28 April 2011

Hansen Architectural Systems
5500 SE Alexander ST
Hillsboro, OR 97123

SUBJ: GUARD POSTS MOUNTED TO WOOD DECKS
RESIDENTIAL INSTALLATIONS 42" GUARD HEIGHT

The attached details and associated calculations demonstrate how to attach the guard posts to wood decks for weather exposed residential installations. The installation details are designed for a finished guard height of 42" above finish floor. The same details may be used for rail heights less than 42" and for commercial installations with a post spacing of 4' on center. Design loading is 200# at the top rail in accordance with 2009 IBC 1607.7.7.1 **and IRC Table R301.5**. Wood components and fasteners are evaluated in accordance with the National Design Specification for Wood Construction.

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Attached:
Connection details, 6 pages

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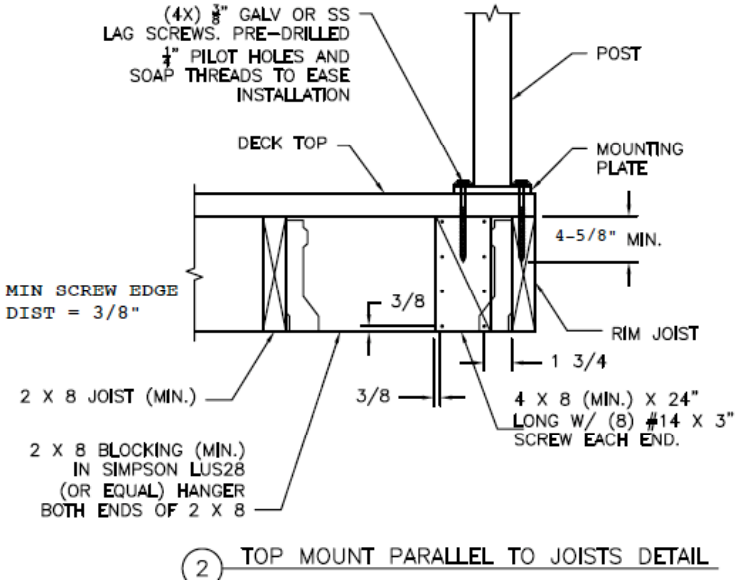
TOP MOUNT WITH GUARD PARALLEL TO JOISTS

Moment at base plate atatchment to deck:
M = 200#*42" = 8,400"#

Determine force on lag screws – lever arm (centerline of lags to edge of base plate) = 4.375"
C = M/a
C = 8,400"#/4.375 = 1,920#
determine wood area required to support compression force based on F_{cT} = 405 psi, C_D = 1.33, and C_b = 1.05
A = 1,920/(405*1.33*1.05) =
A = 3.395 in^2
a = 3.395/(4.875) = 0.696

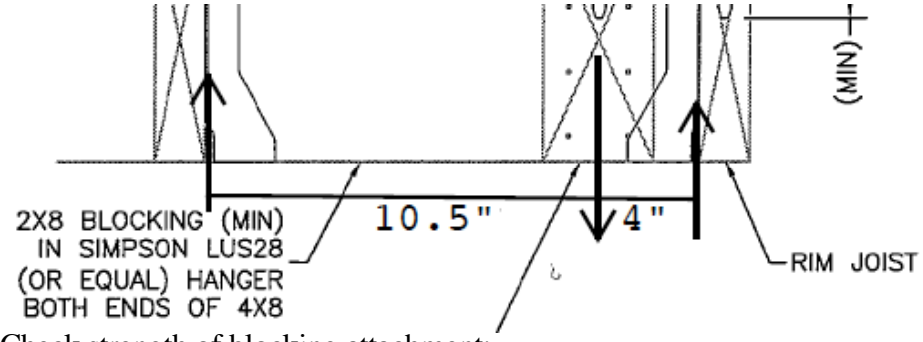


Lag withdrawal load:
T_l = 8400/[2*(4.375-0.696/2)]
T_l = 1,043#

Lag screw withdrawal strength:
W = 243#/in for 3/8" lag screw and G ≥ 0.43 (typ for Hem-Fir pressure treated wood) From NDS Table 11.24
C_D = 1.33 (IBC 16.7.1.3 and C_m = 0.7 (NDS table 10.3.3) for weather exposed wood.
W' = 243*1.33*0.7 = 227#/in
Required embedment length into the solid blocking:
e = T_l/W' = 1,043/227 = 4.59"
Required lag length:
L = 4.59"+3/8"+7/32" + T_d = 5.18"+ decking thickness

NOTE:
If lumber species is Southern Yellow Pine, Douglas Fir or Western Hemlock:
W = 278#/in
e' = 4.59"*(243/278) = 4"
L = 4.0"+3/8"+7/32" + T_d = 4.6"+ decking thickness

NOTE 2:
For 36" rail height the embedment length is:
e_{36} = 4.59"*(36/42) = 3.93"
L_{36} = 3.93"+3/8"+7/32" + T_d = 4.53"+ decking thickness



Check strength of blocking attachment:
For #14 screws through cross blocking and into backing block.
Z = 141#
V_T = 8 screws*141#/screw*2 ends = 2,256# > 1,920# okay
Cross blocking connection to joists @ rim joist:
V = 0.5*1,920#*[(10.5)/14.5] = 695#

Strength of LUS28 from Simpson catalog and ESR-2549
V = 1,055# * (C_D = 1.333)*(C_M = 0.97) = 1,365# ≥ 695# okay.

Torsion on backing block and rim joist:
T = 8,400"#/2 = 4,200"# (restrained both ends)
width = (3.5"+1.5"), depth = 7.25"
d/w = 7.25/5 = 1.45
α = 0.228
$\tau_{max} = T/(\alpha * d * w^2) = 4{,}200"\#/(0.228*7.25*5^2) = 102$ psi

Allowable shear parallel to grain F_v for Hem-Fir
$F'_v = 140psi*C_D*C_M = 140psi*1.33*0.97 = 181$ psi ≥ 102psi

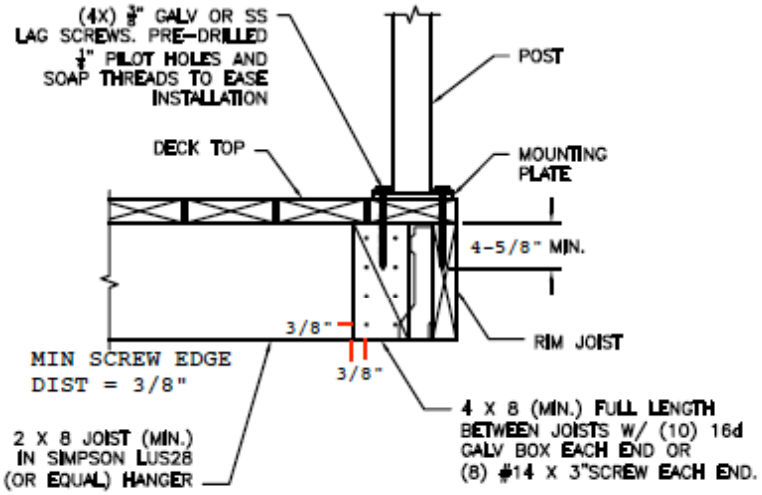
TOP MOUNT WITH GUARD PERPENDICULAR TO JOISTS
Mounting is similar to top mount parallel to joists except that the cross blocking is eliminated.

Lag screw loads are same as previously checked (page 2).

Backing block loads and reactions are same as previously checked.

Torsion stress is same as previously checked.

Strength is adequate based on calculations on pages 2 and 3.



(2) TOP MOUNT PERPENDICULAR TO JOISTS DETAIL

Check for post at end of block:

Assume that the base plate is screwed directly to a joist with the other lag screw in the block 3" away, 3.75" spacing. For a typical residential installation the uplift on the two lag screws is 960# each. The load share to the single joist would then be a maximum of:

V = 960#+(14.5-3)/14.5*960 = 1,721#

For the LUS28 the allowable load with the 1/3 increase for a guard load is 1,365#

Resistance provided by the block screws acting to prevent block and joist from moving:

W' = 1.5"*165#/"*1.33 = 186#/screw

M_r = 2*186#*6.625"+2*186*4.625"+2*186*2.375"+2*186*0.375= 5208"#

$V_r = M_r$ /(14.5"/2) = 5,208"#/7.25 = 718# (resistance equal both ends)

Total resistance = 1,365#+718# = 2,083# > 1,721#

Thus total resistance is adequate.

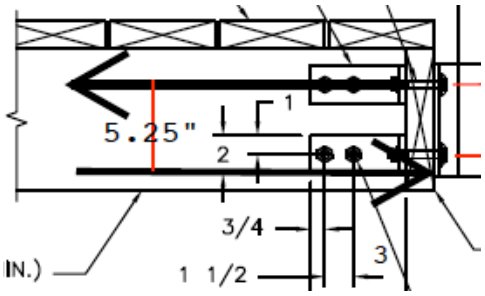
If desired to ignore the resistance from the block then use HUS28 hanger instead of the LUS28.

Rim joist splices shall not be within one joist bay of either side of the blocked bay so that rim joist always extends a minimum of 1 joist beyond the post so that the rim load will always be restrained by a minimum of 2 joists.

FACE MOUNT WITH GUARD PERPENDICULAR TO JOISTS.

For fascia mounted posts:
The post is bolted to the rim joist-
Bolt reactions:
$T = M/A = 200\#*49''/5.25'' = 1{,}867\#$
$T_b = M/(2a)$
where:

$$a = 5.25'' - \frac{0.5*1867}{(4''*405psi*0.67*1.2*1.333)} = 4.71''$$

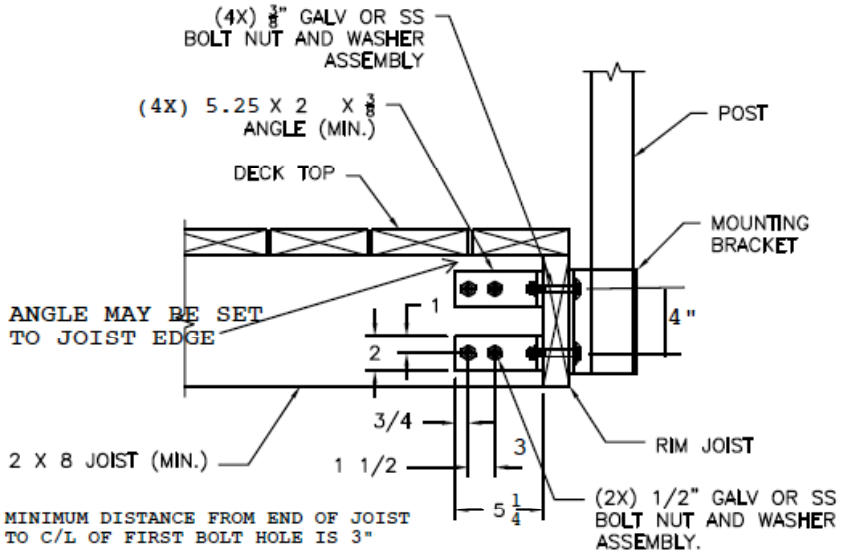


$T_b = 200*49/(2*4.71) = 1{,}040\#$

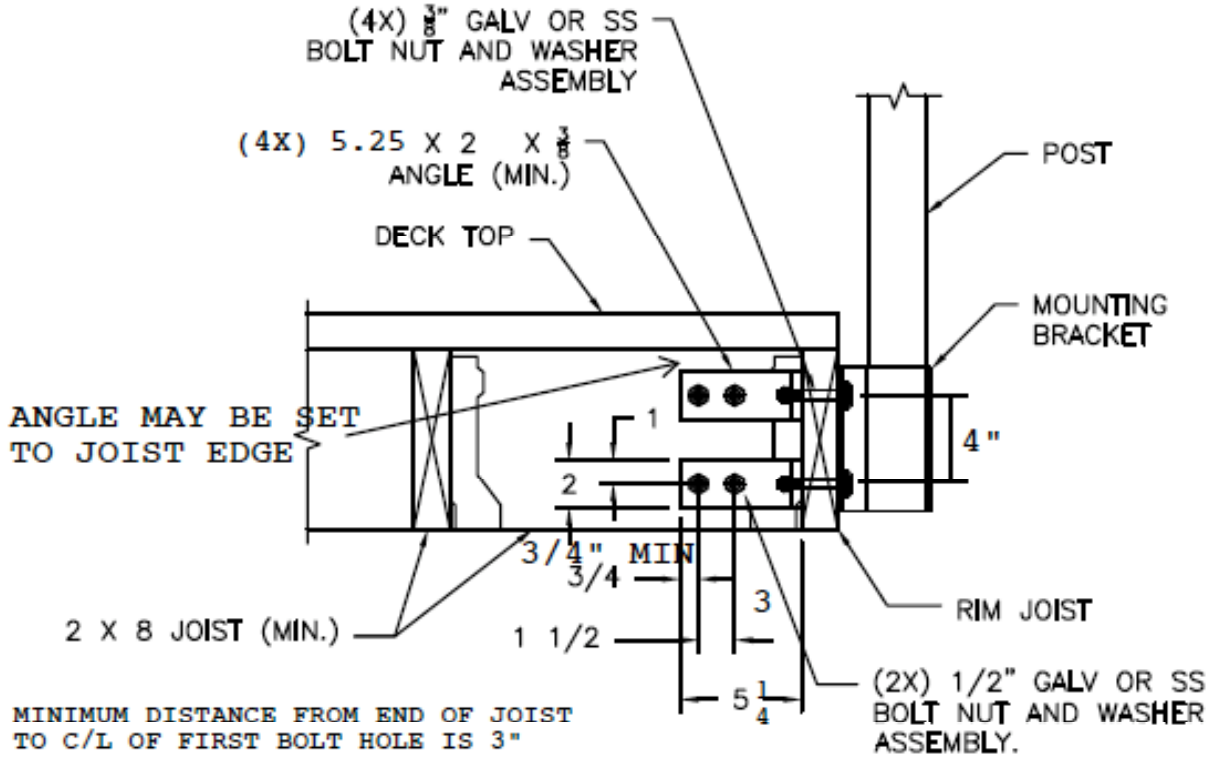
Rim joist is secured by using an angle bracket pair and pair of 1/2″ bolts in double shear.
Shear acting on angle bolts:
$V_b = 200*49/(2*5.25) = 933\#$

(per NDS Table 11G for G≥0.46)
Use Doug-Fir
$Z_{||} = 970\#$ each
Reduction for edge distance and spacing:
$C_\Delta = (3/3.5) = 0.857$ or $(1.5/2) = 0.75$
$Z' = C_D * C_\Delta * Z_{||} = 1.33*0.75*970 = 968\# > 933\#$

Minimum bolt edge distance of 1.5D = 0.75″ is assured because the closest the bolt may be installed to the edge is 1″.



2 FACE MOUNT PERPENDICULAR TO JOISTS DETAIL

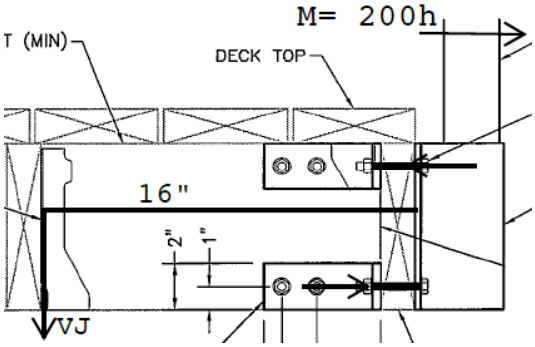


2 FACE MOUNT PARALLEL TO JOISTS DETAIL

When rim joist is parallel to the deck joists a 2x8 block is used to restrain the rim joist from rotating at the post.

Attachment to rim joist same as previously checked.

Check attachment of block to deck joist:
From ∑M about the rim joist = 0



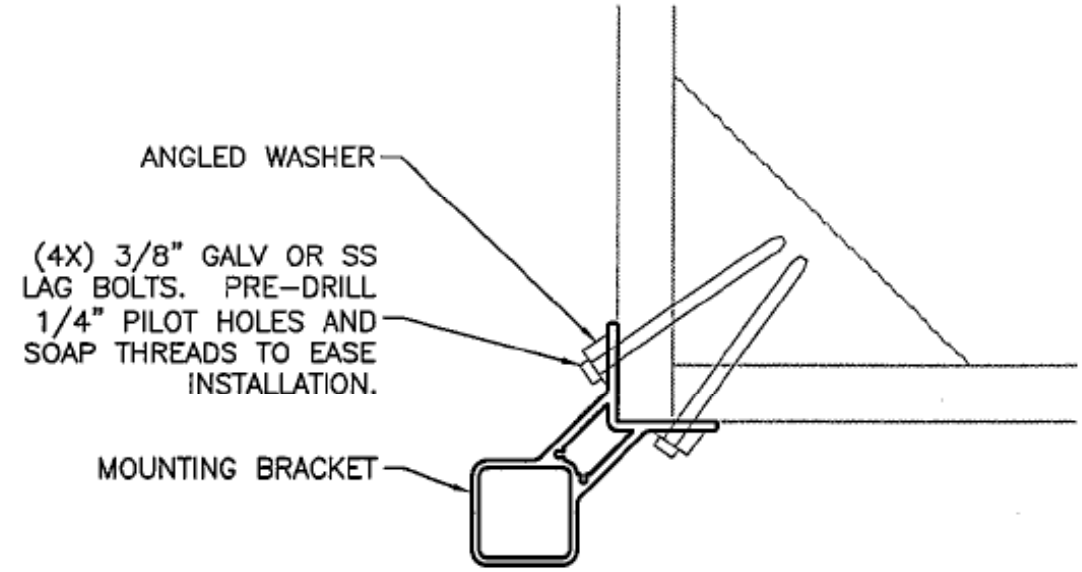
V_J = 200*49”/16” = 613#

Strength of Simpson LUS28 connection:
V_A = 1,365# > 613#

Torsion of rim joist prevented by bracing.

Moment is resolved in joists as an uplift/downward couple causing bending in joist:
For typical 8’ joist span
M_j = 613#*8’/4 = 1,226’#
f'_b = 1,226/S = 1,226*12/13.34 in^3 = 1,103 psi < 850*1.333*1.15 = 1,133 psi< 1,150 psi

Okay for weather exposed treated hem-fir 2x8 joists, use Doug-Fir.



5 TYP CORNER FACE MOUNT PLAN VIEW
1 1/2"=1'-0"

At corners top rails restrain forces acting on post by resolving forces.

Since there is no unresolved force on corner post, connection can be resolved for simple shear:
V = 200#+D
For typical system (1/4" glass infill) D = 14 plf = 70# per post
V = 200+70 = 270#
or horizontal force from load on infill:
H = 25psf*3.5'/2*5' = 219#

For loading in any direction two lags minimum will be loaded in shear.

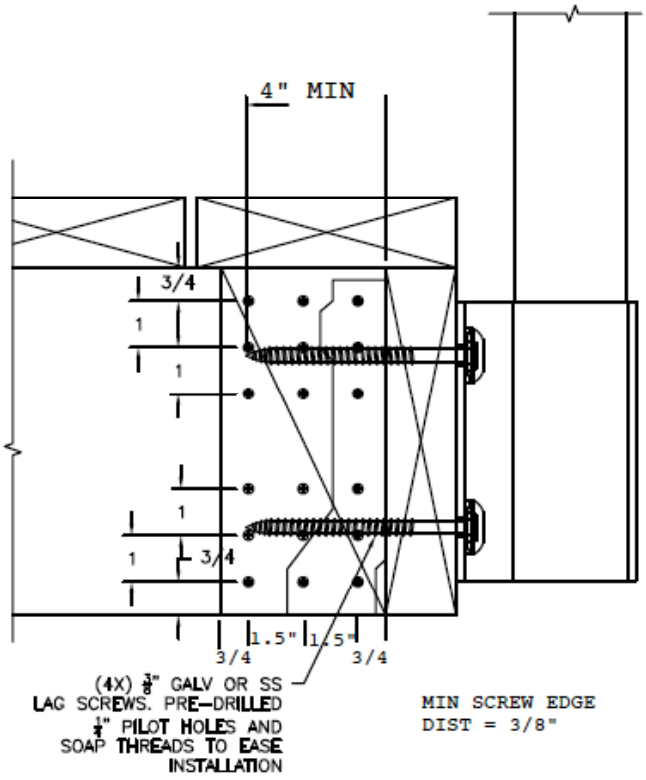
Allowable shear load on 3/8" lag:
Z_T = 160# (minimum shear strength from NDS Table 11K.
160#*2 = 320# > 219# or
160#*4 = 640# > 270#

Connection is okay

FACE MOUNT PERPENDICULAR TO JOISTS
With lag screws:

For fascia mounted posts:
The post is lag screwed to solid blocking behind the rim joist installed between the joists
Lag Screw reactions:
T = M/A = 200#*49″/5.25″ = 1,867#
T_b = M/(2a)
where a = 5.25″-0.5[1867/(4″*405psi*0.67*1.2*1.333)] = 4.71″
T_b = 200*49/(2*4.71) = 1,040#

Withdrawal strength of the lag screws (per NDS Table 11.2A) into DFL or wood of equivalent density G ≥0.49.



for 3/8″ lag screw
W = 296#/in
W′ = C_D*C_M*W
C_D = 1.33 for guard live loads
C_M = 0.7 for rain exposed application
e = embed depth
Determine required depth:
e = T_b/W' = 1,040#/(296*1.33*0.7) = 3.76″
3.76″+7/32″ = 3.98″

Use 4-1/2″ long lag screws
embed depth = 4.5″-0.375″=
e = 4.125″

Check strength of blocking attachment:
For #14 screws through joist and into backing block.
Z = 159# (NDS Table 11L
Z' = 159#*1.333*0.7 = 148#
V_T = 14 screws*148#/screw*2 ends = 4,144#

Torsion resistance from ∑M about the center of the block
S = 2[1.80″+2.55″+3.35″)*4+2*(0.82″+1.85+2.85)] = 81.28 in
M = 81.28″*148# = 12,029″#

Check shear stress in block:
f_v = 3V/(2bd_1) where d_1 = d/2 and V = 1,867#/2 = 933# half to each end.
f_v = 3V/(bd) = 3*933#/(5.5*7.25) = 70.2 psi < F_V*C_D*C_M = 180*1.33*0.97 = 232 psi
If full shear applied to one section: 2*70.2 = 140.2 psi ≤ 232 psi okay to locate post anywhere on block.
Ignores shear strength of the rim joist.

Minimum joist depth is 8″
IF RIM JOIST IS THICKER THAN 4″(actual) THE BLOCKING IS NOT REQUIRED

FACE MOUNT PARALLEL TO JOISTS
With lag screws:

For fascia mounted posts:
The post is lag screwed to solid blocking behind the rim joist installed between the rim joist and the next joist.
Lag Screw reactions:
$T = M/A = 200\#*49'' / 5.25'' = 1{,}867\#$
$T_b = M/(2a)$
where $a = 5.25''-0.5[1867/(4''*405psi*0.67*1.2*1.333)] = 4.71''$
$T_b = 200*49/(2*4.71) = 1{,}040\#$

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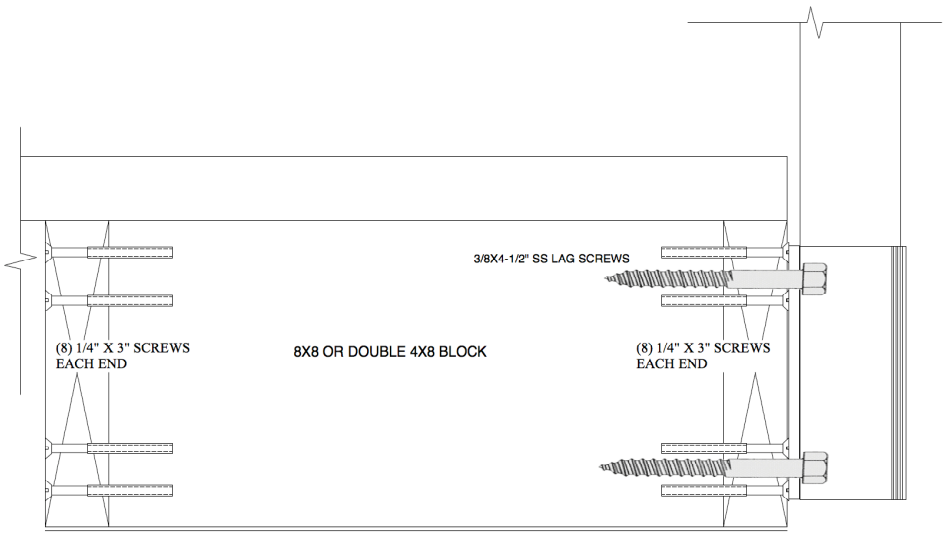

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$C_M = 0.7$ for rain exposed application
e = embed depth
Determine required depth:
$e = T_b/W' = 1{,}040\#/(296*1.33*0.7) = 3.76''$

Use 4-1/2" long lag screws
embed depth = 4.5"-0.375"-7/32" = 3.906"

Check strength of blocking attachment:
For outward force the torsion on the block is resisted by shear between the block and joists.
For #14 screws through joist into blocks.
Z = 141# (NDS Table 11L)
Z' = 141#*1.333*0.7 = 132#
For 8 screws into each block end

Torsion resistance from ∑M about the center of the block
M = 132#*8 screws*14" = 14,784"# > 9,800"#

Shear Strength of #14 x 3" screws.
Screws extend through main member 1.5" thick into side member 1.5"
Main member and side member are of the same species with G ≥ 0.46
Since penetration into side member = 1.5" = D/6.2 use NDS Table 11.3.1A yield equations to determine allowable shear:
l_m = 1.5", l_s = 1.5", F_{em} = 4,000, F_{es} = 4,000, Table 11.3.2 F_{yb} = 70,000 Table I1
R_d = 4.0, Re = F_{em}/F_{es} = 1.0; $R_t = l_m/l_s$ = 1.0

$$k_1 = \{\sqrt{[R_e+2R_e^2(1+R_t+R_t^2)+R_t^2R_e^2]}-R_e(1+R_e)\}/(1+R_e)$$
$$k_1 = \{\sqrt{[1+2*1^2(1+1+1^2)+1^2*1^2]}-1(1+1)\}/(1+1) = 1.225$$

$$k_2 = -1+\sqrt{\{2(1+R_e)+[2*F_{yb}(1+2R_e)D^2]/(3F_{em}l_m^2)\}}$$
$$k_2 = -1+\sqrt{\{2(1+1)+[2*70{,}000(1+2*1)0.242^2]/(3*4{,}000*1.5^2)\}} = 1.216$$

$$k_3 = -1+\sqrt{\{2(1+R_e)/R_e+2F_{yb}(2+R_e)D^2/(3F_{em}l_s^2)\}}$$
$$k_3 = -1+\sqrt{\{2(1+1)/1+2*70{,}000(2+1)0.242^2/(3*4{,}000*1.5^2)\}} = 1.216$$

Mode I_m
$Z = Dl_mF_{em}/R_d$ = 0.242*1.5*4,000/4 = 363#

Mode I_s
$Z = Dl_sF_{es}/R_d$ = 0.242*1.5*4,000/4 = 363#

Mode II
$Z = k_1Dl_sF_{es}/R_d$ = 1.225*0.242*1.5*4,000/4 = 445#

Mode III_m
$Z = k_2Dl_mF_{em}/[(1+2R_e)R_d]$= 1.216*0.242*1.5*4,000/[(1+2*1)*4] = 147#

Mode III_s
$Z = k_3Dl_sF_{em}/[(1+2R_e)R_d]$= 1.216*0.242*1.5*4,000/[(1+2*1)*4] = 147#

Mode IV
$Z = D^2/R_d\{\sqrt{[(2F_{em}F_{yb})/(3(1+R_e))]}\}$= $0.242^2/4\{\sqrt{[(2*4{,}000*70{,}000)/(3(1+1))]}\}$= 141#

Controlling mode is Mode IV allowable shear is 141#

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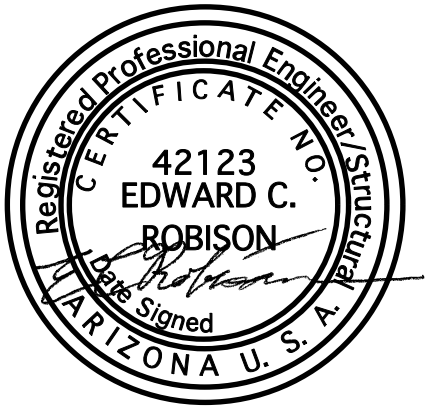
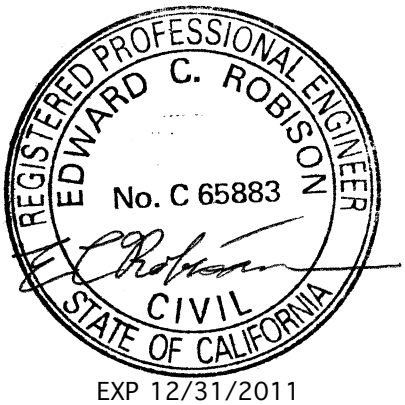


EXP 03/31/2014



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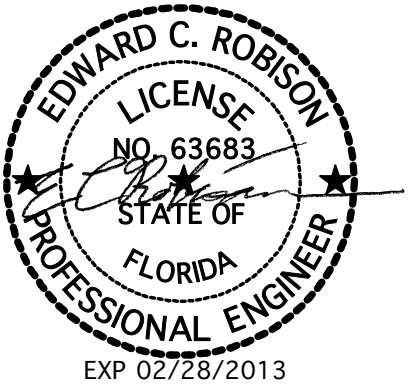

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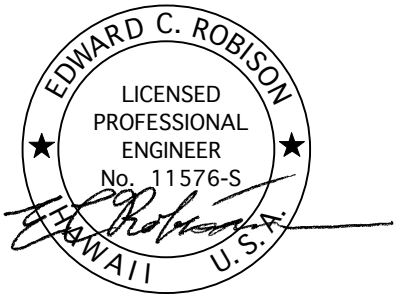

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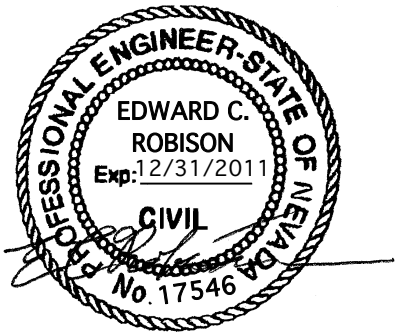

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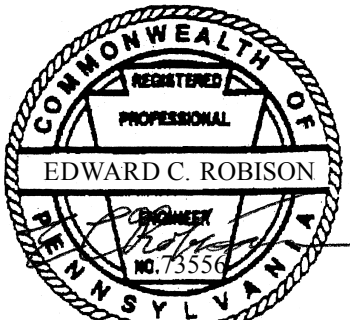

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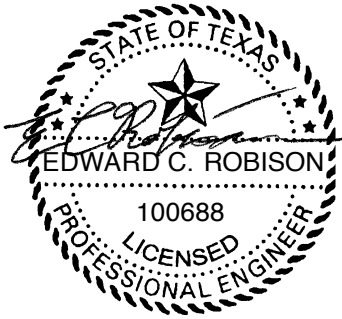

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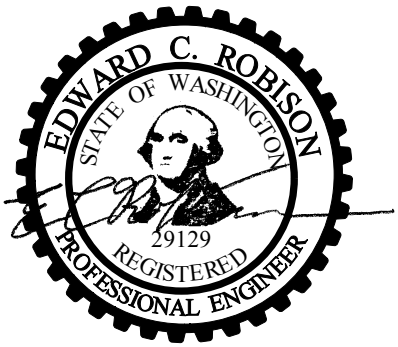

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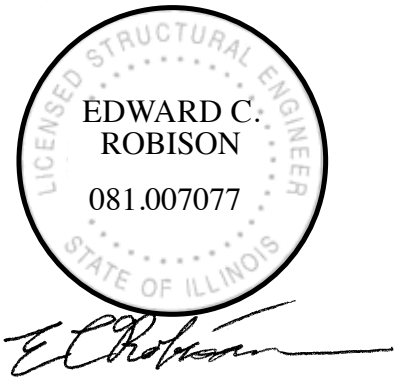

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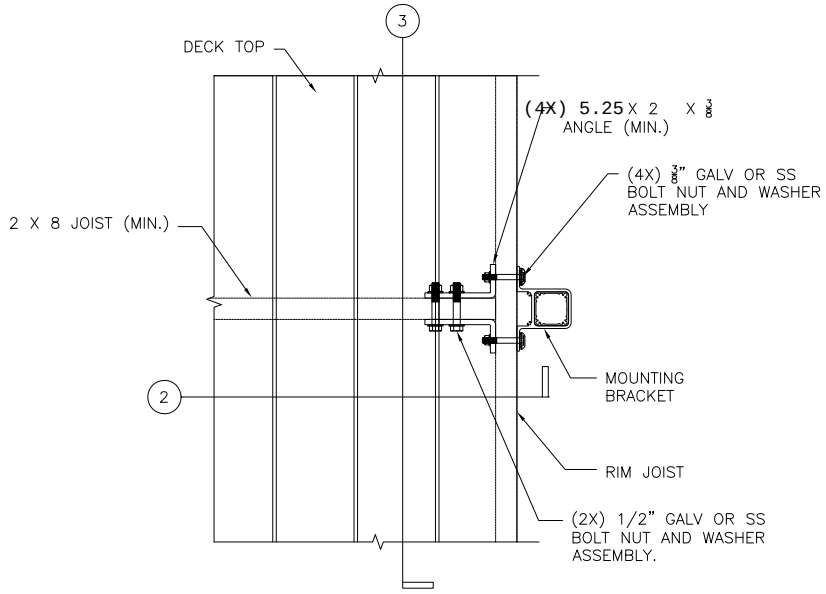
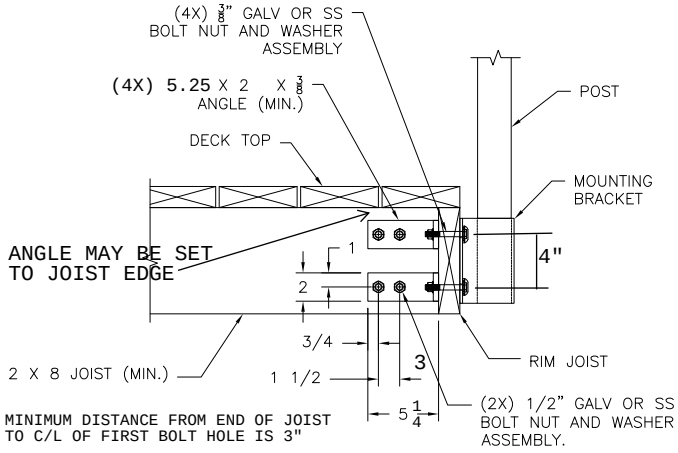
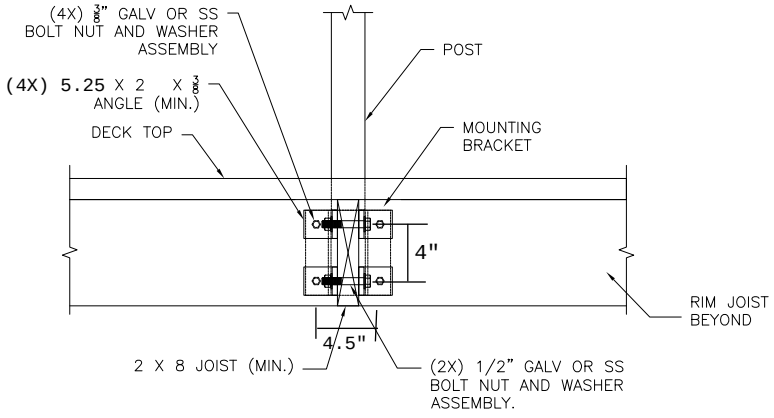


1 FACE MOUNT PERPENDICULAR TO JOISTS DETAIL



2 FACE MOUNT PERPENDICULAR TO JOISTS DETAIL



3 FACE MOUNT PERPENDICULAR TO JOISTS DETAIL

PRESSURE TREATED DOUG-FIR

FACE MOUNT PERPENDICULAR TO JOISTS BOLT CONDITION

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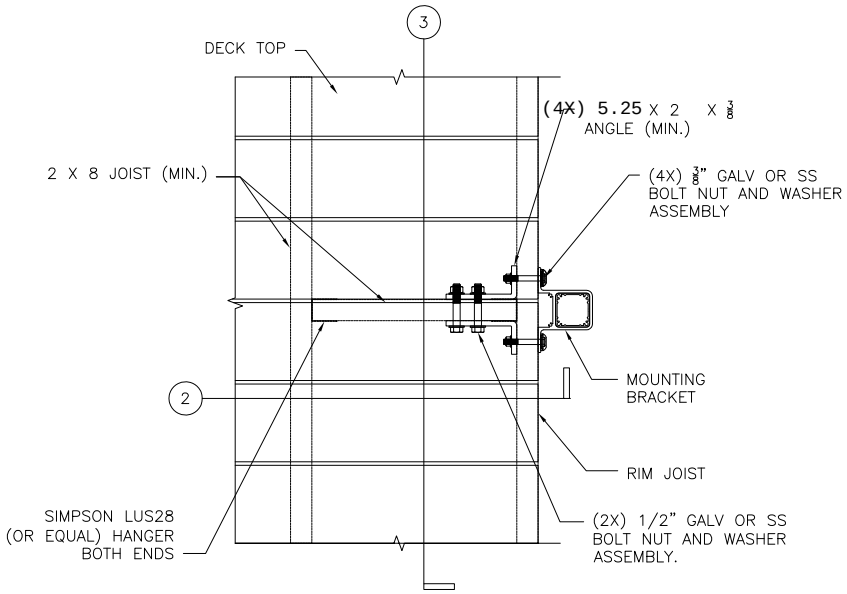
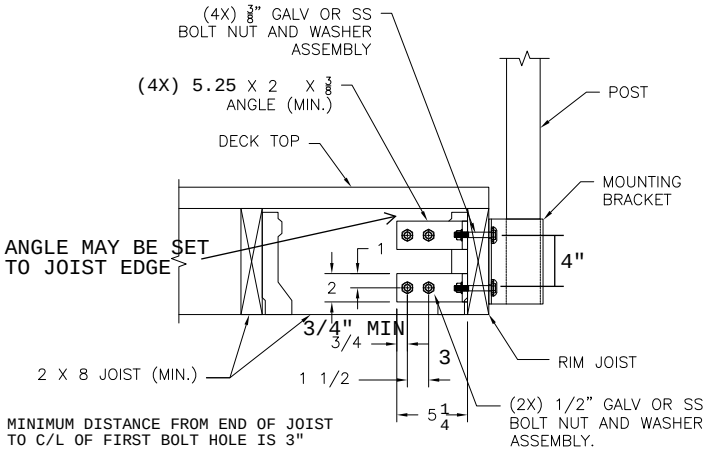


1 FACE MOUNT PARALLEL TO JOISTS DETAIL



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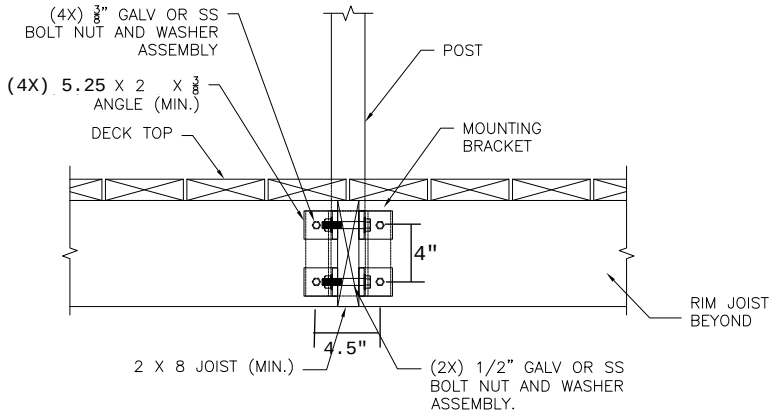

3 FACE MOUNT PARALLEL TO JOISTS DETAIL

PRESSURE TREATED DOUG-FIR

FACE MOUNT PARALLEL TO JOISTS
BOLT CONDITION

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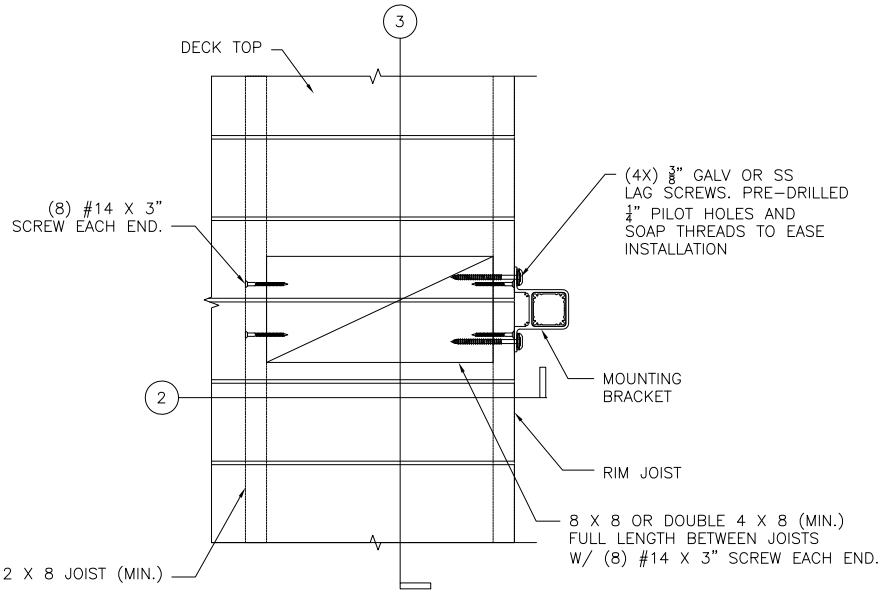
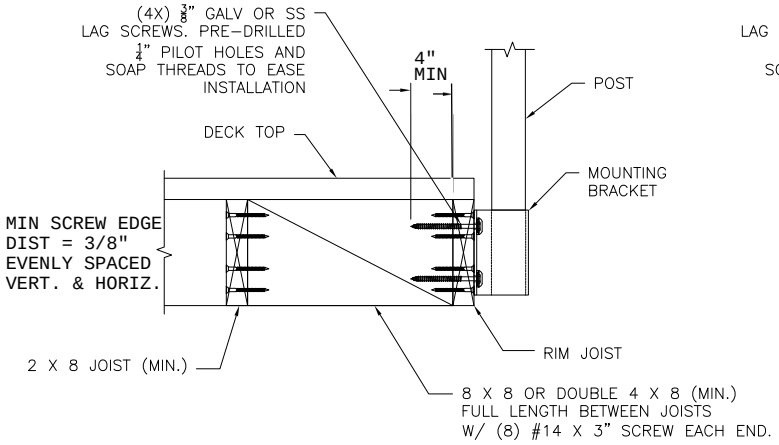
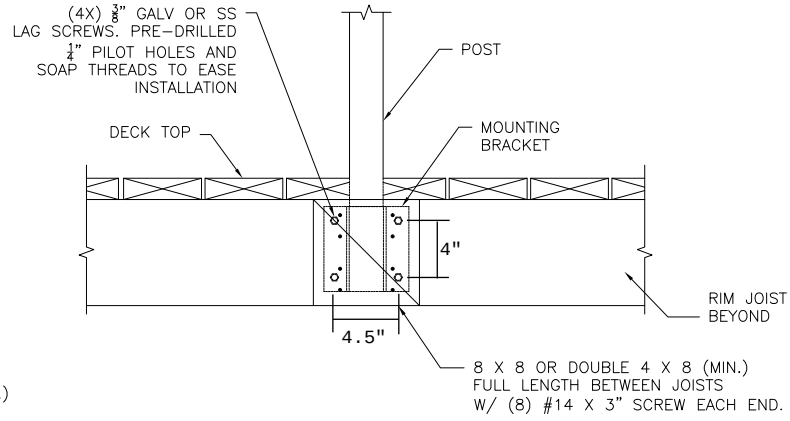


1 FACE MOUNT PARALLEL TO JOISTS DETAIL



2 FACE MOUNT PARALLEL TO JOISTS DETAIL



3 FACE MOUNT PARALLEL TO JOISTS DETAIL

PRESSURE TREATED DOUG-FIR

FACE MOUNT PARALLEL TO JOISTS

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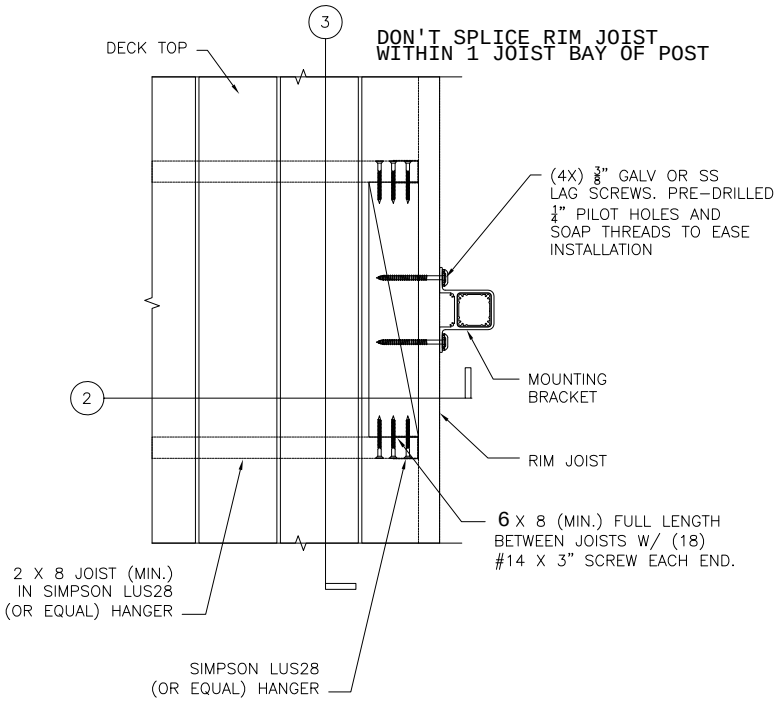
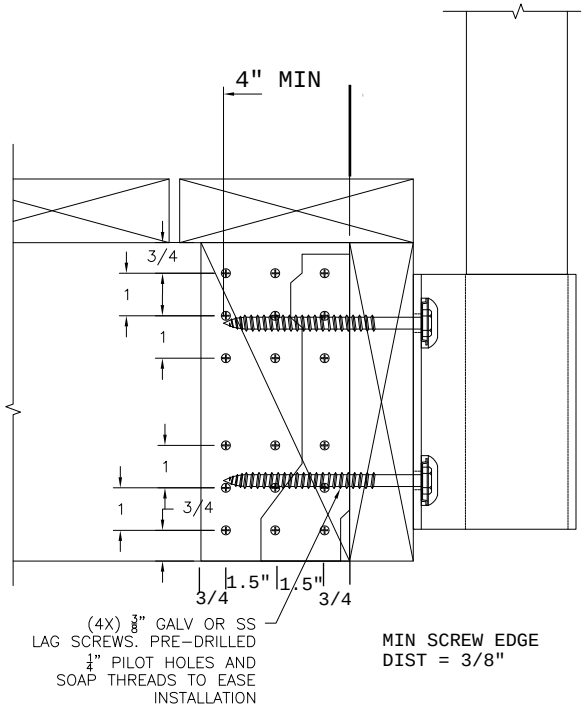
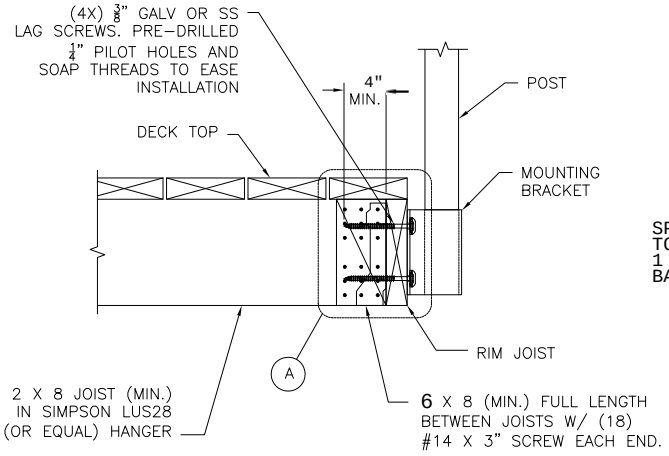


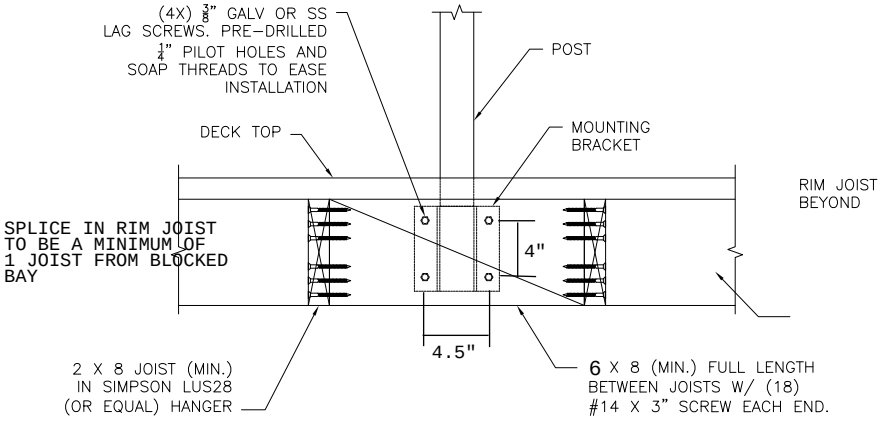
1 FACE MOUNT PERPENDICULAR TO JOISTS DETAIL



A SCREW PATTERN DETAIL



2 FACE MOUNT PERPENDICULAR TO JOISTS DETAIL



3 FACE MOUNT PERPENDICULAR TO JOISTS DETAIL

PRESSURE TREATED DOUG-FIR

FACE MOUNT PERPENDICULAR TO JOISTS

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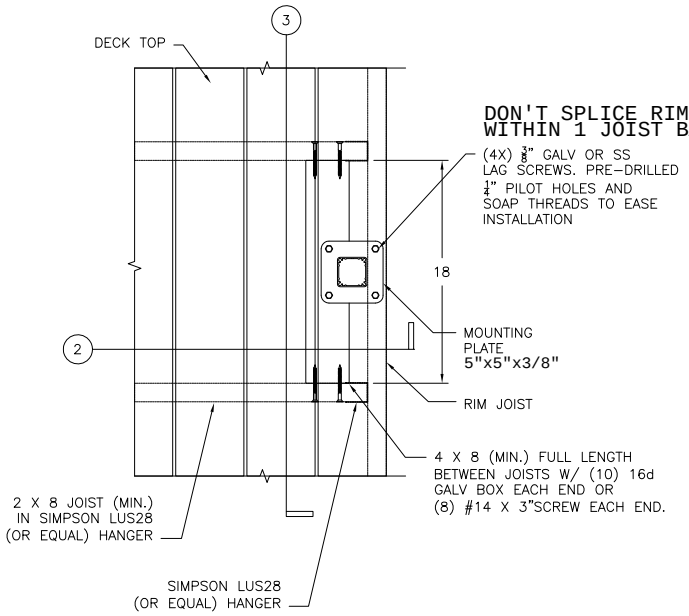
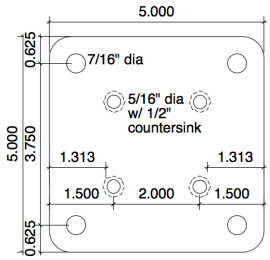
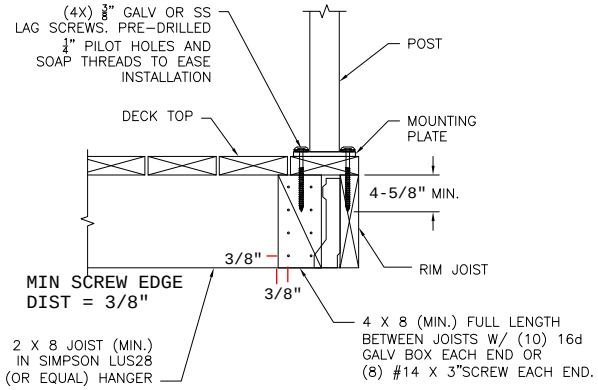


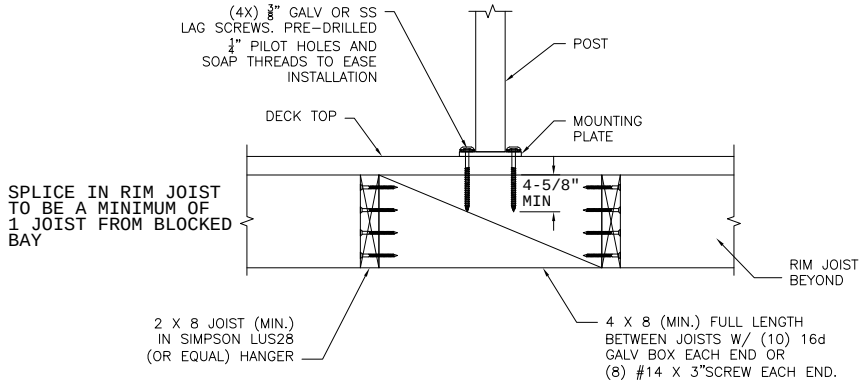
1 TOP MOUNT PERPENDICULAR TO JOISTS DETAIL



STANDARD BASE PLATE



2 TOP MOUNT PERPENDICULAR TO JOISTS DETAIL



3 TOP MOUNT PERPENDICULAR TO JOISTS DETAIL

PRESSURE TREATED HEM-FIR #2 OR BETTER

TOP MOUNT PERPENDICULAR TO JOISTS

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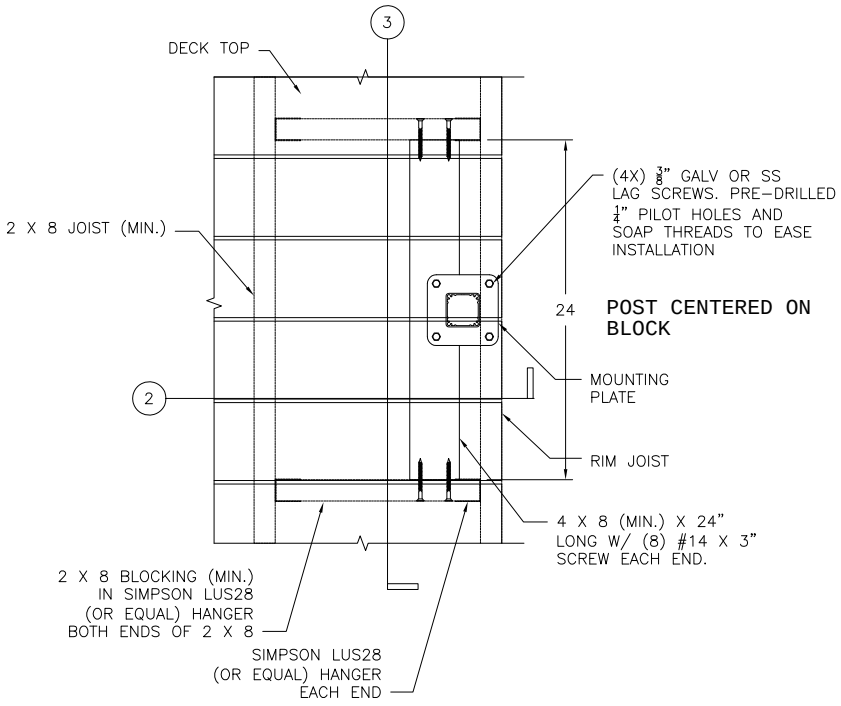
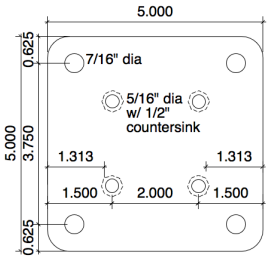
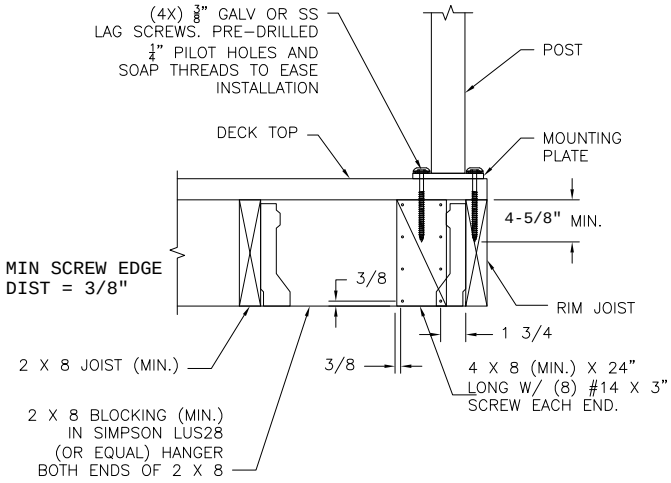


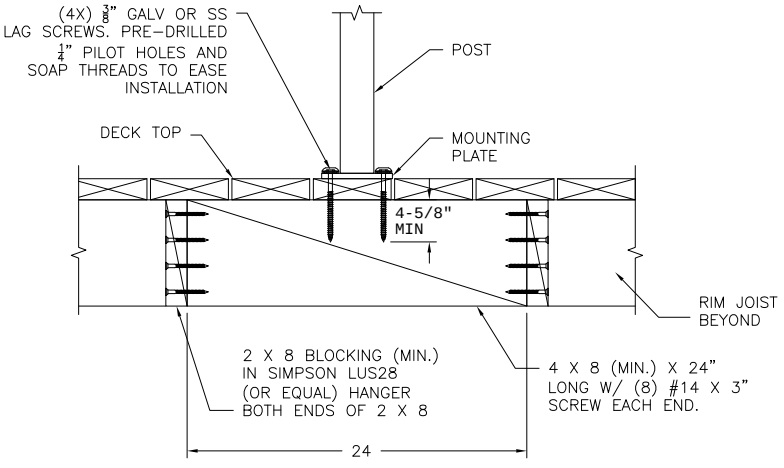


STANDARD BASE PLATE

1 TOP MOUNT PARALLEL TO JOISTS DETAIL



2 TOP MOUNT PARALLEL TO JOISTS DETAIL



3 TOP MOUNT PARALLEL TO JOISTS DETAIL

PRESSURE TREATED HEM-FIR #2 OR BETTER

TOP MOUNT PARALLEL TO JOISTS