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6593 Riverdale St.
San Diego, CA 92120

619-727-4800

Structural Calculations
for
Vibration Isolation Roof Curb CBISC-07

Prepared for:

PROVENT

3847 Wabash Drive
Mira Loma, CA 91725

Date: February 9, 2018

Project Number: PV1802

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Client: ProVent PV1802
Project: CBISC-07 curb for ZF180 Unit
Description: Upper curb rail design

Curb Information

Hcurb =	6	in	(Height from spring isolator to top of upper rail curb)
Lcurb =	114.75	in	(Length of curb)
wcurb =	83.5	in	(Width of curb)
WGTcurb =	599.5	lbs	(Weight of curb+10% for pitched roof)

Unit Information

WGTunit =	2281	lbs	(Weight of Unit + accessories)
Wtmax =	613	lbs	(Maximum corner weight)
Wtmin =	528	lbs	(Minimum corner weight)
Hunit =	48.625	in	(Height of unit above curb)
Hcm =	24.3125	in	(Height from top of curb to center of mass of unit)
Lunit =	125.25	in	(Length of unit)
Wunit =	92	in	(Width of unit)

Seismic Loading - 2015 IBC

Ss =	2.850		(Worst case for majority of CA - Design Category D)
Fa =	1.000		(Interpolated from Table 11.4-1 ASCE 7-10)
Sms =	2.850		(Fa*Ss)
Sds =	1.900		(2/3*Sms)
Ip =	1.25		(Importance Factor Category III Building)
Fpmax =	3.800	Wp	(1.6*Sds*Ip)*Wp
FpmaxASD =	6067	lbs	(0.7*Fpmax) FpmaxASD = 7662 lbs
	(unit only)		(unit and curb)

Wind Loading - 2015 IBC

*** Exposure Category C ***

Kz =	1.13		(For 60 ft roof height, Exposure C - Table 29.3-1 ACSE 7-10)
Kzt =	1.0		(No topographic effects assumed for rooftop mounted units)
Kd =	0.90		(Directionality factor Table 26.6-1 ASCE 7-10)
V =	115		(Max wind velocity, mph for Cat III & IV bldgs Exp. Cat C)
$GCr_{(horiz)}$ =	1.9		(Refer pg. 309 ASCE 7-10)
$GCr_{(vert)}$ =	1.5		(Refer pg. 309 ASCE 7-10)
qz	34.4	psf	= 0.00256*Kz*Kzt*Kd*V^2 (Eq. 29.3-1 ASCE 7-10)
$F_{h\ ASD\ trans}$ =	1865	lbs	= 0.6*qz*GCr*Lunit*(Hunit+Hcurb) (Eq. 29.5-2)
$F_{h\ ASD\ long}$ =	1370	lbs	= 0.6*qz*GCr*Wunit*(Hunit+Hcurb)
$F_{vert\ ASD}$ =	2480	lbs	= 0.6*qz*GCr*Lunit*Wunit (Eq. 29.5-3)

Curb Loading

Transverse:

$Compression_{SEISMIC}$ =	3319	lbs	=[FpmaxASD*Hcm+2*(1+0.14S_{DS})*Wtmax*wcurb]/wcurb
$Tension_{SEISMIC}$ =	2557	lbs	= $Comp_{SEISMIC}$-(0.6-0.14S_{DS})*WGTunit
$Compression_{WIND}$ =	39	lbs	=[$F_{h\ transASD}$*Hcm+2*0.6*Wtmax*wcurb-$F_{vertASD}$*wcurb/2]/wcurb
$Tension_{WIND}$ =	1150	lbs	= $Comp_{WIND}$+Fvert-0.6*WGTunit

---> Negative values indicate Compression load rather than Tension.

Longitudinal:

$Compression_{SEISMIC}$ =	2838	lbs	=[FpmaxASD*Hcm+2*(1+0.14*S_{DS})*Wtmax*Lcurb]/Lcurb
$Tension_{SEISMIC}$ =	2076	lbs	= $Comp_{SEISMIC}$-(0.6-0.14S_{DS})*WGTunit
$Compression_{WIND}$ =	-214	lbs	=[$F_{h\ transASD}$*Hcm+2*0.6*Wtmax*Lcurb-$F_{vertASD}$*Lcurb/2]/Lcurb
$Tension_{WIND}$ =	897	lbs	= $Comp_{WIND}$+Fvert-0.6*WGTunit

---> Negative values indicate Compression load rather than Tension.

Governing Reactions:

Transverse:	$Comp_{MAX}$ =	3319	lbs	---> Along long edge of curb.
(on long edge)	$Tens_{MAX}$ =	2557	lbs	---> Along long edge of curb.
Longitudinal:	$Comp_{MAX}$ =	2838	lbs	---> Along short edge of curb.
(on short edge)	$Tens_{MAX}$ =	2076	lbs	---> Along short edge of curb.

---> Negative values indicate Compression load rather than Tension.

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Curb Design

Fy = 50 ksi Fu = 65 ksi t = 0.0713 [14 Gauge]
E = 29500 ksi

Calculate Section Properties of Curb (curb assumed to be symetric C-Section without Lips)

A'=	[6.000]	in	a =	5.644 in	= A'-(2r+t)
B'=	[1.500]	in	a'=	5.929 in	= A'-t
C'=	[0.000]	in (0 if no lips)	b =	1.322 in	= B'-[r+t/2+α(r+t/2)]
α =	[0.000]	(0 - no Lip; 1 w/ lip)	b'=	1.464 in	= B'-(t/2+αt/2)
R =	0.1069	(Inside bend radius)	c =	0.000 in	= α[C'-(r+t/2)]
t =	0.0713	in	c'=	0.000 in	= α(C'-t/2)
r'=	0.143	in = R+t/2	u =	0.224 in	= πr/2
x =	0.246	in (Distance between centroid and web centerline)			
Ix =	2.996	in (Moment of Inertia about X-Axis)			
Iy =	0.112	in (Moment of Inertia about Y-Axis)			
A =	0.62	in^2			
rx =	2.19	in			
ry =	0.423	in			
rmin =	0.423	in			

Axial Compression

Pu = 3.034 k (Max Axial Comp) Ω_c = 1.80
Pn/Ωc = 3.549 k
Fe = 11.70 ksi
λc = 2.07
Fn = 10.26 ksi
Ly = 83.5 in Lateral unbraced length
k_yL_y/r_y = 158 (assume k=0.8)

$$\frac{P_n}{\Omega_c} = \frac{F_nA}{\Omega_c} \qquad If\ \lambda_c \le 1.5;\ F_n = \left(0.658^{\lambda_c{}^2}\right)F_y \qquad If\ \lambda_c > 1.5;\ F_n = \frac{0.877}{\lambda_c{}^2}F_y \qquad \lambda_c = \sqrt{\frac{F_y}{F_e}} \qquad F_e = \frac{\pi^2E}{\left(kl/r\right)^2}$$

Compression Check = **O.K.**

Check Web Crippling

h = 6 in -- Check limits: C = 7.50
t = 0.0713 in h/t = 84.15 ≤ 200 C_R = 0.08
N = 7.00 N/t = 98.18 ≤ 210 C_N = 0.12
Ωw = 1.75 N/h = 1.167 ≤ 2.0 C_h = 0.048
P_n = 1.883 k R/t = 1.50 ≤ 12.0
P_n/Ω_w = 1.076 k
Long side: Pu_{Trans} = 1.106 k **web stiffener REQ'D** # clips = 3
Short side: Pu_{Long} = 0.946 k **O.K.** # clips = 3

(See table C3.4.1-2, fastened to support, two flange, end loading)

$$P_n = Ct^2F_y\sin(90)\left(1 - C_R\sqrt{\frac{R}{t}}\right)\left(1 + C_N\sqrt{\frac{N}{t}}\right)\left(1 - C_h\sqrt{\frac{h}{t}}\right)$$

Check Web Stiffener 16Ga x 3/4in x 7in (C-channel)

width of stiffener = 7.000 in ts = 0.0566 [16 Gauge]
web of stiff. w = 6.717 in Rs = 0.0849 in
***Check w/ts ≤ 1.28√E/Fys Ω_c = 1.70
w/ts = 118.675
1.28√(E/Fys) = 31.091 --> w/ts over limit Use C3.7.2

$$P_n = 0.7\left(P_{wc} + A_eF_y\right) \ge P_{wc}$$

Pwc = 1.883 k Ae = 0.380 in^2
Pn = 14.625 k
Pn/Ω_c = 8.603 k **O.K.**

Corner Connections **(Use 1/4" φ SAE Grade 8 bolts w/ 1/4-20-UNC Threaded insert)**

Tcrnmax = 1517 lbs Max($F_{pmaxASD}$/4 -OR- $Fh_{ASDtrans}$/4 corner connections)
Vcrnmax = 1278 lbs (Max Ten/2 corner connections per side)

Bolt:	Tall =	[5000] lbs	Vall =	[4470] lbs	
Threaded Insert:	Tall =	[4289] lbs	Vall =	[661] lbs	

# of Bolts required for Tension = 0.4 **(By Inspection, Threaded Inserts Control)**
# of Bolts required for Shear = 1.9 ***If combined fails:
# of Bolts Used = 2.0 USE --> 3.0
Check Combined Stress in Bolts & Inserts: 1.144 N.G. StressComb = 0.763 O.K.

Check 1/8" welded connection <--- USE WELD Ω = 2.35
Assume L/t > 25: 25*t = 1.783 in
Lreq'd = 0.864 in

$$P_n/\Omega = \frac{1}{\Omega}0.75tLF_u \ge V_{req} \qquad L_{req'd} = \frac{V_{req}\Omega}{0.75tF_u}$$

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Connection Curb Clip to Upper Rail | #10 SMS screws | Ω = 3.0

t1 = 0.0713 in (hold down clip thickness - 14 Ga) | Fu1 = 65 ksi

t2 = 0.0713 in (upper rail thickness) | Fu2 = 65 ksi

d = 0.190 in (screw diameter) | dw = 0.375 in (nom. washer diameter)

t2/t1 = 1.0

For t2/t1 ≤ 1.0: | Pns = 2266 #

Shear: $P_{ns} = 4.2F_{u2}\sqrt{t_2^3 d}$ 2.27 k

$P_{ns} = 2.7t_1 dF_{u1}$ 2.38 k

$P_{ns} = 2.7t_2 dF_{u2}$ 2.38 k

For t2/t1 ≥ 2.5: | Pns = 2377 #

$P_{ns} = 2.7t_1 dF_{u1}$ 2.38 k

$P_{ns} = 2.7t_2 dF_{u2}$ 2.38 k

Pns/Ω = 755 #

Pss/Ω = 540 # <- Controls

Tension: Pnot = 0.748 k (screw pull-out strength) $P_{not} = 0.85t_c dF_{u2}; \quad t_c = \min(t_1, t_2)$

Pnov = 2.607 k (screw pull-over strength) $P_{nov} = 1.5t_1 d_w F_{u1}$

Pts/Ω = 249 # <- Controls

Pts/Ω = 820 # (full tensile screw capacity)

	Shear (k)	# clips	V_{clip} (k)	V_{allow} (k)	# screws	spacing		
Long side:	3.03	3	1.01	2.160	4	2.0 in	3 clips w/ 4 - #10 SMS screws	**O.K.**
Short side:	3.03	3	1.01	2.160	4	2.0 in	3 clips w/ 4 - #10 SMS screws	**O.K.**

clip width = 7.00 in | clip height = 2.5 in

min spacing = 0.57 in O.K. | edge distance = 0.5 in (min. 1.5d)

Check Block shear rupture: | thinnest part = 0.0713 AISI BSR applies

Fy = 50 ksi | Ω = 2.22 bolt/screw connection

Agv = 0.428 in^2 | Anv = 0.380 in^2 | Ant = 0.082 in^2

Rn/Ω = 8.192 k $R_n = 0.6F_y A_{gv} + F_u A_{nt} \le 0.6F_u A_{nv} + F_u A_{nt}$

BSR O.K. (AISI Sect. E5.3)

Curb Loads (copied from above)

Transverse: (on long edge)	$Comp_{MAX}$ =	3319	lbs
	$Tens_{MAX}$ =	2557	lbs
	$Shear_{MAX}$ =	3034	lbs
Longitudinal: (on short edge)	$Comp_{MAX}$ =	2838	lbs
	$Tens_{MAX}$ =	2076	lbs
	$Shear_{MAX}$ =	3034	lbs

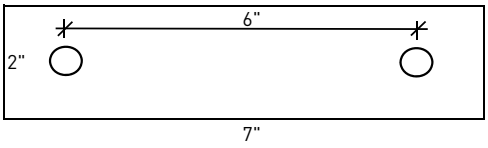
Loads at each JQA Isolator

Transverse loading: (on long edge)	$Comp_{MAX}$ =	1106.3	lbs
	$Tens_{MAX}$ =	852.3	lbs
# isolators: 3	$Shear_{MAX}$ =	1011.2	lbs
Longitudinal loading: (on short edge)	$Comp_{MAX}$ =	945.9	lbs
	$Tens_{MAX}$ =	691.9	lbs
# isolators: 3	$Shear_{MAX}$ =	1011.2	lbs

Max compression force on isolator: 1.106 k ≤ 1.660 k **O.K.**

Max uplift on isolator: 0.852 k

Max shear on isolator: 1.011 k



Forces on top bolt:

d_b = 0.375 in

upper rail, t = 0.0713 in

Tension = 0.852 k

Shear = 1.011 k

Shear on curb rail: $P_n = teF_u$ Ω = 2.00 (Appendix A, Section E3.1 AISI)

Pn/Ω = 4.635 k e = 1.0 in

Shear O.K.

Net section rupture: $P_n = A_n F_t$ Ω = 2.22 (Appendix A, Section E3.2 AISI)

Pn/Ω = 4.989 k An = 0.116 in

N.S.R. O.K. $F_t = (0.1 + 3d/s)F_u \le F_u =$ 43.063 ksi

Bolt Bearing Strength: $P_n = Cm_f dtF_u$ Ω = 2.50 (Section E3.3.1 AISI)

Pn/Ω = 2.086 k d/t = 5.26

Bearing O.K. C = 3.00 mf = 1.00

Shear and tension in bolt: (Appendix A, Section E3.4 AISI)

Tension $P_{nt} = A_b F_{nt}$ Fnt = 40.5 ksi A_b = 0.1104 in^2

Pnt/Ω = 1.988 k **Bolt tension O.K.** Ωt = 2.25 (Table E3.4-1, AISI)

Shear $P_{nv} = A_b F_{nv}$ Fnv = 24.0 ksi Ωv = 2.40 (Table E3.4-1, AISI)

Pnv/Ω = 1.104 k **Bolt shear O.K.**

$F'_{nt} = 1.3F_{nt} - \frac{\Omega F_{nt}}{F_{nv}} f_v \le F_{nt}$ fv = 9.16 ksi O.K.

Combined Not Applicable F'nt = 15.57 ksi Fnv/Ω = 10.00 ksi

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Client: ProVent PV1802
Project: CBISC-07 curb for ZF180 Unit
Description: Base curb design

Curb Information

Hcurb =	25	in	(Height from support structure to top of curb)
Lcurb =	115.25	in	(Length of curb)
wcurb =	84	in	(Width of curb)
WGTcurb =	599.5	lbs	(Weight of curb+10% for pitched roof)

Unit Information

WGTunit =	2281	lbs	(Weight of Unit + accessories)
Wtmax =	613	lbs	(Maximum corner weight)
Wtmin =	528	lbs	(Minimum corner weight)
Hunit =	48.625	in	(Height of unit above curb)
Hcm =	34.3125	in	(Height from top of curb to center of mass of unit)
Lunit =	125.25	in	(Length of unit)
Wunit =	92	in	(Width of unit)

Seismic Loading - 2015 IBC

Ss =	2.850		(Worst case for majority of CA - Design Category D)
Fa =	1.000		(Interpolated from Table 11.4-1 ASCE 7-10)
Sms =	2.850		(Fa*Ss)
Sds =	1.900		(2/3*Sms)
Ip =	1.25		(Importance Factor Category III Building)
Fpmax =	3.800	Wp	(1.6*Sds*Ip)*Wp
FpmaxASD =	6067	lbs	(0.7*Fpmax) FpmaxASD = 7662 lbs
	(unit only)		(unit and curb)

Wind Loading - 2015 IBC

*** Exposure Category C ***

Kz =	1.13		(For 60 ft roof height, Exposure C - Table 29.3-1 ACSE 7-10)
Kzt =	1.0		(No topographic effects assumed for rooftop mounted units)
Kd =	0.90		(Directionality factor Table 26.6-1 ASCE 7-10)
V =	115		(Max wind velocity, mph for Cat III & IV bldgs Exp. Cat C)
$GCr_{(horiz)}$ =	1.9		(Refer pg. 309 ASCE 7-10)
$GCr_{(vert)}$ =	1.5		(Refer pg. 309 ASCE 7-10)
qz	34.4	psf	= 0.00256*Kz*Kzt*Kd*V^2 (Eq. 29.3-1 ASCE 7-10)
$F_{h\ ASD\ trans}$ =	2514	lbs	= 0.6*qz*GCr*Lunit*(Hunit+Hcurb) (Eq. 29.5-2)
$F_{h\ ASD\ long}$ =	1846	lbs	= 0.6*qz*GCr*Wunit*(Hunit+Hcurb)
$F_{vert\ ASD}$ =	2480	lbs	= 0.6*qz*GCr*Lunit*Wunit (Eq. 29.5-3)

Curb Loading

Transverse:

$Compression_{SEISMIC}$ =	4031	lbs	=[FpmaxASD*Hcm+2*(1+0.14S_{DS})*Wtmax*wcurb]/wcurb
$Tension_{SEISMIC}$ =	3269	lbs	= $Comp_{SEISMIC}$-(0.6-0.14S_{DS})*WGTunit
$Compression_{WIND}$ =	523	lbs	=[$F_{h\ transASD}$*Hcm+2*0.6*Wtmax*wcurb-$F_{vertASD}$*wcurb/2]/wcurb
$Tension_{WIND}$ =	1634	lbs	= $Comp_{WIND}$+Fvert-0.6*WGTunit

---> Negative values indicate Compression load rather than Tension.

Longitudinal:

$Compression_{SEISMIC}$ =	3359	lbs	=[FpmaxASD*Hcm+2*(1+0.14*S_{DS})*Wtmax*Lcurb]/Lcurb
$Tension_{SEISMIC}$ =	2597	lbs	= $Comp_{SEISMIC}$-(0.6-0.14S_{DS})*WGTunit
$Compression_{WIND}$ =	45	lbs	=[$F_{h\ transASD}$*Hcm+2*0.6*Wtmax*Lcurb-$F_{vertASD}$*Lcurb/2]/Lcurb
$Tension_{WIND}$ =	1157	lbs	= $Comp_{WIND}$+Fvert-0.6*WGTunit

---> Negative values indicate Compression load rather than Tension.

Governing Reactions:

Transverse:	$Comp_{MAX}$ =	4031	lbs	---> Along long edge of curb.
(on long edge)	$Tens_{MAX}$ =	3269	lbs	---> Along long edge of curb.
Longitudinal:	$Comp_{MAX}$ =	3359	lbs	---> Along short edge of curb.
(on short edge)	$Tens_{MAX}$ =	2597	lbs	---> Along short edge of curb.

---> Negative values indicate Compression load rather than Tension.

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Curb Design

Fy = 50 ksi Fu = 65 ksi t = 0.1017 [12 Gauge]
E = 29500 ksi

Calculate Section Properties of Curb (curb assumed to be symetric C-Section without Lips)

A'=	25.000 in		a =	24.492 in	= A'-(2r+t)
B'=	2.000 in		a'=	24.898 in	= A'-t
C'=	0.000 in	(0 if no lips)	b =	1.746 in	= B'-[r+t/2+α(r+t/2)]
α =	0.000	(0 - no Lip; 1 w/ lip)	b'=	1.949 in	= B'-(t/2+αt/2)
R =	0.1525	(Inside bend radius)	c =	0.000 in	= α[C'-(r+t/2)]
t =	0.1017 in		c'=	0.000 in	= α(C'-t/2)
r'=	0.203 in	= R+t/2	u =	0.319 in	= πr/2

x = 0.133 in (Distance between centroid and web centerline)
Ix = 189.589 in (Moment of Inertia about X-Axis)
Iy = 0.451 in (Moment of Inertia about Y-Axis)
A = 2.91 in^2
rx = 8.07 in
ry = 0.393 in
rmin = 0.393 in

Axial Compression

Pu = 3.034 k (Max Axial Comp) Ω_c = 1.80
Pn/Ωc = 7.266 k
Fe = 5.12 ksi
λc = 3.12
Fn = 4.49 ksi
Ly = 117.25 in Lateral unbraced length
k_yL_y/r_y = 238 (assume k=0.8)

$$\frac{P_n}{\Omega_c}=\frac{F_nA}{\Omega_c} \qquad If\ \lambda_c \le 1.5;\ F_n=\left(0.658^{\lambda_c{}^2}\right)F_y \qquad If\ \lambda_c > 1.5;\ F_n=\frac{0.877}{\lambda_c{}^2}F_y$$

$$\lambda_c=\sqrt{\frac{F_y}{F_e}} \qquad F_e=\frac{\pi^2E}{\left(kl/r\right)^2}$$

Compression Check = **O.K.**

Check Web Crippling

h = 25 in -- Check limits: C = 4.00
t = 0.1017 in h/t = 245.82 ≤ 200 C_R = 0.14
N = 7.00 N/t = 68.83 ≤ 210 C_N = 0.35
Ωw = 1.75 N/h = 0.28 ≤ 2.0 C_h = 0.02
Pn = 4.106 k R/t = 1.50 ≤ 9.0 (See table C3.4.1-2, fastened to support, one flange, end loading)
Pn/Ωw = 2.346 k
Long side: Pu_{Trans} = 1.344 k **O.K.** # clips = 3
Short side: Pu_{Long} = 1.679 k **O.K.** # clips = 2

$$P_n=Ct^2F_y\sin(90)\left(1-C_R\sqrt{\frac{R}{t}}\right)\left(1+C_N\sqrt{\frac{N}{t}}\right)\left(1-C_h\sqrt{\frac{h}{t}}\right)$$

*****h/t > 200; use web stiffeners**

Check Web Stiffener N/A

width of stiffener = 7.000 in ts = 0.0566 [16 Gauge]
web of stiff. w = 6.717 in Rs = 0.0849 in
***Check w/ts ≤ 1.28√E/Fys Ωc = 1.70

w/ts = 118.675
1.28√(E/Fys) = 31.091 --> w/ts over limit Use C3.7.2

$$P_n=0.7\left(P_{wc}+A_eF_y\right)\ge P_{wc}$$

Pwc = 4.106 k Ae = 0.380 in^2
Pn = 16.181 k
Pn/Ωc = 9.518 k **O.K.**

Corner Connections (Use 1/4" φ SAE Grade 8 bolts w/ 1/4-20-UNC Threaded insert)

Tcrnmax = 1517 lbs Max($F_{pmaxASD}$/4 -OR- $Fh_{ASDtrans}$/4 corner connections)
Vcrnmax = 1634 lbs (Max Ten/2 corner connections per side)

Bolt:	Tall =	5000 lbs	Vall =	4470 lbs	
Threaded Insert:	Tall =	4289 lbs	Vall =	661 lbs	

# of Bolts required for Tension = 0.4 (By Inspection, Threaded Inserts Control)
# of Bolts required for Shear = 2.5 ***If combined fails:
# of Bolts Used = 3.0 USE --> 4.0
Check Combined Stress in Bolts & Inserts: 0.942 O.K. StressComb = 0.707 O.K.

Check 1/8" welded connection <--- USE WELD Ω = 2.35
Assume L/t > 25: 25*t = 2.543 in $P_n/\Omega=\frac{1}{\Omega}0.75tLF_u\ge V_{req}$ $L_{req'd}=\frac{V_{req}\Omega}{0.75tF_u}$
Lreq'd = 0.775 in

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Curb Loads (copied from upper rail calcs)

Transverse: (on long edge)	$Comp_{MAX}$ =	3319	lbs
	$Tens_{MAX}$ =	2557	lbs
	$Shear_{MAX}$ =	3034	lbs
Longitudinal: (on short edge)	$Comp_{MAX}$ =	2838	lbs
	$Tens_{MAX}$ =	2076	lbs
	$Shear_{MAX}$ =	3034	lbs

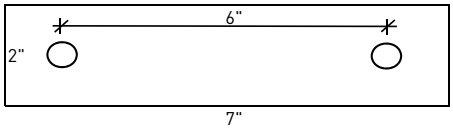
Loads at each JQA Isolator

Transverse loading: (on long edge)	$Comp_{MAX}$ =	1106.3	lbs
	$Tens_{MAX}$ =	852.3	lbs
# isolators: 3	$Shear_{MAX}$ =	1011.2	lbs
Longitudinal loading: (on short edge)	$Comp_{MAX}$ =	945.9	lbs
	$Tens_{MAX}$ =	691.9	lbs
# isolators: 3	$Shear_{MAX}$ =	1011.2	lbs

Max compression force on isolator: 1.106 k ≤ 1.660 k **O.K.**

Max uplift on isolator: 0.852 k

Max shear on isolator: 1.011 k



Forces on bottom bolts:

d_b = 0.5 in

base curb, t = 0.1017 in

Tension = 0.426 k / bolt

Shear = 0.506 k / bolt

Shear on base curb: $P_n = teF_u$ Ω = 2.00 (Appendix A, Section E3.1 AISI)

Pn/Ω = 6.611 k e = 1.0 in

Shear O.K.

Net section rupture: $P_n = A_nF_t$ Ω = 2.22 (Appendix A, Section E3.2 AISI)

Pn/Ω = 8.428 k An = 0.153 in

N.S.R. O.K. $F_t = (0.1 + 3d/s)F_u \le F_u =$ 55.250 ksi

Bolt Bearing Strength: $P_n = Cm_f dtF_u$ Ω = 2.50 (Section E3.3.1 AISI)

Pn/Ω = 3.966 k d/t = 4.92

Bearing O.K. C = 3.00 mf = 1.00

Shear and tension in bolt: (Appendix A, Section E3.4 AISI)

Tension $P_{nt} = A_bF_{nt}$ Fnt = 45.0 ksi A_b = 0.1963 in^2

Pnt/Ω = 3.927 k **Bolt tension O.K.** Ωt = 2.25 (Table E3.4-1, AISI)

Shear $P_{nv} = A_bF_{nv}$ Fnv = 27.0 ksi Ωv = 2.40 (Table E3.4-1, AISI)

Pnv/Ω = 2.209 k **Bolt shear O.K.**

$$F'_{nt} = 1.3F_{nt} - \frac{\Omega F_{nt}}{F_{nv}} f_v \le F_{nt}$$

fv = 2.58 ksi O.K.

Combined Not Applicable F'nt = 45.00 ksi Fnv/Ω = 11.25 ksi

Connection of Curb to Supporting Structure

Roof Loading SEISMIC: (0.6-0.14SDS)D + 0.7E WIND: 0.6D + W

Transverse:	$Uplift_{MAX}$ =	6272	lbs	$Shear_{MAX}$ =	3831 lbs
$Compression_{SEISMIC}$ =	7234 lbs	=[FpmaxASD*(Hcm+Hcurb)+(1+0.14S_{DS})*($WGT_{unit+curb}$/2)*wcurb]/wcurb			
$Tension_{SEISMIC}$ =	6272 lbs	=$Comp_{SEISMIC}$-(0.6-0.14S_{DS})*(WGTunit+curb)			
$Compression_{WIND}$ =	1399 lbs	=[$F_{h\ transASD}$*(Hcm+Hcurb)+0.6*($WGT_{unit+curb}$/2)*wcurb-$F_{vertASD}$*wcurb/2]/wcurb			
$Tension_{WIND}$ =	2151 lbs	=[$F_{h\ transASD}$*(Hcm+Hcurb)-0.6*($WGT_{unit+curb}$/2)*wcurb+$F_{vertASD}$*wcurb/2]/wcurb			
Longitudinal:	$Uplift_{MAX}$ =	4805	lbs	$Shear_{MAX}$ =	3831 lbs
$Compression_{SEISMIC}$ =	5767 lbs	=[FpmaxASD*(Hcm+Hcurb)+(1+0.14S_{DS})*($WGT_{unit+curb}$/2)*Lcurb]/Lcurb			
$Tension_{SEISMIC}$ =	4805 lbs	=$Comp_{SEISMIC}$-(0.6-0.14S_{DS})*(WGTunit+curb)			
$Compression_{WIND}$ =	574 lbs	=[$F_{h\ transASD}$*(Hcm+Hcurb)+0.6*($WGT_{unit+curb}$/2)*Lcurb-$F_{vertASD}$*Lcurb/2]/Lcurb			
$Tension_{WIND}$ =	1326 lbs	=[$F_{h\ transASD}$*(Hcm+Hcurb)-0.6*($WGT_{unit+curb}$/2)*Lcurb+$F_{vertASD}$*Lcurb/2]/Lcurb			

Wood Attachment: **1/4" φ Simpson SDS screws** **w/ 3.5" Min. Embed**

	$Tall_{metal}$ =	324	lbs	$Vall_{metal}$ =	1020 lbs
Transverse:	$Tall_{wood}$ =	642	lbs	$Vall_{wood}$ =	272 lbs
# of Screws Req'd for Uplift =	19.36	# of Bolts Required =	20		
# of Screws Req'd for Shear =	14.08	Req'd Min Spacing =	5.6	in o.c.	

Use 20 - 1/4" ϕ Simpson SDS screws @ 5.6 in o.c. along long side of curb w/ 3.5" Min. Embed

Longitudinal:

# of Screws Req'd for Uplift =	14.83	# of Bolts Required =	15
# of Screws Req'd for Shear =	14.08	Req'd Min Spacing =	5.4 in o.c.

Use 15 - 1/4" ϕ Simpson SDS screws @ 5.4 in o.c. along short side of curb w/ 3.5" Min. Embed

Steel Deck Attachment: **1/2" φ A307 Bolts attached to steel angle below deck**

	$Tall_{steel}$ =	4417	lbs	$Vall_{steel}$ =	2316 lbs
Transverse:	$Tall_{bolt}$ =	1325	lbs	$Vall_{bolt}$ =	1325 lbs
# of Bolts Req'd for Uplift =	4.73	# of Bolts Required =	5		
# of Bolts Req'd for Shear =	2.89	Req'd Min Spacing =	25.8	in o.c.	

Use 5 - 1/2" ϕ A307 Bolts attached to steel angle below deck @ 25.8 in o.c. along long side of curb

Longitudinal:

# of Bolts Req'd for Uplift =	3.63	# of Bolts Required =	4
# of Bolts Req'd for Shear =	2.89	Req'd Min Spacing =	24.0 in o.c.

Use 4 - 1/2" ϕ A307 Bolts attached to steel angle below deck @ 24 in o.c. along long side of curb

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For Concrete anchorage: SEISMIC [0.6-0.14SDS]D + 0.7Ω_o E (Ω_o = 2.5)

Concrete Attachment: 3/4" φ Hilti Hit-HY 200 adhesive anchors w/ 6" embed

$Tall_{LRFD}$ = 1919 lbs $Vall_{LRFD}$ = 3188 lbs $\propto = (1 + 0.2SDS)D + 2.5E$ =1.87

$Tall_{ASD} = Tall_{LRFD}/\alpha$ = 1026.2 lbs $Vall_{ASD} = Vall_{LRFD}/\alpha$ = 1704.8 lbs $(D = 0.465, E = 0.535)$

Transverse: $Uplift_{MAX}$ = 14387 lbs $Shear_{MAX}$ = 9578 lbs

$Compression_{SEISMIC}$ = 15349 lbs =[2.5*FpmaxASD*(Hcm+Hcurb)+(1+0.14S_{DS})*($WGT_{unit+curb}$/2)*wcurb]/wcurb

$Tension_{SEISMIC}$ = 14387 lbs =$Comp_{SEISMIC}$-(0.6-0.14S_{DS})*(WGTunit+curb)

$Shear_{SEISMIC}$ = 9578 lbs =2.5*FpmaxASD/2

Min Bolts Req'd Uplift = 14.02 spacing = 6.52 in o.c. Tapplied = 846.3 lbs

Min Bolts Req'd Shear = 5.62 spacing = 18.25 in o.c. Vapplied = 563.4 lbs

Try using 17 bolts
spaced at 6.45 in o.c.

COMBINED LOADING = $\frac{T_{applied}}{T_{allow,ASD}} + \frac{V_{apllied}}{V_{allow,ASD}} \leq 1.2$ = 1.16

Use 17 - 3/4" ϕ Hilti Hit-HY 200 adhesive anchors @ 6.5 in o.c. max. along long side of curb w/ 6" embed

Longitudinal: $Uplift_{MAX}$ = 10719 lbs $Shear_{MAX}$ = 9578 lbs

$Compression_{SEISMIC}$ = 11681 lbs =[2.5*FpmaxASD*(Hcm+Hcurb)+(1+0.14S_{DS})*($WGT_{unit+curb}$/2)*Lcurb]/Lcurb

$Tension_{SEISMIC}$ = 10719 lbs =$Comp_{SEISMIC}$-(0.6-0.14S_{DS})*(WGTunit+curb)

$Shear_{SEISMIC}$ = 9578 lbs =2.5*FpmaxASD/2

Min Bolts Req'd Uplift = 10.45 spacing = 6 in o.c. Tapplied = 765.7 lbs

Min Bolts Req'd Shear = 5.62 spacing = 12 in o.c. Vapplied = 684.1 lbs

Try using 14 bolts
spaced at 5.54 in o.c.

COMBINED LOADING = $\frac{T_{applied}}{T_{allow,ASD}} + \frac{V_{apllied}}{V_{allow,ASD}} \leq 1.2$ = 1.15

Use 14 - 3/4" ϕ Hilti Hit-HY 200 adhesive anchors @ 5.5 in o.c. max. along short side of curb w/ 6" embed