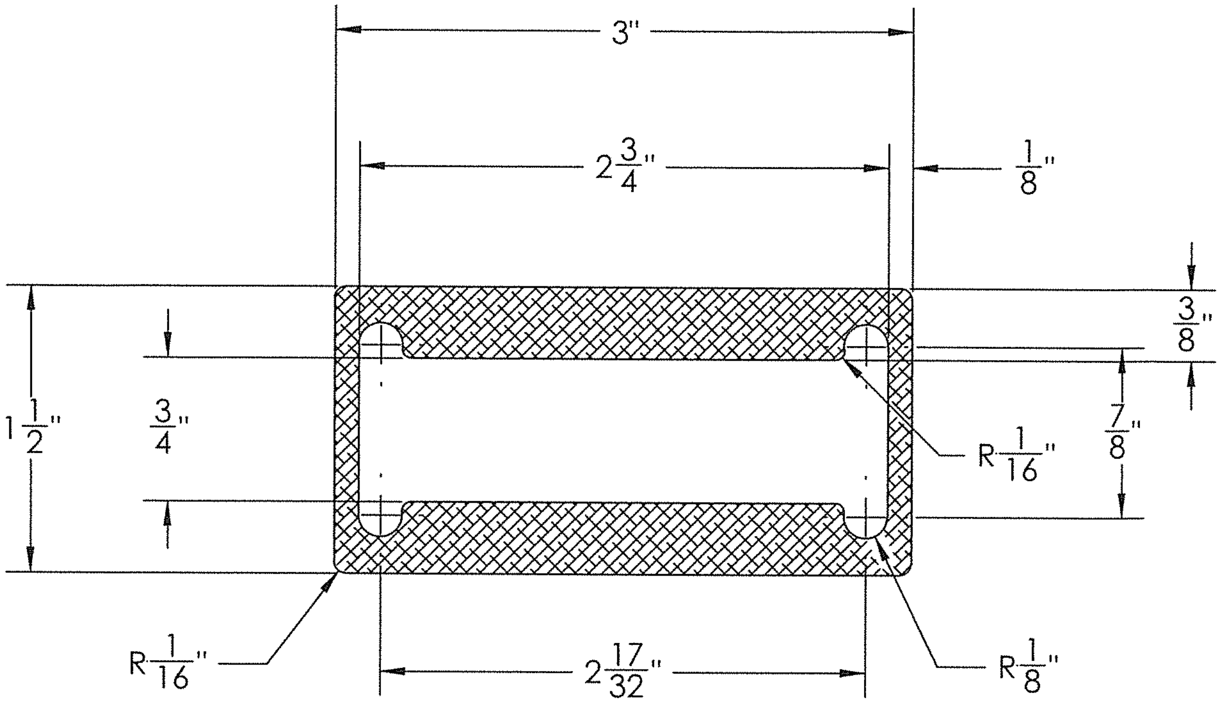
DRAFTPERSON BCALARA

RAILCRAFT® ALUMINUM RAILING SYSTEMS

23 JULY 2009

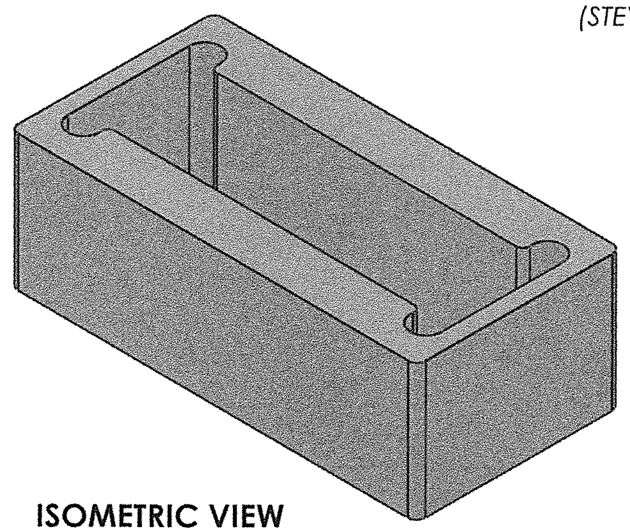
DRAWING NAME 1-5/8" SUPER POST3-inch PHYSICAL PROPERTIES

1 / 1



TOP VIEW PROFILE
SCALE 1:1"

NOTE:
SCREW CHASE REMOVED FROM ORIGINAL (STEVE WEI)

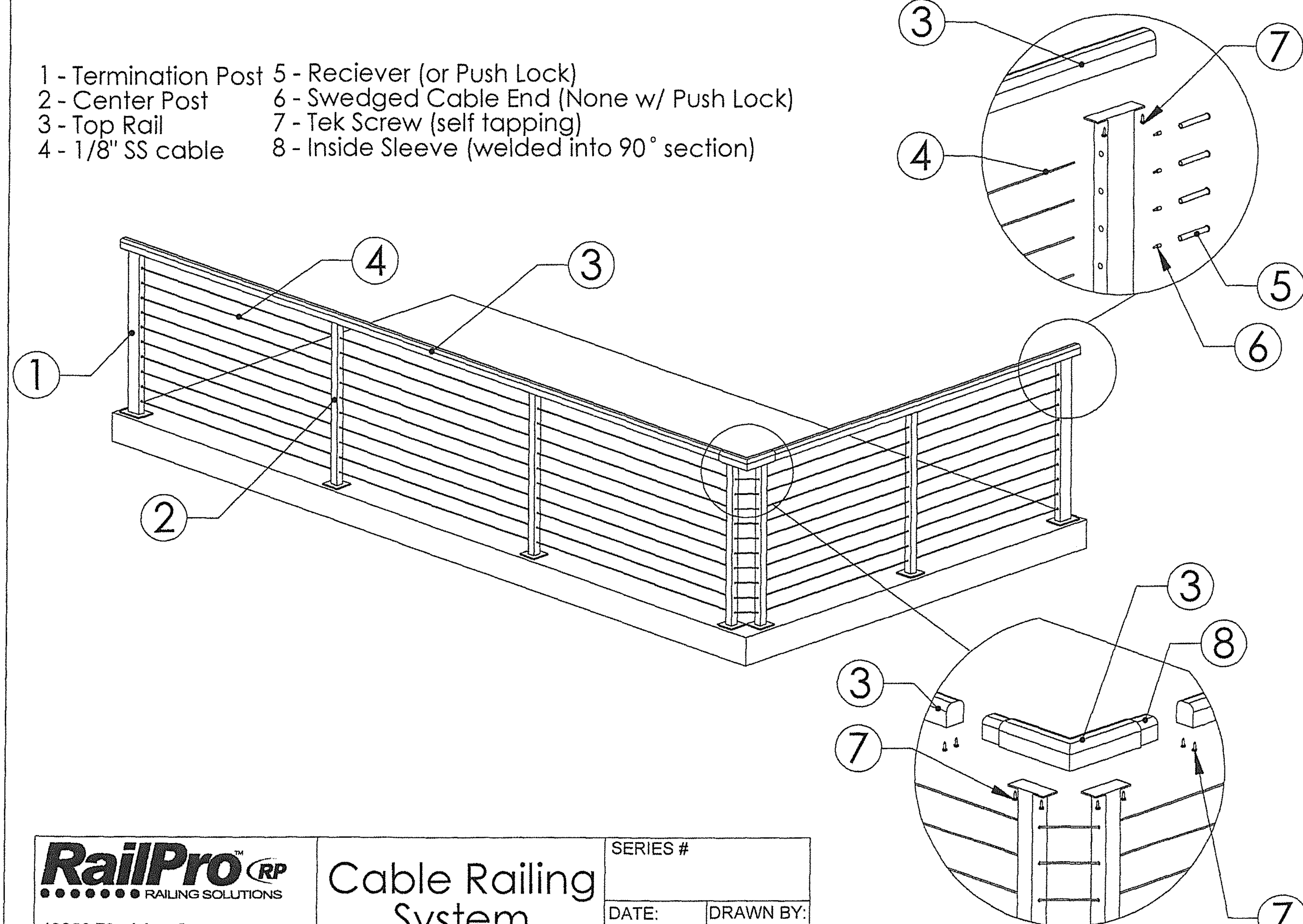


ISOMETRIC VIEW

RAILCRAFT® ALUMINUM RAILING SYSTEMS	UNLESS OTHERWISE SPECIFIED:		NAME	DATE
	DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL± ANGULAR: MACH± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	JGUIANG	10AUG10
		CHECKED	STEVE WEI	10AUG10
		ENG APPR.		
		MFG APPR.		
RAILCRAFT INTERNATIONAL INC. 13272 Comber Way Surrey, B.C. Canada, V3W 5V9	INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
	MATERIAL ALLOY & TEMPER:6005A-T6	PROPRIETARY AND CONFIDENTIAL THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF RAILCRAFT INTERNATIONAL INC. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF RAILCRAFT INTERNATIONAL INC. IS PROHIBITED.		
	FINISH MILL FINISH			
	SOLIDWORKS 2010			

DATE DRAWN:	10 AUGUST 2010		
DWG. NO.	**CABLE POST (REVISED)**		
SIZE A	DWG. NO.		REV. 0
SCALE:1:1	WEIGHT:		SHEET 1 OF 1

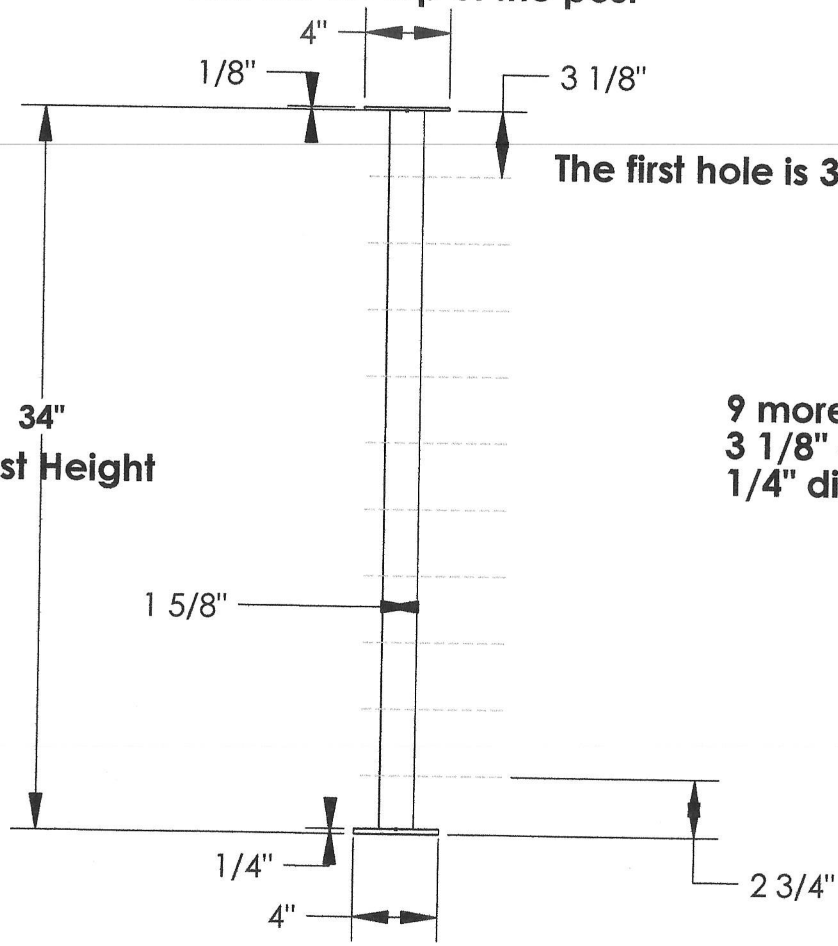
1 - Termination Post
2 - Center Post
3 - Top Rail
4 - 1/8" SS cable
5 - Reciever (or Push Lock)
6 - Swedged Cable End (None w/ Push Lock)
7 - Tek Screw (self tapping)
8 - Inside Sleeve (welded into 90° section)



RailPro RP RAILING SOLUTIONS 18856 72nd Ave S Kent Wa. 98032	Cable Railing System	SERIES #	
		DATE:	DRAWN BY: DTS

36" RH

Top plate is 1 5/8" x 4" x 1/8"
This sits on top of the post



The first hole is 3 1/8" down from the top of the post

9 more holes @
3 1/8" on center
1/4" diameter

Base plate is 4" x 4" x 3/8"

STRUCTURAL
REGISTERED PROFESSIONAL
ENGINEER
18346PE
OREGON
March 19, 1996
PEDER R. GOLBERG
EXPIRES: 6-30-23

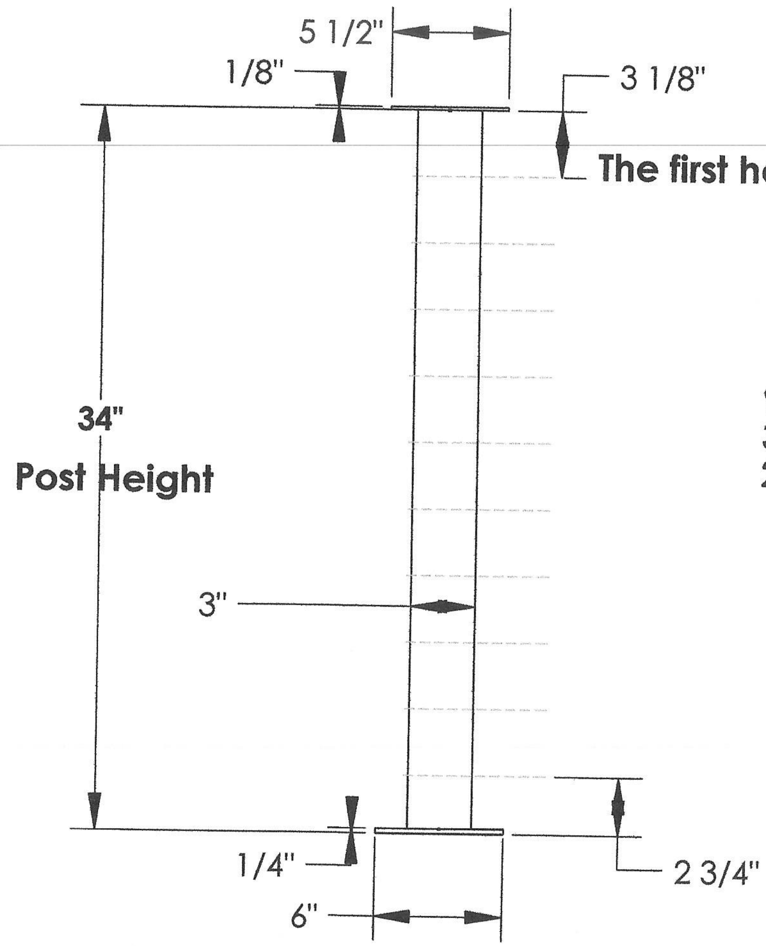
PEDER ROSS GOLBERG
STATE OF WASHINGTON
0032353
REGISTERED
PROFESSIONAL ENGINEER
EXPIRES 10/13/23

Post Material
1 5/8" square

RailPro™ RP RAILING SOLUTIONS	<#>		DATE	Aproved for Installation
			DRAWN	

36" RH

Top plate is 1 1/2" x 5 1/2" x 1/8"
This sits on top of the post



The first hole is 3 1/8" down from the top of the post

9 more holes @
3 1/8" on center
29/64" diameter

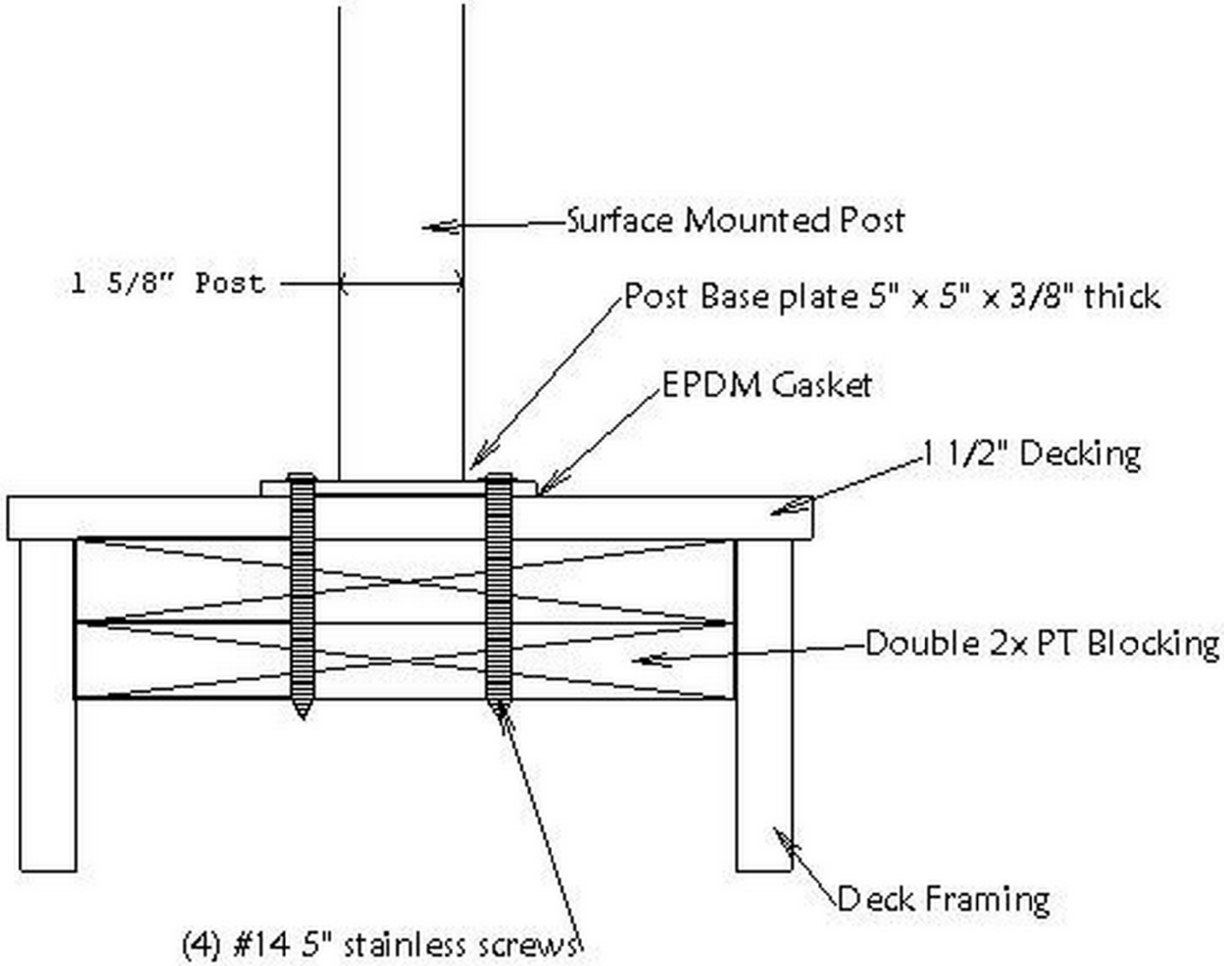
Base plate is 4" x 6" x 3/8"

STRUCTURAL
REGISTERED PROFESSIONAL
ENGINEER
18346PE
OREGON
March 19, 1996
PEDER R. GOLBERG
EXPIRES: 6-30-23

PEDER ROSS GOLBERG
STATE OF WASHINGTON
0032353
REGISTERED
PROFESSIONAL ENGINEER
EXPIRES 10/13/23

Post Material
1 1/2" x 3"

RailPro™ RP RAILING SOLUTIONS	<#>		DATE	Aproved for Installation
			DRAWN	



STRUCTURAL
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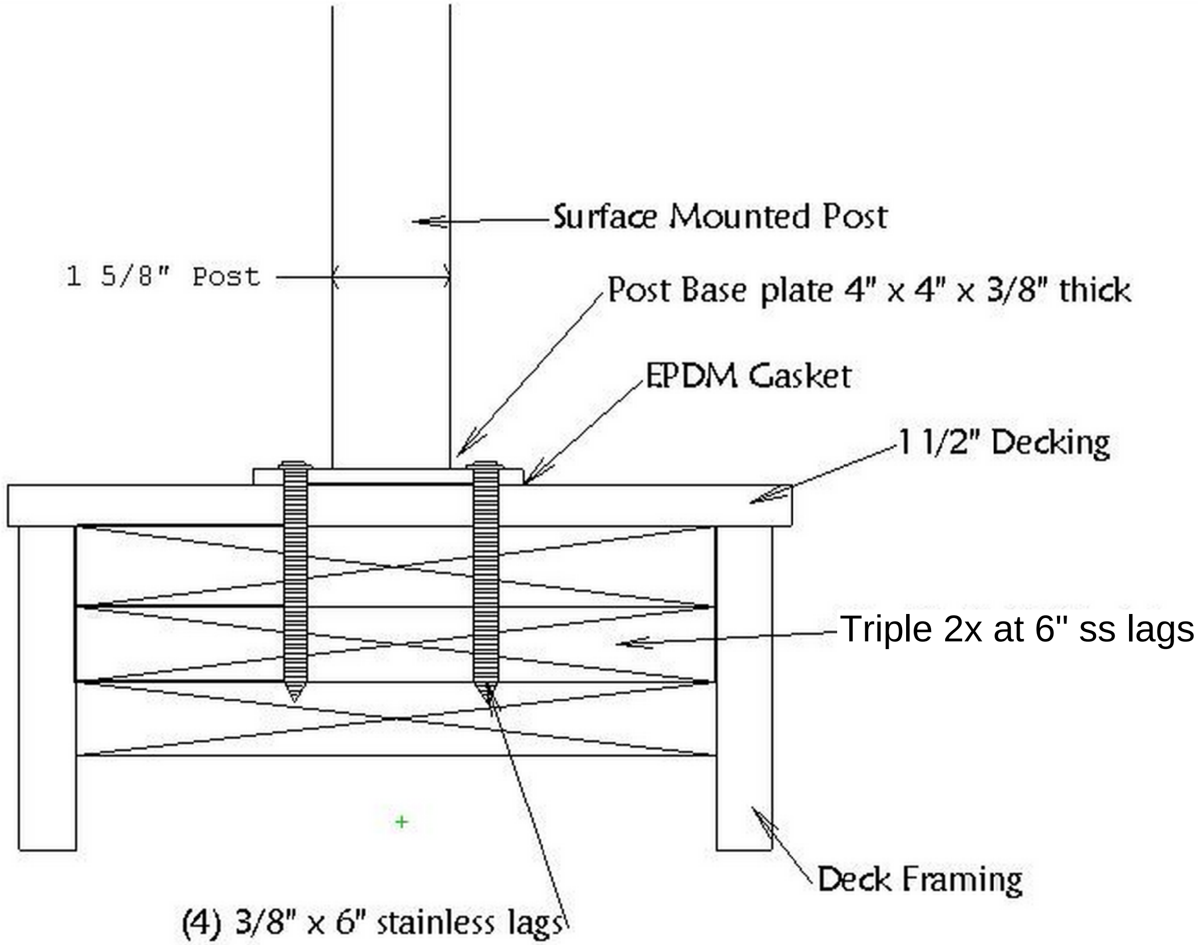
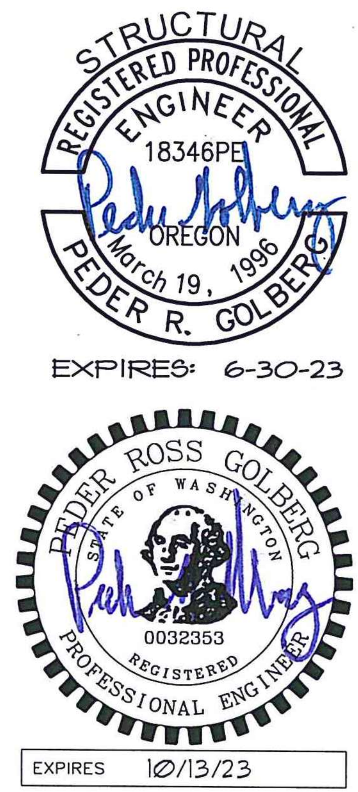
18346PE
OREGON
March 19, 1996
PEDER R. GOLBERG
EXPIRES: 6-30-23

PEDER ROSS GOLBERG
STATE OF WASHINGTON
0032353
REGISTERED PROFESSIONAL ENGINEER
EXPIRES 10/13/23

RailPro RP RAILING SOLUTIONS	Surface Mounted Details - Cable Railing	Date:	Approved for Installation
		MF	

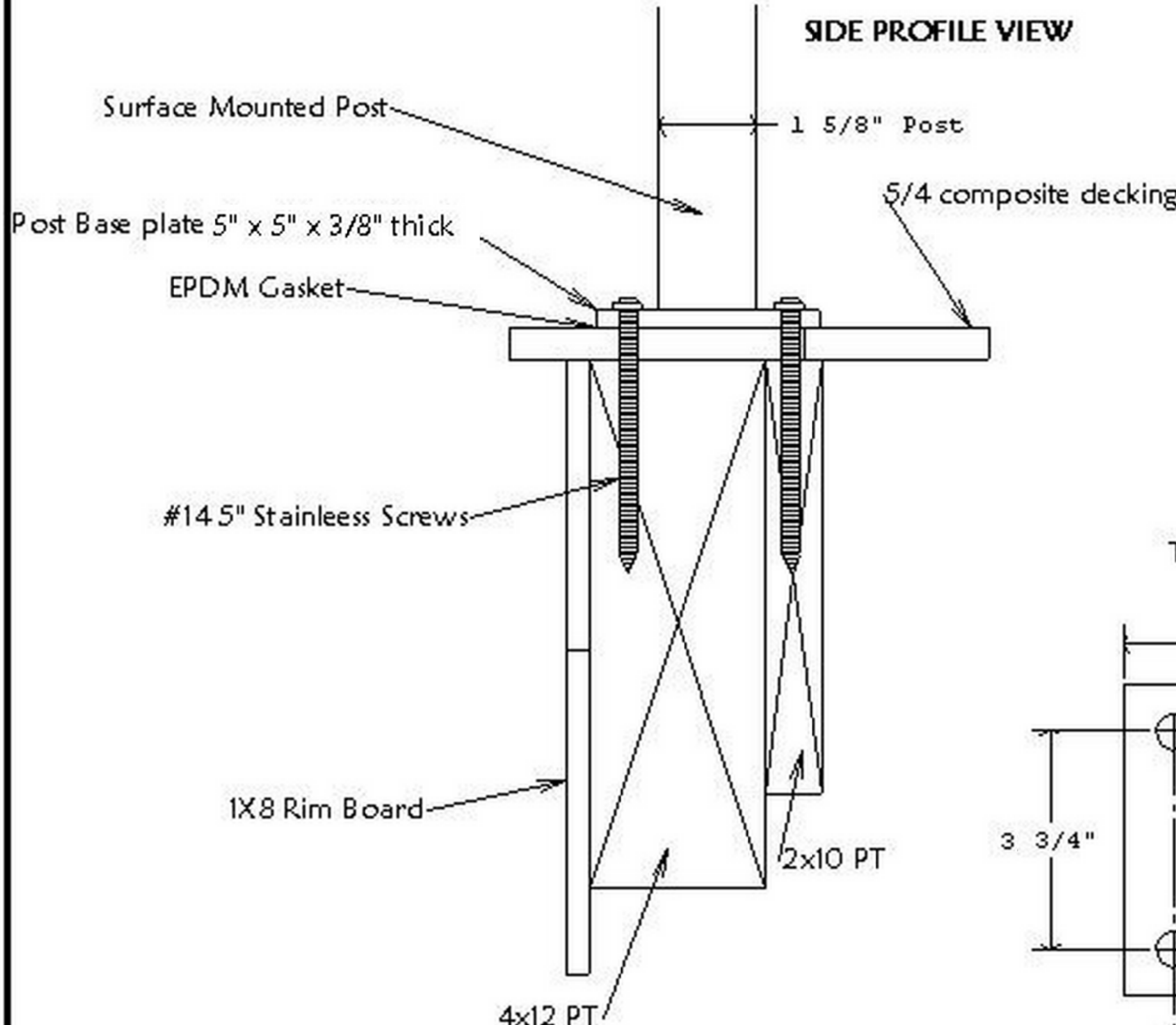




RailPro RP RAILING SOLUTIONS

Surface Mounted Details - Cable Railing

Date.	Approved for Installation
MF	



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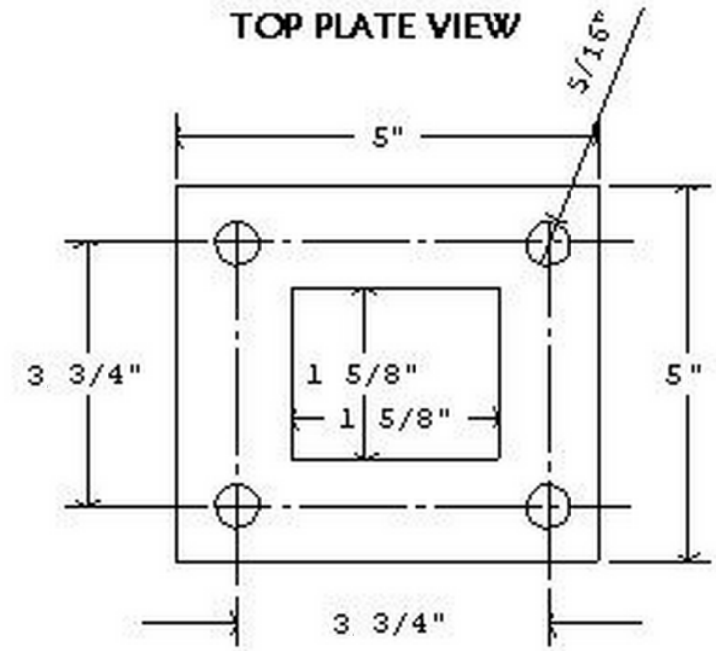

RailPro RP RAILING SOLUTIONS

Surface Mounted Details - Cable Railing	Date:	Approved for Installation
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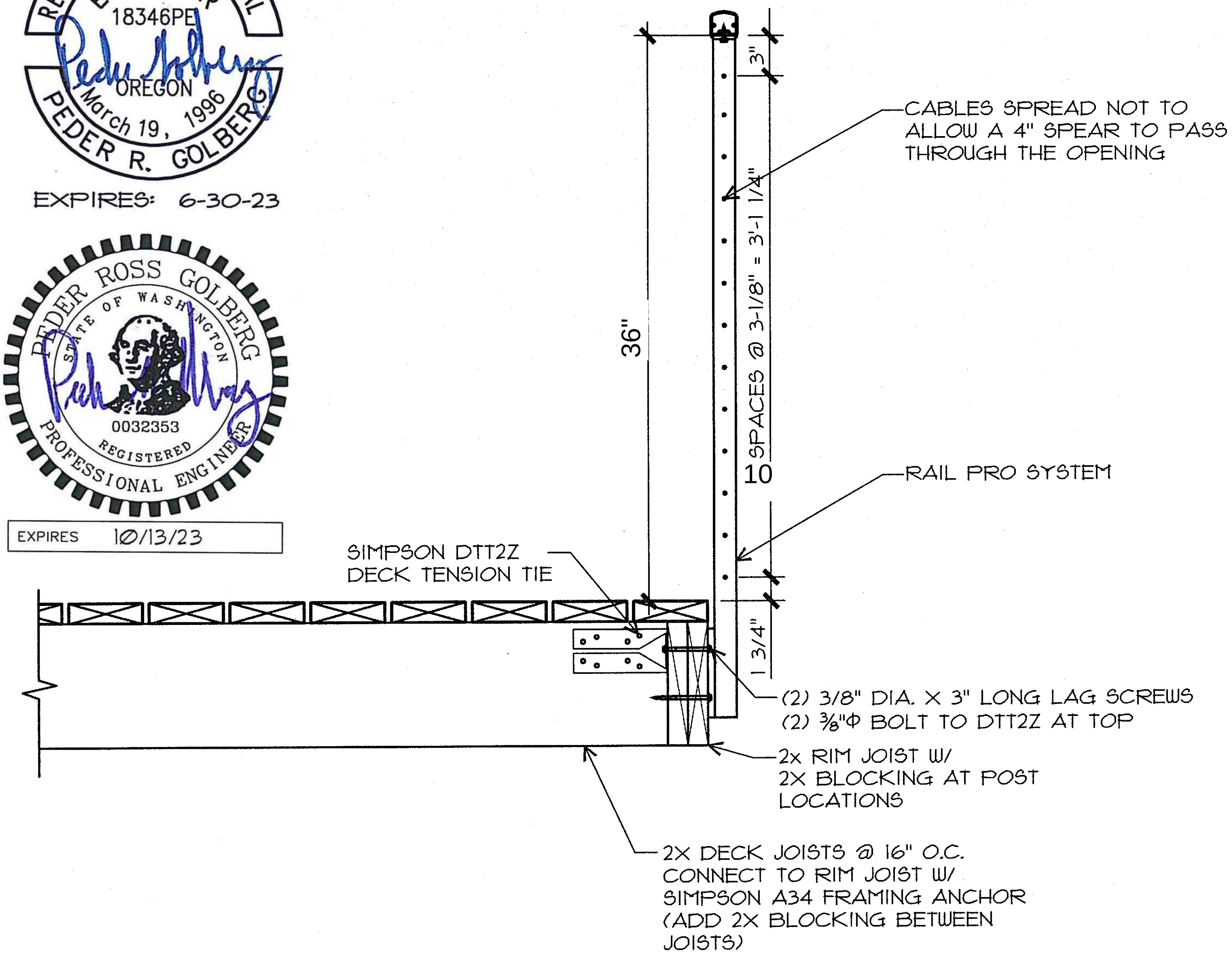
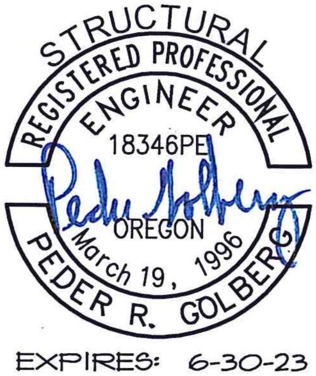


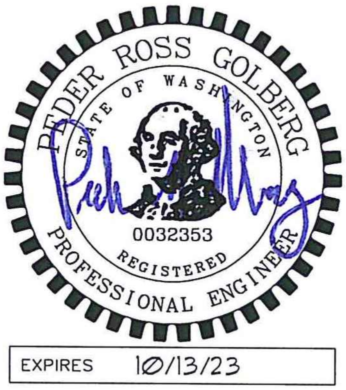
2
S5

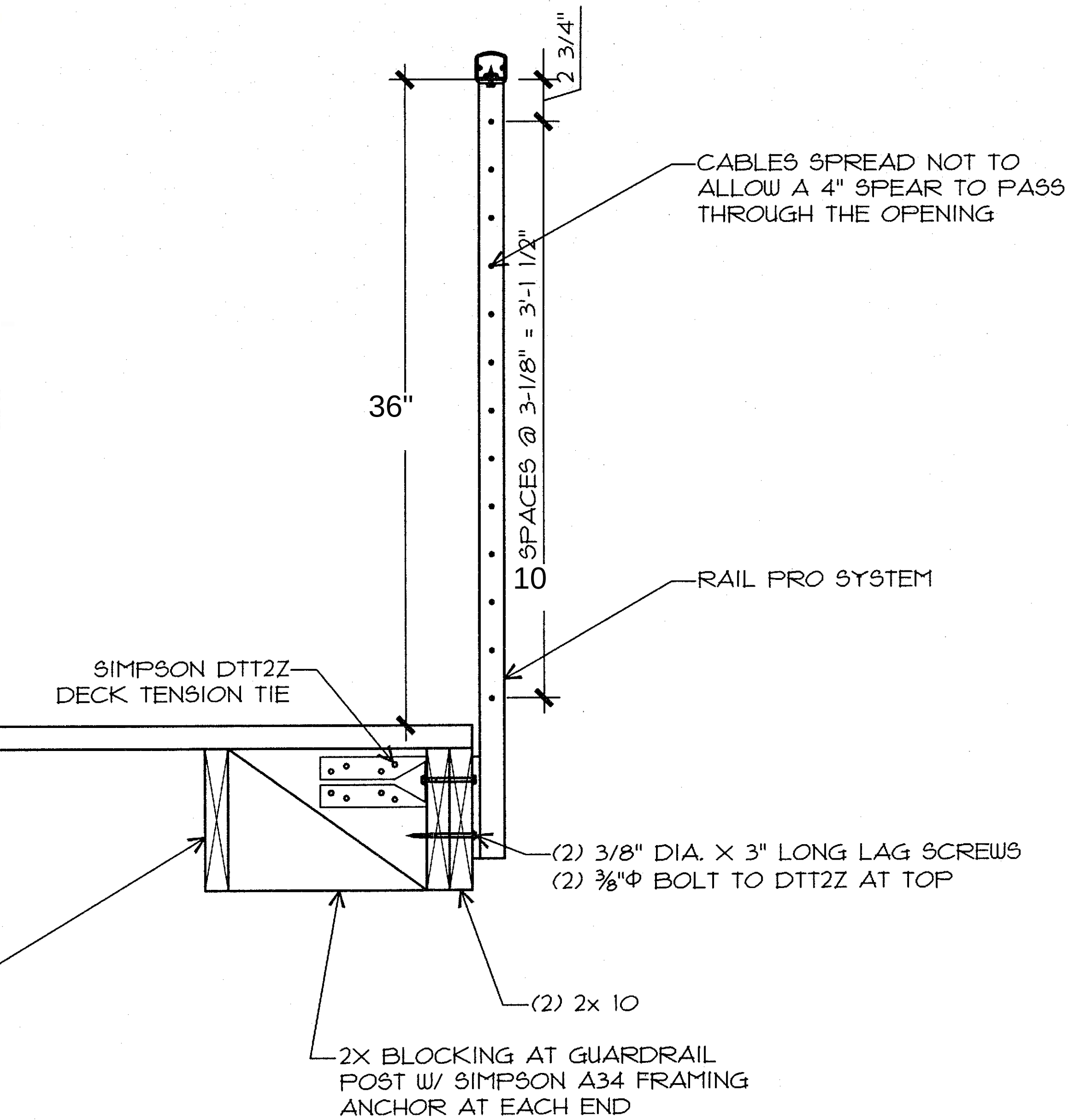
DECK

1" = 1'-0"

6/5/15







4
S5

DECK

1" = 1'-0"

6/5/15