MOUR GROUP
ENGINEERING + DESIGN

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: August 1, 2019

Project Number: PV1802

For wood, concrete and steel attachment see Roof Anchorage Detail, Form No. CB-60.

Welded Isolation springs housingare standard. For bolted spring housing, neoprene pads and spring cups see Weldment and Bolting Detail, Form No. CB-61

FEATURES

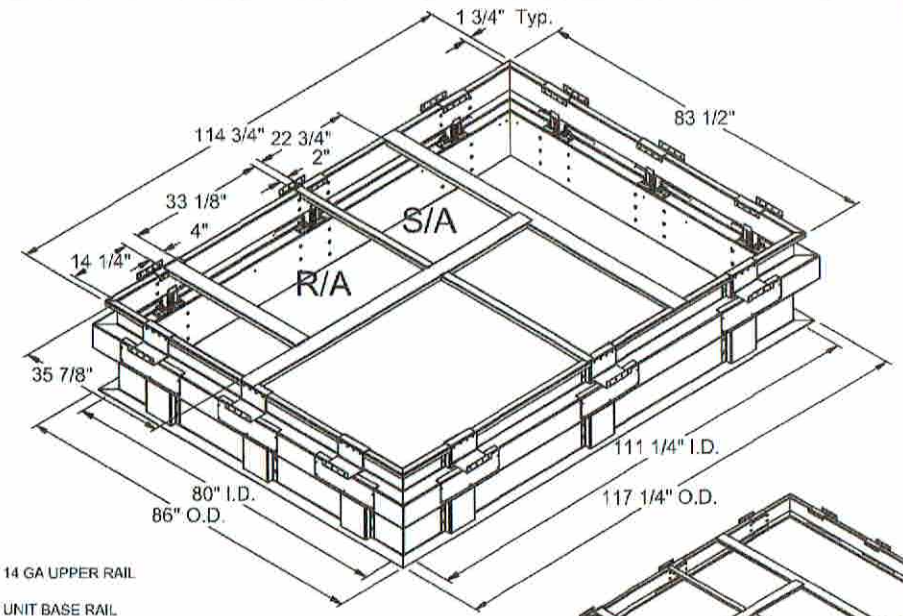
- Roof curb base 12 ga.
- Roof curb upper rail 14 ga.
- Fully welded construction.
- Gasketing package provided.
- Heat treated wood nailer provided.
- insulated deck pans provided.
- Pitched curbs and taller curbs are available.

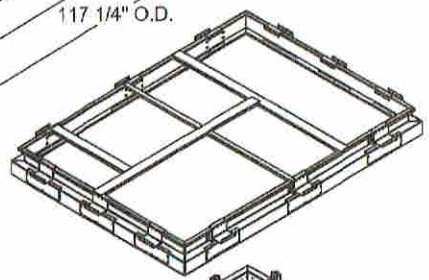
NOTES

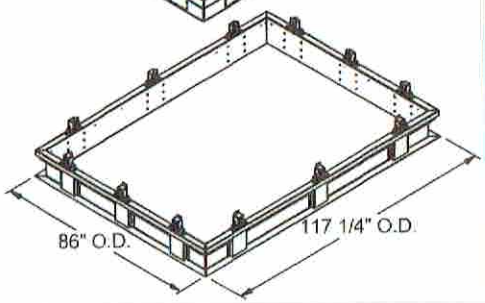
- Attach ductwork to roof curb. Flanges of duct rest on top of the curb, Support ductwork below the curb.
- Thru the curb utillities are available. Contact you York distributor or Provent directly.

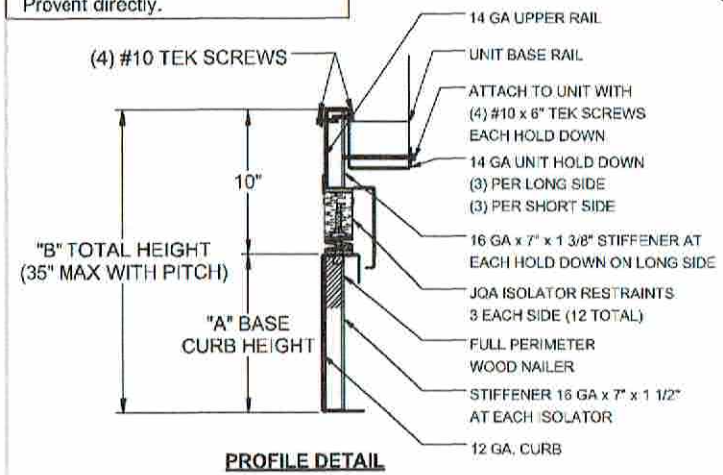
VIBRATION ISOLATION ROOF CURBS
YORK UNITS

ZF 180









PROFILE DETAIL

PROVENT P/N	A	B	EST. WEIGHT
CBISCSLU18018**	8"	18"	475 Lbs
CBISCSLU18021**	11"	21"	525 Lbs
CBISCSLU18024**	14"	24"	575 Lbs

**Note: Spring configuration must be added to part number at time of order

Meets seismic requirements for the following codes:
CBC 2016
IBC 2015

REGISTERED PROFESSIONAL ENGINEER
GLENN A. MOURITZEN
NO. 3578
EXP. 06/30/2021
STRUCTURAL
STATE OF CALIFORNIA
8/1/19

ProVent

3847 WABASH DRIVE
MIRA LOMA, CA 91752

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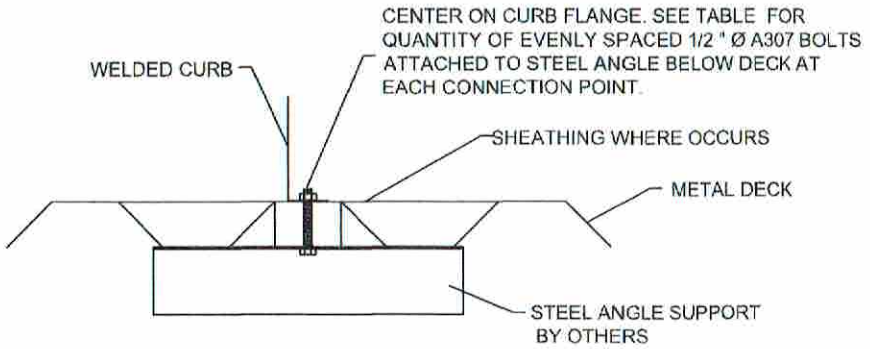
SUBMITED TO:
COMPANY:
JOB NAME:
EQUIPMENT:
NOTES:

FORM NO:	PART NUMBER:	
CBISC-07	-	
DATE:	REV:	DRAWN BY:
01/29/18	-	ALL

STEEL ATTACHMENT



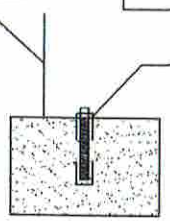
CURB	NO. OF ANCHORAGE BOLTS REQUIRED	
	LONG SIDE	SHORT SIDE
LXS	2 @ 34.5" O.C	XX @ 2 @ 19" O.C
LXL	2 @ 34.5" O.C.XX	2 @ 29" O.C
SUN3672	2 @ 60" O.C	2 @ 24.25" O.C
PRD3715	2 @ 68.38" O.C	2 @ 38.5" O.C
PRS	2 @ 58.38" O.C	2 @ 28.19" O.C.
PRL	2 @ 72" O.C	2 @ 41" O.C
SLU180	2 @ 102.25" O.C.	2 @ 71" O.C.
SLM1830	2 @ 113.25" O.C	2 @ 71" O.C.

Meets seismic requirements for the following codes:
CBC 2016
IBC 2015

ASSUMES:
CONC SLAB
f'c= 4000PSI MINIMUM
6" MIN THICKNESS
NORMAL WEIGHT CONCRETE
OR SAND LIGHT WEIGHT

ROOF ANCHORAGE DETAIL		
CBKD Series	CBWC Series	CBISC Series
LXS	LXS	LXS
LXL	LXL	LXL
SUN3672	SUN3672	SUN3672
PRD3715	PRD3715	PRD3715
PRS	PRS	PRS
PRL	PRL	PRL
	SLU180	SLU180
	SLM1830	SLM1830

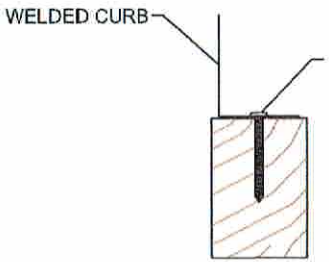
CONCRETE ATTACHMENT



CURB	NO. OF ANCHORAGE BOLTS REQUIRED	
	LONG SIDE	SHORT SIDE
LXS	10 @ 3.73" O.C.	9 @ 2.38" O.C.
LXL	8 @ 4.93" O.C.	7 @ 4.83" O.C.
SUN3672	9 @ 7.5" O.C.	6 @ 4.85" O.C.
PRD3715	17 @ 4.27" O.C.	13 @ 3.21" O.C.
PRS	9 @ 7.3" O.C.	7 @ 4.7" O.C.
PRL	11 @ 7.2" O.C.	9 @ 5.13" O.C.
SLU180	16 @ 6.82" O.C.	13 @ 5.92" O.C.
SLM1830	18 @ 6.66" O.C.	13 @ 5.92" O.C.

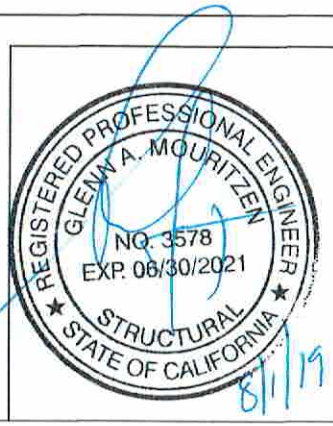
* SIX INCHES FROM EACH CORNER EVENLY SPACED.
** CENTERED.

WOOD ATTACHMENT



CURB	NO. OF ANCHORAGE SCREWS REQUIRED	
	LONG SIDE	SHORT SIDE
LXS	7 @ 6.42" O.C.	4 @ 7.67" O.C.
LXL	7 @ 6.42" O.C.	6 @ 6.6" O.C.
SUN3672	4 @ 21.33" O.C.	3 @ 14.13" O.C.
PRD3715	8 @ 10.34" O.C.	6 @ 8.5" O.C.
PRS	4 @ 20.79" O.C.	3 @ 16.09" O.C.
PRL	4 @ 25.33" O.C.	3 @ 22.5" O.C.
SLU180	7 @ 17.71" O.C.	7 @ 12.5" O.C.
SLM1830	8 @ 16.75" O.C.	6 @ 15" O.C.

FOUR INCHES FROM EACH CORNER EVENLY SPACED



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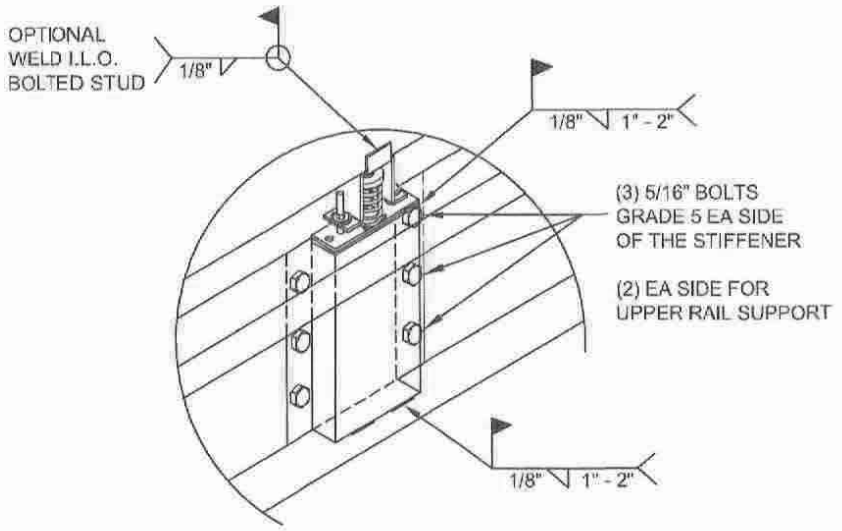
SUBMITTED TO: _____
COMPANY: _____
JOB NAME: _____
EQUIPMENT: _____
NOTES: _____

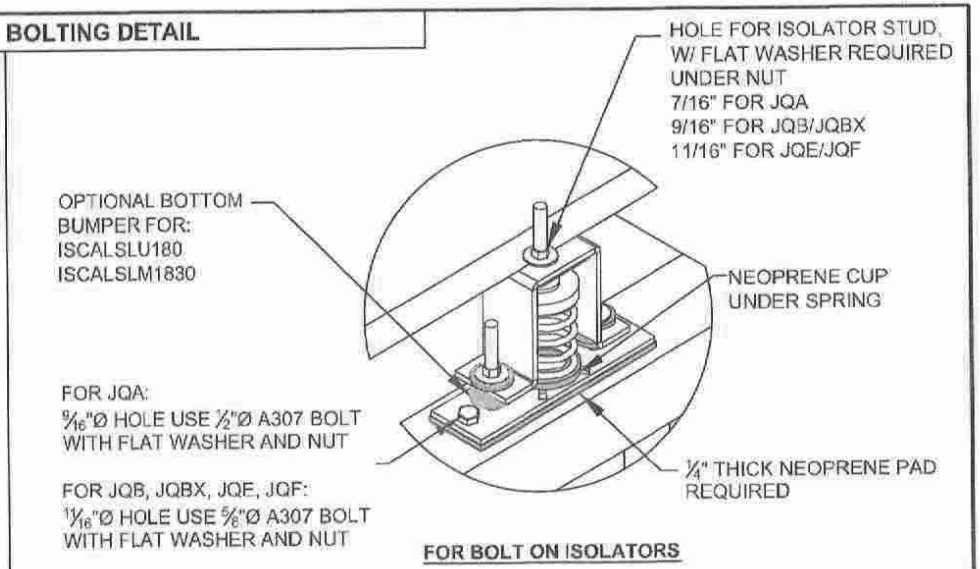
FORM NO: CB-60

DATE:	REV:	DRAWN BY:
07/31/18	3	ALL

WELDMENT AND BOLTING DETAIL



BASE CURB SUPPORT



FOR BOLT ON ISOLATORS

ProVent

3847 WABASH DRIVE
MIRA LOMA, CA 91725

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SUBMITTED TO:
COMPANY:
JOB NAME:
EQUIPMENT:
NOTES:

FORM NO:		
CB-61		
DATE:	**REV:**	**DRAWN BY:**
02/08/18	1	ALL

MOUR GROUP
ENGINEERING + DESIGN

6593 Riverdale St.
San Diego, CA 92120
(619)727-4800

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+a(r+t/2)]
a =	0.000 (0 - no Lip; 1 w/ lip)		b'=	1.464 in	= B'-(t/2+at/2)
R =	0.1069 (Inside bend radius)		c =	0.000 in	= a[C'-(r+t/2)]
t =	0.0713 in		c'=	0.000 in	= a(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 in²
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)

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

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
Ω_w = 1.75 N/h = 1.167 ≤ 2.0 C_h = 0.048
P_n = 1.883 k R/t = 1.50 ≤ 12.0 [See table C3.4.1-2, fastened to support, two flange, end loading]
P_n/Ω_w = 1.076 k

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

Long side: Pu_{Trans} = 1.106 k **web stiffener REQ'D** # clips = 3
Short side: Pu_{Long} = 0.946 k **O.K.** # clips = 3

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

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

Pwc = 1.883 k Ae = 0.380 in²
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

Pns/Ω = 755 #

Pss/Ω = 540 # <- Controls

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

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

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 in² — Anv = 0.380 in² — Ant = 0.082 in²

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

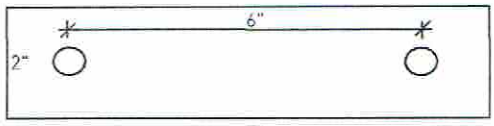
Max compression force on isolator: 1.106 k ≤ 1.660 k **O.K.**

Max uplift on isolator: 0.852 k

Max shear on isolator: 1.011 k

Loads at each JOA Isolator

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



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 in²

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 (unit only)	(0.7*Fpmax) FpmaxASD = 7662 lbs (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 in²
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)

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

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

Compression Check = O.K.

Check Web Crippling

h = 25 in -- Check limits:
t = 0.1017 in h/t = 245.82 ≤ 200
N = 7.00 N/t = 68.83 ≤ 210
Ω_w = 1.75 N/h = 0.28 ≤ 2.0
P_n = 4.106 k R/t = 1.50 ≤ 9.0
P_n/Ω_w = 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

C = 4.00
C_R = 0.14
C_N = 0.35
C_h = 0.02
(See table C3.4.1-2, fastened to support, one flange, end loading)

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

***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 Ω_c = 1.70
w/ts = 118.675
1.28√(E/Fys) = 31.091 --> w/ts over limit Use C3.7.2

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

Pwc = 4.106 k Ae = 0.380 in²
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
Lreq'd = 0.775 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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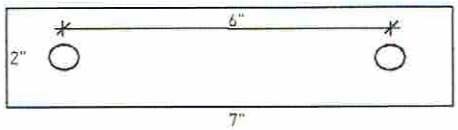
Curb Loads (copied from upper rail calcs)

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 IQA 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 $(0.6-0.14SDS)D + 0.7\Omega_o E$ $(\Omega_o = 2.5)$

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

$T_{all_{LRFD}}$ = 1919 lbs $V_{all_{LRFD}}$ = 3188 lbs $\alpha = (1 + 0.2SDS)D + 2.5E = 1.87$

$T_{all_{ASD}} = T_{all_{LRFD}}/\alpha$ = 1026.2 lbs $V_{all_{ASD}} = V_{all_{LRFD}}/\alpha$ = 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 = $\frac{T_{applied}}{T_{allow,ASD}} + \frac{V_{applied}}{V_{allow,ASD}} \leq 1.2$ = 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 = $\frac{T_{applied}}{T_{allow,ASD}} + \frac{V_{applied}}{V_{allow,ASD}} \leq 1.2$ = 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