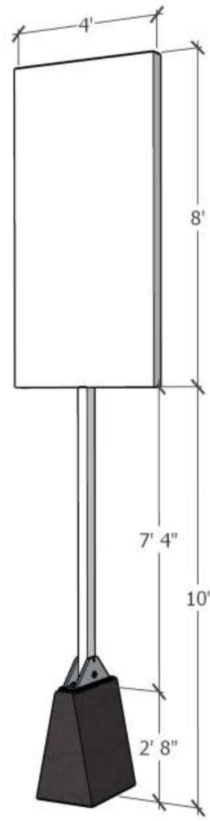
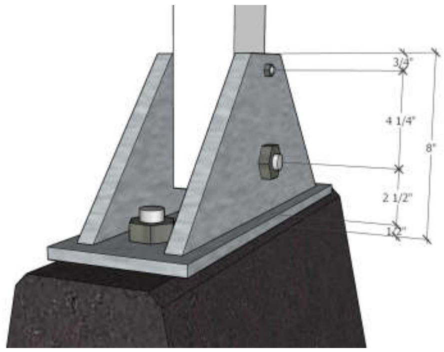
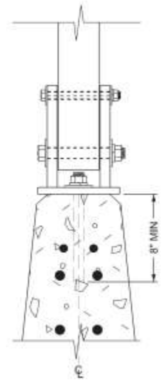
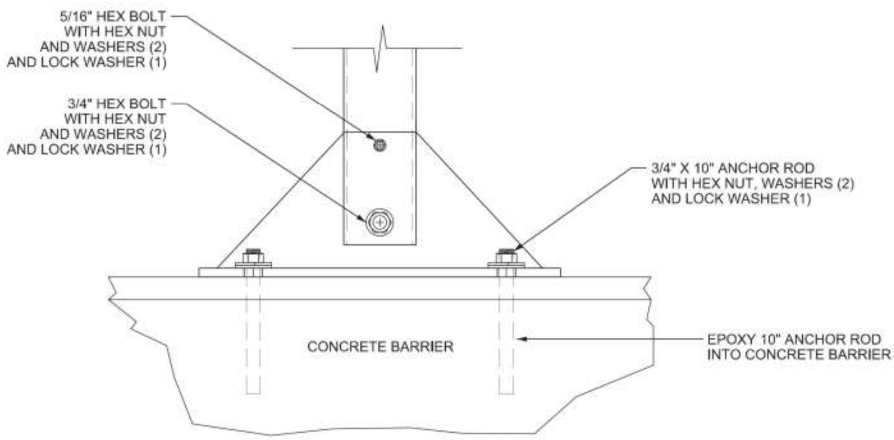
SUBJECT:
L Professional Opinion 20-08 – Utah Sign Support Bracket Sacrificial Pin Design for 115 mph Wind Speed

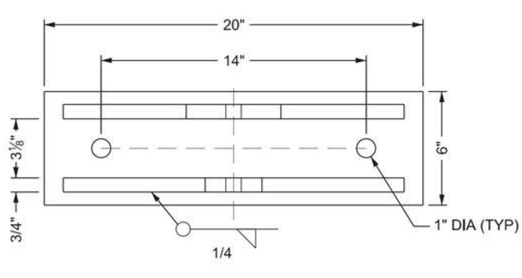
The presented worksheet calculates the force on the support pins of a sign panel system. An overview of the sign panel configuration and the support bracket details are presented in the following. Two different sized hex bolts are used at the bottom of the sign post to support the sign panel. The force on the bolts induced by the wind load on the panel is worked out.



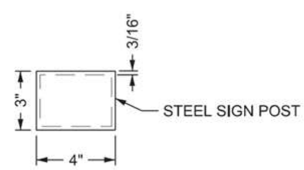




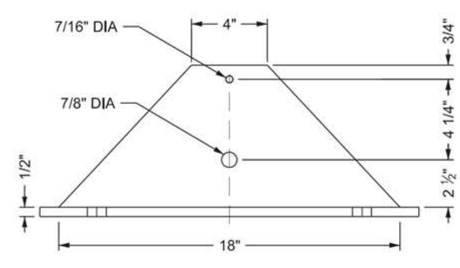




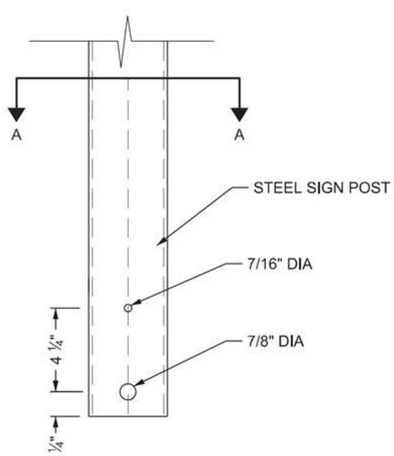
TOP VIEW



SECTION A-A



SIDE VIEW



Notes:
1. USE 32 SQ FT MAXIMUM SIGN PANEL AREA.
2. USE SIGN BASE IN MEDIAN APPLICATIONS ONLY, WITH MINIMUM SHOULDER WIDTH OF 4 FT AND MINIMUM BARRIER HEIGHT OF 32 INCH.
3. REFER TO STD DWG SN 2B FOR SIGN MOUNTING HEIGHT AND WIDTH REQUIREMENTS.
4. POST LENGTH DERTEMINED BY SIGN SIZE.
5. USE ASTM A36 STEEL FOR PIVOT SIGN BASE.
6.MEET ASTM A 123 GALVANIZING AFTER FABRICATION IS COMPLETE.
7. STEEL SIGN POST TO MEET STANDARD SPECIFICATION 02891.
8. USE BOLTS, NUTS AND WASHERS CONFORMING TO ASTM F3125, GRADE A325.
9. DURING INSTALLATION, IF REBAR IS ENCOUNDTERED, ADJUST THE BRACKET LOCATION LONGITUDINALLY. FILL ANY UNUSED HOLES WITH EPOXY.

1. General Information and Input

Geometry:

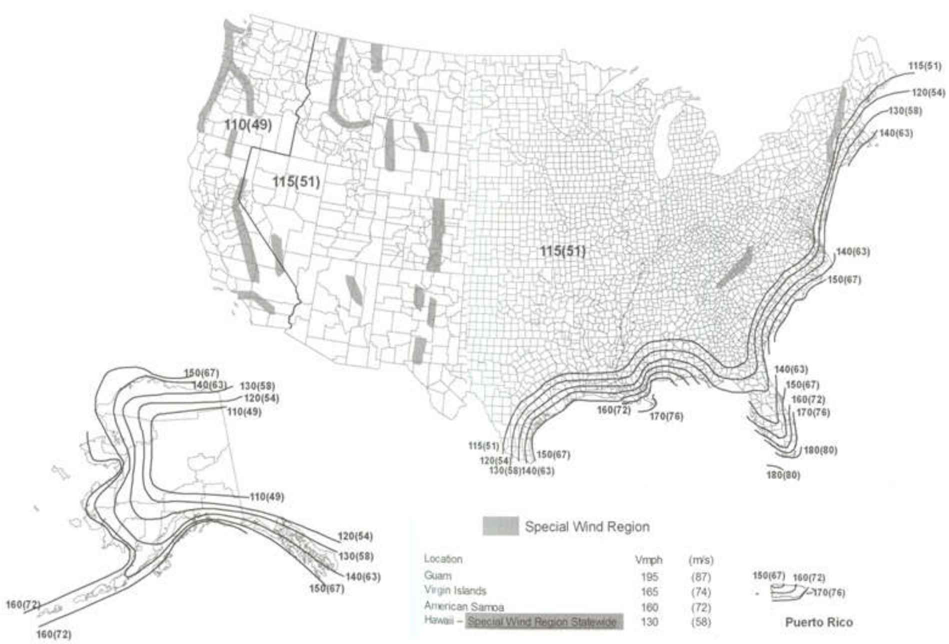
$H_{total} := 18\ ft$	*Distance from top of sign panel to ground*
$H_{barrier} := 32\ in$	*Height of concrete barrier*
$H_{panel} := 8\ ft$	*Height of sign panel*
$B_{panel} := 4\ ft$	*Width of sign panel*
$d_{bottom} := 3\ in$	*Distnace from center of bottom bolt to pivot base*
$s_{bolt} := 4.25\ in$	*Bolt spacing*

Bolt size (Grade A325):

$d_{bolt\_top} := \frac{5}{16}\ in$	*Top bolt diameter*
$d_{bolt\_bot} := \frac{3}{4}\ in$	*Bottom bolt diameter*

Design wind speed:

$V := 115\ mph$	*Design wind speed per AASHTO LRFD 3.8.1.1.2*



Notes:
1. Values are nominal design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00143, MRI = 700 Years).

*(*Figure taken from AASHTO LRFD)*

Figure 3.8.1.1.2-1—Design Wind Speed, *V*, in mph (m/s)

2. Wind load on sign panel (AASHTO LRFD)

Wind pressure on the sign panel:

$V = 115\ mph$ — *Design 3-second gust wind speed specified in article Table 3.8.1.1.2-1 (mph)*

$K_z := 1$ — *Pressure exposure and elevation coefficien specified in article Table C3.8.1.2.1-1*

$G := 0.85$ — *Gust effect factor specified in article Table 3.8.1.2.1-1*

$C_D := 1.2$ — *Drag coefficient specified in article Table 3.8.1.2.1-2*

$$P_z := 2.56 \cdot 10^{-6} \cdot V^2 \cdot K_z \cdot G \cdot C_D \cdot \left(\frac{1}{mph^2} \cdot ksf\right) = 0.035\ ksf$$ *Equation 3.8.1.2.1-1*

Resultant wind load on the sign panel:

$$P_u := P_z \cdot H_{panel} \cdot B_{panel} = 1.105\ kip$$

Table 3.8.1.1.2-1—Design 3-Second Gust Wind Speed for Different Load Combinations, *V*

Load Combination	3-Second Gust Wind Speed (mph), *V*
Strength III	Wind speed taken from Figure 3.8.1.1.2-1
Strength V	80
Service I	70
Service IV	0.75 of the speed used for the Strength III limit state

Table C3.8.1.2.1-1—Pressure Exposure and Elevation Coefficients, *Kz*

Structure Height, *Z* (ft)	Wind Exposure Category B	Wind Exposure Category C	Wind Exposure Category D
≤ 33	0.71	1.00	1.15
40	0.75	1.05	1.20
50	0.81	1.10	1.25
60	0.85	1.14	1.29
70	0.89	1.18	1.32
80	0.92	1.21	1.35
90	0.95	1.24	1.38
100	0.98	1.27	1.41
120	1.03	1.32	1.45
140	1.07	1.36	1.49
160	1.11	1.40	1.52
180	1.15	1.43	1.55
200	1.18	1.46	1.58
250	1.24	1.52	1.63
300	1.30	1.57	1.68

Table 3.8.1.2.1-1—Gust Effect Factor, *G*

Structure Type	Gust Effect Factor, *G*
Sound Barriers	0.85
All other structures	1.00

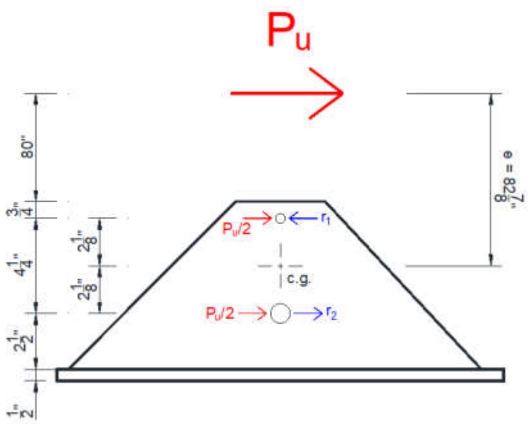
Table 3.8.1.2.1-2—Drag Coefficient, C_D

Component		Drag Coefficient, C_D Windward	Drag Coefficient, C_D Leeward
I-Girder and Box-Girder Bridge Superstructures		1.3	N/A
Trusses, Columns, and Arches	Sharp-Edged Member	2.0	1.0
	Round Member	1.0	0.5
Bridge Substructure		1.6	N/A
Sound Barriers		1.2	N/A

*(*Tables taken from AASHTO LRFD)*

3. Bolt shear force due to wind load (elastic method)

Assume the resultant wind load is acting as a point load at the center of the sign panel, the following eccentrically loaded bolt group configuration can be drawn.



Total load on bolt group:

$P_u = 1.105\ kip$

Load eccentricity:

$$e := H_{total} - H_{panel} - H_{barrier} - d_{bottom} - \frac{s_{bolt}}{2}$$

$e = 82.875\ in$

Direct shear force per bolt:

$$r_{pxu} := \frac{P_u}{2} = 0.553\ kip$$

$r_{pyu} := 0$

Additonal shear force due to eccentricity:

Distance from center of bolt to center of gravity

$x_{top} := 0\ in$ $\quad y_{top} := \frac{s_{bolt}}{2} = 2.125\ in$ *Top bolt*

$x_{bot} := 0\ in$ $\quad y_{bot} := \frac{s_{bolt}}{2} = 2.125\ in$ *Bottom bolt*

Polar moment of inertia:

$I_x := {y_{top}}^2 + {y_{bot}}^2 = 9.031\ in^2$

$I_y := {x_{top}}^2 + {x_{bot}}^2 = 0\ in^2$

$I_p := I_x + I_y = 9.031\ in^2$

Resultant force on bolts due to the eccentric load:

$$r_{mxu\_top} := \frac{P_u \cdot e \cdot y_{top}}{I_p} = 21.55\ kip \qquad r_{myu\_top} := \frac{P_u \cdot e \cdot x_{top}}{I_p} = 0\ kip$$ *Top bolt*

$$r_{mxu\_bot} := \frac{P_u \cdot e \cdot y_{bot}}{I_p} = 21.55\ kip \qquad r_{myu\_bot} := \frac{P_u \cdot e \cdot x_{bot}}{I_p} = 0\ kip$$ *Bottom bolt*

Total shear force on the bolts:

$$r_{u\_top} := \sqrt{\left(r_{pxu} - r_{mxu\_top}\right)^2 + \left(r_{pyu} + r_{myu\_top}\right)^2} = 21\ kip$$ *Top bolt*

$$r_{u\_bot} := \sqrt{\left(r_{pxu} + r_{mxu\_bot}\right)^2 + \left(r_{pyu} + r_{myu\_bot}\right)^2} = 22.1\ kip$$ *Bottom bolt*

4. Check bolt capacity

$\phi := 0.75$ *AISC J3.2*

Shear stress of bolts A S Table 3.2 :

$F_{nv\_n} := 48\ ksi$ *Nominal shear stress of A325 bolts, when threads are not excluded from shear planes*

$F_{nv\_x} := 60\ ksi$ *Nominal shear stress of A325 bolts, when threads are excluded from shear planes*

ominal area of bolts:

$$A_{b\_top} := \frac{\pi \cdot d_{bolt\_top}^{\ 2}}{4} = 0.077\ in^2$$ *Top bolt*

$$A_{b\_bot} := \frac{\pi \cdot d_{bolt\_bot}^{\ 2}}{4} = 0.442\ in^2$$ *Bottom bolt*

ominal shear strength of bolts double shear :

Threads not excluded *from shear planes:*

$R_{n\_top\_n} := 2 \cdot F_{nv\_n} \cdot A_{b\_top} = 7.36\ kip$ *Top bolt*

$R_{n\_bot\_n} := 2 \cdot F_{nv\_n} \cdot A_{b\_bot} = 42.41\ kip$ *Bottom bolt*

Threads excluded *from shear planes:*

$R_{n\_top\_x} := 2 \cdot F_{nv\_x} \cdot A_{b\_top} = 9.2\ kip$ *Top bolt*

$R_{n\_bot\_x} := 2 \cdot F_{nv\_x} \cdot A_{b\_bot} = 53.01\ kip$ *Bottom bolt*

Design shear strength of bolts double shear :

Threads not excluded *from shear planes:*

$\phi \cdot R_{n\_top\_n} = 5.52\ kip$ Shear force on top bolt $r_{u\_top} = 21\ kip$

$\phi \cdot R_{n\_bot\_n} = 31.81\ kip$ Shear force on bottom bolt $r_{u\_bot} = 22.1\ kip$

Threads excluded *from shear planes:*

$\phi \cdot R_{n\_top\_x} = 6.9\ kip$ Shear force on top bolt $r_{u\_top} = 21\ kip$

$\phi \cdot R_{n\_bot\_x} = 39.76\ kip$ Shear force on bottom bolt $r_{u\_bot} = 22.1\ kip$